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RESEARCH ARTICLE

Analysing the drivers of farmers' knowledge level on cabbage (*Brassica oleracea* var. *capitata*) cultivation technology: Evidence from Khordha district, Odisha, India

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Abstract

This study was conducted to assess the extent of knowledge possessed by cabbage farmers on cabbage cultivation technology in Khordha district of Odisha and to identify the socio-economic factors driving their knowledge level. An ex-post facto research design was employed, with a sample of 120 cabbage growers selected randomly. Multi-stage sampling was utilised to select respondents from 6 purposively chosen villages in Balianta and Balipatna blocks of Khordha. A pre-tested, structured interview schedule was used to gather the data, which were further analysed using descriptive and inferential statistics such as correlation, multiple linear regression, step-wise multiple regression and path analysis. The results showed that 78.3 % of the respondents had a medium level of knowledge, while 18.3 % and 3.4 % of them had low and high levels of knowledge on cabbage cultivation technology respectively. Significant contributors to the knowledge level of cabbage farmers included age, educational qualification, annual family income, experience in cabbage cultivation, social participation and innovativeness. The findings thus indicate that certain targeted measures like improving educational facilities, imparting training to farmers, improving extension advisory services and strengthening community-based learning approaches could bridge the knowledge gap among the farmers, thereby ensuring sustainable yield of cabbage and improved livelihood in the region.

Keywords: cabbage; extension; horticulture; information dissemination; rural development; technology adoption

Introduction

India's agricultural sector has progressed remarkably in the recent years. In the second quarter of the fiscal year 2025, the agriculture sector had a growth rate of 3.5 %. From 2017 to 2023, the growth was significant, averaging 5 % per year. As a result, India's agricultural economy has developed into a resilient and self-sustaining economy (1).

Horticulture is expanding rapidly across the country as a promising sector. Horticultural crops are high-value crops that yield more than field crops, making them more profitable in the market (2). This has led to horticulture being a key driver of economic development in India. Horticultural crops account for 33 % of the agricultural gross value added (GVA) despite using only 13.1 % of the gross cropped area (3). This has been reflected in the enhancement of farm income and livelihood of many farmers who practice horticulture. With a compound annual growth rate (CAGR) of 4.7 % between 2015–2016 and 2021–2022, horticulture has become a rapidly expanding sector (4).

Through initiatives like the National Horticulture Mission (NHM) and Mission for Integrated Development of Horticulture (MIDH), the government has been successful in expanding the horticultural sector and improving farmers' quality of life (5). There has been increased growth in the area and production of horticultural crops, especially after the introduction of schemes like NHM (6). As a result, the production of horticultural crops in India has increased by 3.9 %, surpassing the production of field crops (7).

Horticultural crops have also been at the forefront of sustainable agriculture due to the increased need for sustainability. Horticultural crops are essential to diversified farming, which promotes a sustainable economy in addition to providing people with nutritional security (8). India's horticulture industry has advanced significantly in terms of area, production and productivity over the years due to the rising demand for horticultural crops in the country (9).

Horticultural crops in India have helped farmers double their farm income by accounting for 37 % of all agricultural commodity exports (10). Over the last few years, horticultural crop production in the country has increased by 3.9 %, reaching 334.60 million tonnes in 2020–2021 (7). This has paved way for a greater income diversification, employment generation and enhanced export in the economy (11).

Amongst the horticultural crops grown in India, cabbage (*Brassica oleracea* var. *capitata*) is a crop that contributes significantly to vegetable production. It is widely grown in states like West Bengal, Odisha and Bihar due to its adaptability and high demand (4). It has a significant market size in India due to its rapid growth period, nutritional benefits and high yield potential. India is the second-largest producer of cabbage in the world, accounting for 13.66 % of the global production (12). Over time, India's production of cabbage has grown significantly. From a total production of 7.95 million metric tonnes in 2011, cabbage production in India has risen to 9.825 million metric tonnes in 2022 and 10.049 million metric tonnes in 2023 (13). This clearly justifies the scope of research in this area.

The cultivation of cabbage in India has transformed over time due to technological improvements, making it more profitable, high-yielding and scientifically innovative. The knowledge of farmers on modern cultivation practices drives major improvements in cabbage farm productivity. It affects efficiency and profitability in farming, whereas farmers who have informed knowledge on recommended modern cultivation practices achieve 20–30 % higher yield than those who rely on traditional methods (14, 15).

Precise farm decisions based on farmers' knowledge have been shown to contribute to efficient farm productivity of cabbage (16). A previous study revealed that farmers' access to information affected their level of knowledge on cabbage cultivation, which further influenced the technical efficiency of the farm (17). Even though the crop was widely grown in Meghalaya, farm productivity was still low since farmers lacked knowledge on many aspects of cultivation (18).

The farm decisions of cabbage farmers on pest control, input management, marketing management and other aspects of their farms are influenced by their knowledge of cabbage cultivation. Long-term profitability is increased when farmers have greater knowledge (19). Therefore, this suggests that further research on the level of knowledge possessed by cabbage farmers is necessary.

Cabbage production has significantly increased in Odisha, which is a leading producer of cabbage in India. In 2021, Odisha produced 1130560 tonnes of cabbage in an area of 37740 hectares, accounting for 11.77 % of the country's total production (20). Of all the districts in Odisha, Khordha district is well known for its substantial contribution to the production of cabbage. In an area of 2200 ha, 63160 metric tonnes of cabbage are produced there, indicating the widespread cultivation of cabbage in the region (21).

There is a high market demand for cabbage from the Khordha region in the state. However, farmers still face problems with respect to reduced yield and pest attack, owing to their lack of knowledge on certain aspects of cabbage cultivation technology. The productivity of cabbage can be increased through proper dissemination of information among the farmers cultivating it. In this regard, it is important to determine the knowledge level of farmers on the recommended cultivation technology of cabbage and to analyse the factors that affect their knowledge levels. Additionally, there has been no prior research assessing the gaps in the knowledge level of farmers of the region with respect to cabbage cultivation technology.

Considering the prospects of cabbage cultivation in the state of Odisha and especially the widespread production of cabbage in the study area of Khordha district, the current study was undertaken with the objective of assessing the knowledge level of cabbage farmers from Khordha district of Odisha on cabbage cultivation technology and identifying the factors that affect the knowledge level of respondents.

Materials and Methods

The current study was undertaken using an ex-post facto research design (22–24). The Khordha district of Odisha was purposively selected as the locale for the study due to its high production of cabbage in the state. A multi-stage sampling technique was used to choose the sample for the study, where selection was done at various stages; district, block, village and gram panchayat level, to arrive at the sample.

Out of the 10 blocks in Khordha district, Balianta and Balipatna blocks were selected purposively because they had more cabbage growers than other blocks. From each of the 2 blocks, 3 gram panchayats were selected purposively for the study, thus adding up to a total of 6 gram panchayats. Three gram panchayats were selected from Balianta block, namely Jhinti Sasan, Purohitpur and Puranapradhan. Similarly, Garedipanchan, Somanasasan and Rajas gram panchayats were selected from Balipatna block. Finally, 6 villages (1 from each gram panchayat) were selected through purposive sampling based on the area under cabbage cultivation. From Balianta block, Jhinti Sasan, Chadheibara and Puranapradhan villages were selected. From Balipatna block, Garedipanchan, Somanapradhan and Rajas villages were selected. With assistance from the Farm Information Advisory Centre (FIAC), a list of cabbage farmers from each village was compiled.

Twenty cabbage growers were selected from each of the 6 villages using simple random sampling. A sample size of 120 respondents was chosen in order to gather primary data. Before collecting data, consent was collected from the respondents in advance and ethical considerations were taken into account while collecting the data. The maps of the locale of the study are depicted in Fig. 1 and the sampling procedure for the study is illustrated in Fig. 2.

A well-structured, pre-tested interview schedule was used to gather the data through personal interviews. Prior to finalising the interview schedule, it was pretested with a 10 % sample other than the respondents under study. The interview schedule served as a primary tool of data collection, covering the socio-economic profile of the respondents and the knowledge level of the respondents on cabbage cultivation technology. In this study, the socio-economic profile of respondents was studied using 11 socio-economic variables which were designated as independent variables, whereas the knowledge level of farmers on cabbage cultivation technology was selected as the dependent variable. The independent variables included age, educational qualification, family size, occupation, land holding size, annual family income, extension contact, experience in cabbage cultivation, social participation, mass media exposure and innovativeness. The measurements for the independent variables are depicted in Table 1. The independent variables were analysed using statistical tools like mean, standard deviation, frequency and percentage.

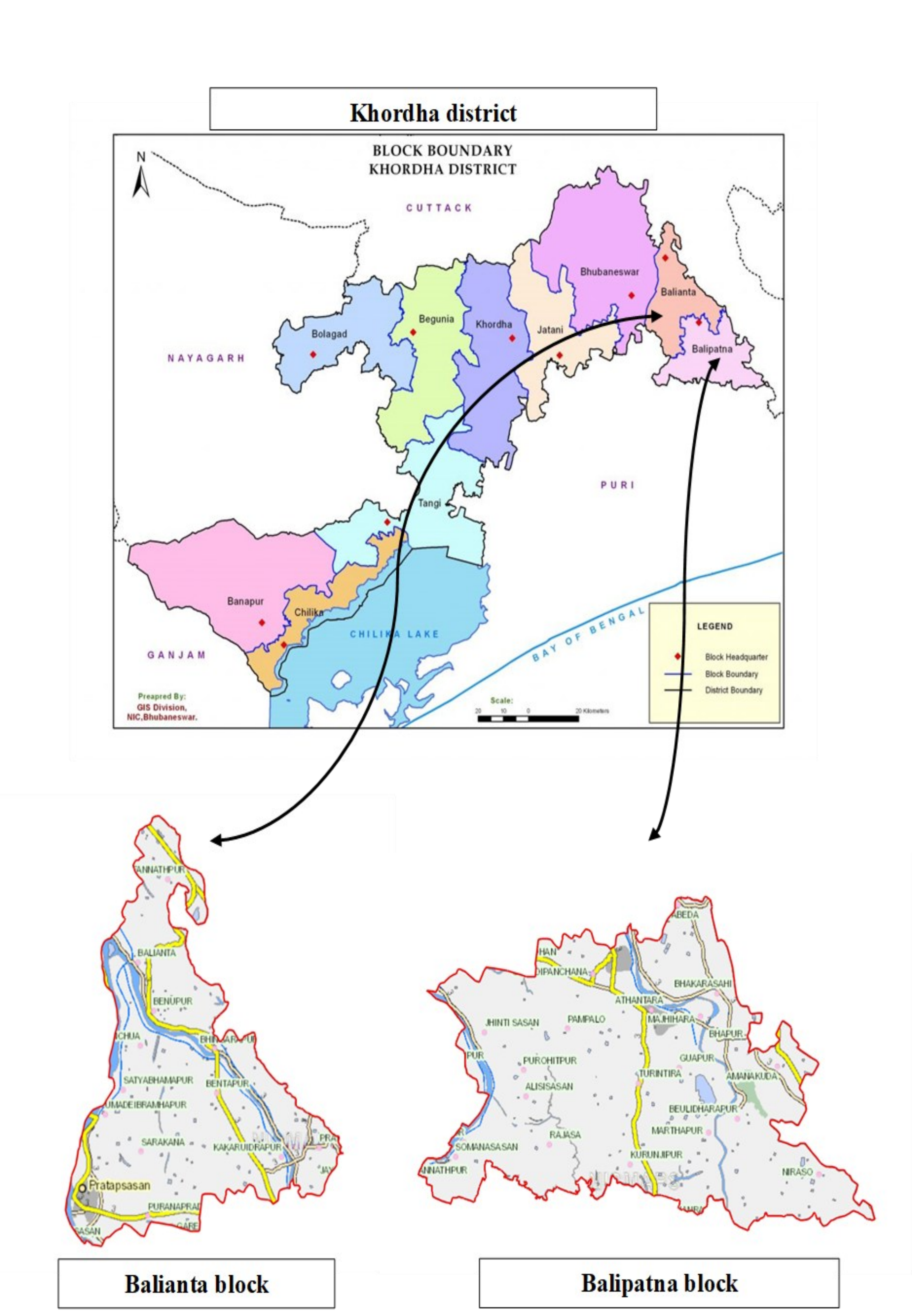

Fig. 1. Maps of the locale of study depicting the map of Khordha district and the maps of Balianta and Balipatna blocks.

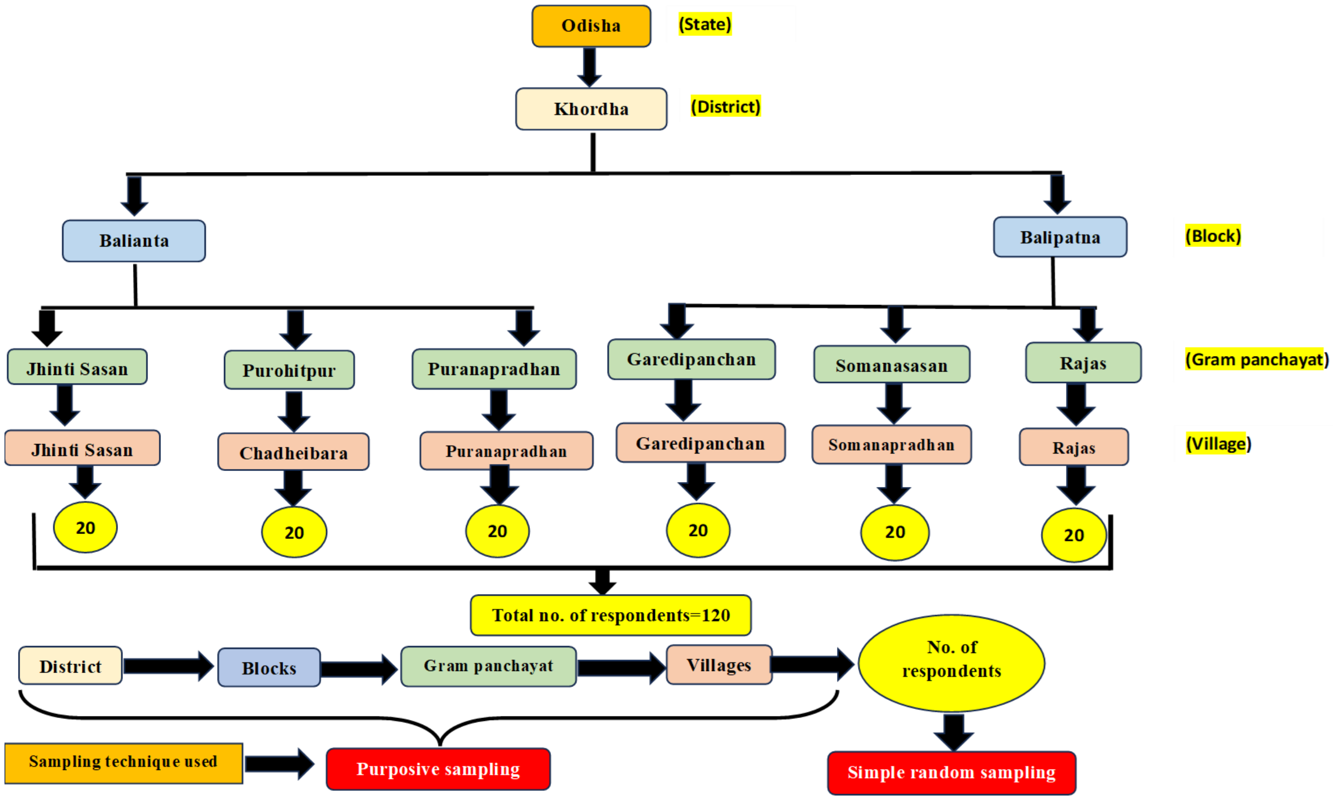

Fig. 2. Sampling procedure for the study.

Table 1. Socio-economic variables under study and their measurements

Sl.No.	Variable	Measurement	Reference
1.	Age (X1)	A standard scale with modifications	(25)
2.	Educational qualification (X2)	A standard scale with slight modifications	(26)
3.	Family size (X3)	A standard scale	(27)
4.	Occupation (X4)	A standard scale with modification	(28)
5.	Land holding size (X5)	A standard scale	(29)
6.	Annual family income (X6)	Schedule developed for study	-
7.	Extension contact (X7)	A standard scale	(30)
8.	Experience in cabbage cultivation (X8)	Schedule developed for study	-
9.	Social participation (X9)	A standard scale with modifications	(31)
10.	Mass media exposure (X10)	A standard scale	(32)
11.	Innovativeness (X11)	A standard scale with slight modifications	(33)

Knowledge is defined as the body of comprehended information that an individual possesses (34). In the context of agriculture, knowledge refers to the collection of ideas, meanings and abilities acquired by individuals or groups over time through information processing (35). It has also been described as behaviour and test scenarios that focused on remembering concepts, information, or phenomena through recognition or recall (36).

In this study, the knowledge level of farmers on cabbage cultivation technology was selected as the dependent variable. It was operationalised as the level of comprehensive understanding of respondents on the package of practices used in cabbage cultivation. A standard scale was applied to measure the knowledge level of respondents based on the standard package of practices (37). Each practice was framed into a statement to collect responses from the respondents. The statements were formulated using earlier scientific literature as a basis and with inputs from scientists, experts and advisors. A knowledge test comprising of 20 statements was formed, where a correct response was given a score of '1' and an incorrect one was given a score of '0.' This scale was administered to the respondents to collect data. The highest attainable knowledge score was 20. To calculate the overall knowledge score for each respondent, the scores across all questions were added together.

The knowledge index was used for quantifying the knowledge level of each respondent (38). It was arrived at by dividing the total knowledge score obtained by a respondent by the maximum knowledge score that can be obtained and then multiplying the value by 100 (Eqn. 1).

$$\text{Knowledge index} = \frac{\text{Total knowledge score obtained by the respondent}}{\text{Maximum possible knowledge score obtained by the respondent}} \times 100 \quad \text{(Eqn. 1)}$$

The knowledge index was calculated for each of the respondents. Further, the mean and standard deviation were calculated in order to classify the respondents into various levels of knowledge. The respondents were categorised into low, medium and high knowledge levels, based on the mean and standard deviation (S.D.) as shown in Table 2.

Table 2. Categorisation of knowledge level of respondents

Sl.No.	Level of knowledge	Score
1.	Low knowledge level	<Mean-S.D.
2.	Medium knowledge level	In between Mean ± S.D
3.	High knowledge level	>Mean + S.D.

The results obtained were coded, tabulated in Microsoft Excel and analysed properly for further interpretation. The data were subjected to various descriptive and inferential statistical techniques like frequency, percentage, mean, standard deviation, Pearson's correlation, multiple linear regression, stepwise multiple regression and path analysis. Statistical softwares like Microsoft Excel, Statistical Package for the Social Sciences (SPSS version 26.0) and Jamovi were used for the analysis.

Results and Discussion

Socio-economic profile of cabbage farmers

The socio-economic profile attributes of the cabbage farmers in the study area were examined. Table 3 indicates the distribution of respondents according to their socio-economic profile, whereas Fig. 3 graphically illustrates the socio-economic profile of respondents in the form of a bar graph.

According to the findings revealed in Table 3 and Fig. 3, most of the cabbage farmers in the study area were old-aged (56.7 %), followed by middle-aged farmers (38.3 %) and young farmers (5 %). Similar findings were reported earlier (17). It was found that most of the respondents (45 %) had a high school degree, whereas 22.5 % had higher secondary education, 17.5 % had studied till middle school, 5.83 % had a graduate degree, 5 % had functional literacy and 4.17 % of them had primary school education. The findings were similar to the results obtained in a previous study on cabbage growers in Karnataka (39).

Most of the respondents under study had a small family (86.7 %), whereas 8.3 % had a medium-sized family and 5 % had a large family. This was because it is easy to sustain financially and

Table 3. Distribution of respondents according to their socio-economic profile (n=120)

Sl. No.	Socio-economic Variables	Category	Frequency	Percentage	Mean	Standard Deviation
1.	Age (X1)	Young (less than 30 years)	6	5	2.51	0.6
		Middle aged (30–50 years)	46	38.3		
		Old (above 50 years)	68	56.7		
2.	Educational qualification (X2)	Functionally literate	6	5	3.93	1.11
		Primary school	5	4.17		
		Middle school	21	17.5		
		High school	54	45		
		Higher secondary	27	22.5		
		Graduate	7	5.83		
		Above graduate	0	0		
3.	Family size (X3)	Small family (<5 members)	104	86.7	1.18	0.5
		Medium family (5–8 members)	10	8.3		
		Large family (>8 members)	6	5		
4.	Occupation (X4)	Farming	95	79.17	1.41	1.004
		Farming + Animal husbandry	15	12.5		
		Farming+ Labour	0	0		
		Farming + Business	6	5		
		Farming+ Service	3	2.5		
		Farming + Business+ Service	1	0.83		
5.	Land holding size (X5)	Landless	11	9.2	2.37	0.81
		Marginal (upto 1 ha)	68	56.6		
		Small (1.1–2 ha)	26	21.6		
		Medium (2.1–4 ha)	15	12.6		
		Large (above 4 ha)	0	0		
6.	Annual family income (X6)	Low income (<Rs 1610.27)	0	0	99491.6	97881.4
		Medium income (Rs 1610.27 to Rs 197373.05)	114	95		
		High income (>Rs 197373.05)	6	5		
7.	Extension contact (X7)	Low extension contact (<12.47)	26	21.67	16	3.42
		Medium extension contact (12.47 to 19.3)	69	57.5		
		High extension contact (>19.3)	25	20.83		
8.	Experience in cabbage cultivation (X8)	Low experience (<5.65 years)	21	17.5	10.27	4.61
		Medium experience (5.65 to 14.8 years)	75	62.5		
		High experience (>14.8)	24	20		
9.	Social participation (X9)	Low social participation (<13)	17	14.16	14.86	1.87
		Medium social participation (13 to 16.7)	85	70.84		
		High social participation (>16.7)	18	15		
10.	Mass media exposure (X10)	Low mass media exposure (<10.85)	23	19.17	13	2.13
		Medium mass media exposure (10.85–15.12)	86	71.62		
		High mass media exposure (>15.12)	11	9.21		
11.	Innovativeness (X11)	Low innovativeness (<12.42)	15	12.5	15.45	3.021
		Medium innovativeness (12.42–18.47)	81	67.5		
		High innovativeness (>18.47)	24	20		

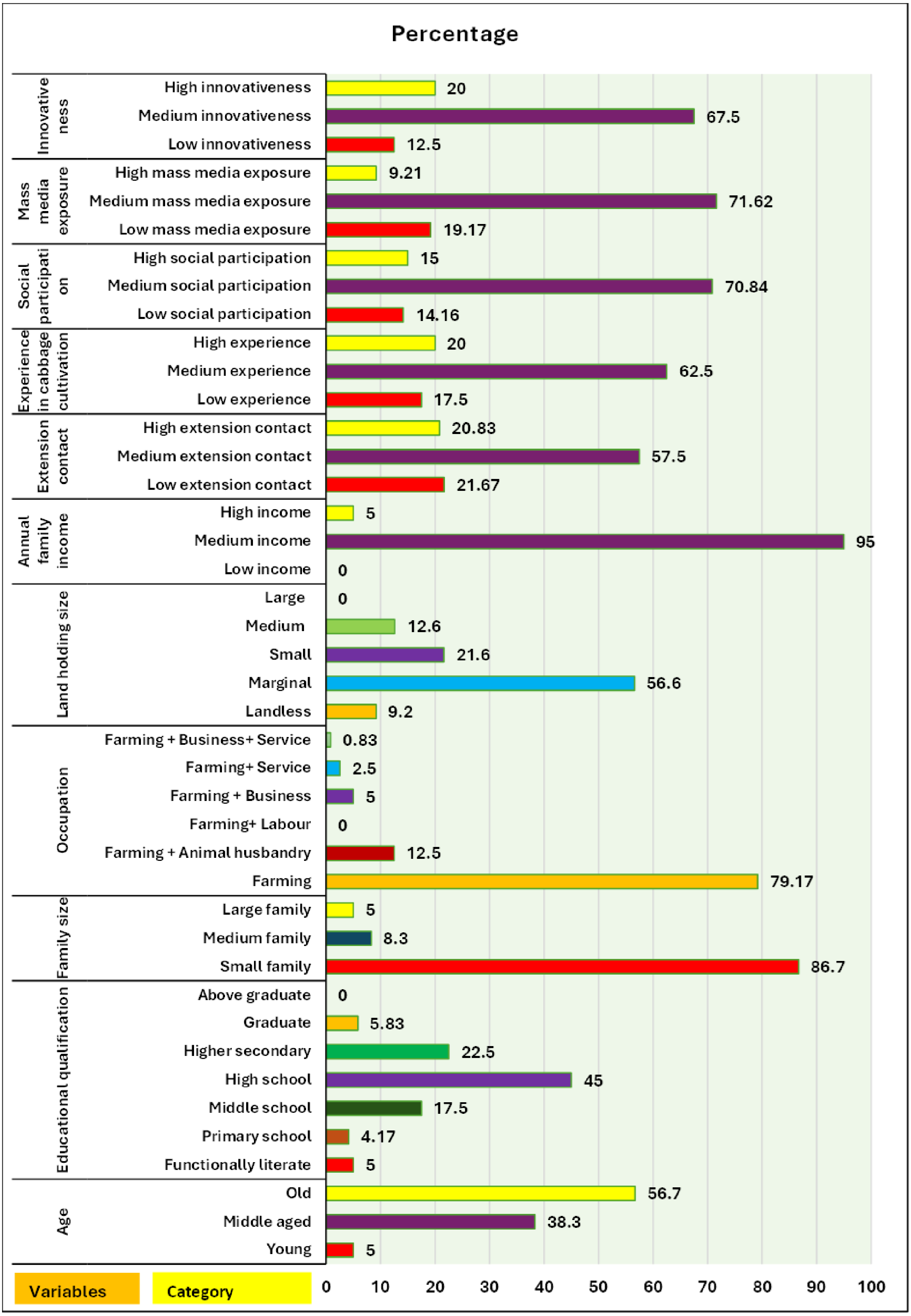

Fig. 3. Bar graph depicting the socio-economic profile of respondents in the study area.

pool the resources in a small-sized family, as compared to a large-sized family. The findings were similar to the results obtained in a study on vegetable growers in Odisha (40).

The findings also revealed that 79.17 % of the respondents were engaged in farming only, followed by 12.5 % in farming and animal husbandry, 5 % in farming and business, 2.5 % in farming and service and 0.83 % in farming, business and service. Similar findings were also reported in a study on cabbage farmers in Tamil Nadu (41). The reason behind most of the respondents having farming as their major occupation was because people were more accustomed to farming in general and hence found it suitable to continue with it instead of trying anything else.

Considering the land holding size of the respondents, most of them (56.6 %) were marginal farmers, followed by 21.6 % small farmers, 12.6 % medium farmers and 9.2 % landless farmers. The primary reason for most of the farmers being marginal farmers could be attributed to land fragmentation. Similar findings were reported earlier (41).

As per the findings, most of the respondents (95 %) had a medium level of annual family income, while only 5 % of them had a high level of income. The cause attributed to the medium level of income of the respondents could be that farming was the primary livelihood for most of them and many of them were marginal farmers, as has been revealed through the findings. Similar insights were concluded previously (42).

It was revealed that 57.5 % of respondents had medium extension contact, followed by 21.67 % with low extension contact and 20.83 % with high extension contact. Most of the respondents were local in their nature and since extension officials were present in the block offices most of the time, therefore farmers did not frequently visit them. Hence, most of the cabbage growers had medium extension contact. Similar results were obtained previously which reported that 54.63 % of vegetable farmers had medium level of extension contact (43).

The data indicate that, most of the farmers (62.5 %) had medium level of experience, followed by 20 % with high level of experience and 17.5 % with low level of experience. Similar results were obtained in a study on cabbage farmers in Meghalaya, India (44).

Most of the respondents (70.84 %) had a medium level of social participation, with 15 % having a high level and 14.16 % having a low level of social participation. With respect to the mass media exposure of the farmers under study, the majority (71.62 %) of them had medium level of mass media exposure, followed by low (19.17 %) and high (9.21 %) mass media exposure. The respondents had more affinity towards traditional media sources like radio and television, owing to their lack of resources and low financial condition, thereby resulting in medium level of mass media exposure. The findings obtained in this study are in conformity with the results obtained earlier (45).

The cabbage farmers in the study area had a medium level of innovativeness (67.5 %), followed by high (20 %) and low (12.5 %) innovativeness. The results signify that the respondents were generally cautious about modern cultivation practices but were willing to adopt new practices when facilitated with support.

Knowledge level of cabbage farmers on cabbage cultivation technology

The knowledge level of respondents on cabbage cultivation technology was tabulated by calculating the knowledge index for each respondent. The respondents were further divided into categories of low, medium and high knowledge, based on mean and standard deviation, as detailed in the methodology. Table 4 indicates the distribution of respondents based on their level of knowledge on cabbage cultivation technology.

According to Table 4, the majority (78.3 %) of respondents had medium knowledge level followed by 18.3 % with low knowledge level and 3.4 % of respondents with high knowledge level. The mean and standard deviation of the knowledge level were 83 and 12.27 respectively.

The findings generated were similar to the results reported in research on cabbage farmers of Tamil Nadu, where they found that the majority of the cabbage growers had medium level of knowledge (46). Similar findings were observed with respect to the knowledge level of cabbage farmers in Karnataka (47). In terms of the knowledge level of vegetable growers who received training from the government, 77.50 % fell within the medium knowledge category, thus justifying the findings from the current study (48).

The reason for the majority of the respondents having medium level of knowledge about cabbage cultivation was because they were more exposed to mass media and information sources, had more innovativeness and frequently made contact with various extension personnel to gain knowledge on various aspects of cabbage cultivation practices (46). Moreover, there existed many challenges including medium level of education, lack of affordability and accessibility for mass media channels, which led to the medium level of knowledge of the respondents.

Relationship between socio-economic characteristics and knowledge level of cabbage farmers

Karl Pearson's coefficient of correlation was used to find out the nature of the relationship between the socio-economic profile of cabbage farmers in the study area of Khordha and the knowledge level of these respondents on cabbage cultivation technology. The knowledge level of farmers on cabbage cultivation technology was selected as the dependent variable (Y1) and the socio-economic attributes of the respondents were designated as independent variables (X1, X2,……, X11). The correlation analysis of the socio-economic attributes of respondents and knowledge level is depicted in Table 5.

As revealed in Table 5, there was a significantly positive correlation (*r*=0.211*) between age and knowledge of cabbage farmers (at 5 % level of significance), thus indicating that the older

Table 4. Distribution of respondents according to their knowledge level on cabbage cultivation technology (n=120)

Sl. No.	Category of knowledge	Frequency	Percentage
1.	Low level of knowledge (<70.72)	22	18.3
2.	Medium level of knowledge (70.72 to 95.27)	94	78.3
3.	High level of knowledge (>95.27)	4	3.4
	Mean=83	SD=12.27	

Table 5. Correlation analysis of knowledge level of cabbage farmers on cabbage cultivation technology (Y1) with their socio-economic attributes (X1 ,X2 , ..., X11) (n=120)

Sl. No.	Independent variables	Coefficient of correlation "r"	p- value
1.	Age (X1)	0.211*	0.021
2.	Educational qualification (X2)	0.452***	<0.001
3.	Family size (X3)	-0.123 NS	0.178
4.	Occupation (X4)	-0.07 NS	0.441
5.	Land holding size (X5)	0.157 NS	0.085
6.	Annual family income (X6)	0.144 NS	0.115
7.	Extension contact (X7)	0.203*	0.026
8.	Experience in cabbage cultivation (X8)	0.245**	0.007
9.	Social participation (X9)	0.07 NS	0.447
10.	Mass media exposure (X10)	0.405***	<0.001
11.	Innovativeness (X11)	0.64***	<0.001

* Significant at 5 % level of significance ** Significant at 1 % level of significance
*** Significant at 0.1 % level of significance NS- Non significant

farmers had more knowledge than the young farmers. The educational qualification of farmers had significantly moderate and positive correlation (r=0.452***) with knowledge (at 0.1 % level of significance), implying that the attainment of higher educational qualification enhanced the knowledge of the respondents. Similar findings were reported earlier (49).

Extension contacts (r=0.203*) and experience of farmers in cabbage cultivation (r=0.245**) were also significantly and positively correlated with knowledge, at 5 % and 1 % level of significance respectively. Similar findings were reported with respect to the knowledge of cabbage farmers in Jammu and Kashmir, India (50). This emphasises that the cabbage farmers with more experience and with more engagement with extension personnel had more awareness and knowledge on cabbage cultivation technology. Further, mass media exposure (r=0.405***) and innovativeness (r=0.64***) had strongly positive and significant correlation with knowledge at the 0.1 % level of significance, indicating that respondents who were exposed to various mass media channels and were more innovative in trying out advanced practices had more knowledge on cabbage cultivation. However, variables such as family size, occupation, land holding size, annual family income and social participation had no significant correlations with knowledge. The findings obtained are in alignment with the results obtained earlier (51).

Furthermore, multiple linear regression was carried out to find the degree and extent of the relationship between the socio-economic variables of the respondents and their knowledge level on cabbage cultivation technology. Table 6 depicts the multiple linear regression analysis of socio-economic profile attributes of respondents with the level of knowledge on cabbage cultivation technology.

As per the multiple linear regression analysis depicted in Table 6, educational qualification (X2) of respondents had a highly significant and positive influence (b=3.045***, p<0.001) on knowledge level (Y1) of respondents on cabbage cultivation technology, indicating that respondents who were highly educated had more knowledge on cabbage cultivation technology. Similar findings were reported in Uttar Pradesh, India (43).

The knowledge level of respondents was positively and very significantly affected by variables like annual family income (X6) (b=0.0000340***, p<0.001), experience in cabbage cultivation (X8) (b=0.486*, p=0.018), social participation (X9) (b=1.663**, p=0.005) and innovativeness (X11) (b=2.988***, p<0.001). Similar findings were

Table 6. Multiple linear regression analysis of socio-economic attributes (X1, X2, ….., X11) of respondents with their level of knowledge on cabbage cultivation technology (Y1) (n=120)

Sl. No.	Independent variables	Knowledge level (Y1)			
		Regression coefficient (b)	Standard Error (SE)	t-Stat	p-value
1.	Age (X1)	3.009*	1.494	2.014	0.047
2.	Educational qualification (X2)	3.045***	0.837	3.637	<0.001
3.	Family size (X3)	-3.094	1.684	-1.837	0.069
4.	Occupation (X4)	-2.035*	1.006	-2.024	0.045
5.	Land holding size (X5)	-3.508**	1.333	-2.632	0.01
6.	Annual family income (X6)	0.000034***	0.00000966	3.522	<0.001
7.	Extension contact (X7)	-0.103	0.338	-0.304	0.762
8.	Experience in cabbage cultivation (X8)	0.486*	0.202	2.400	0.018
9.	Social participation (X9)	1.663**	0.579	2.874	0.005
10.	Mass media exposure (X10)	-1.312	0.742	-1.769	0.080
11.	Innovativeness (X11)	2.988***	0.465	6.427	<0.001
	R=0.788	R^2=0.621	Adjusted R^2=0.583	F-value =16.1	p-value<0.001

* Significant at 5 % level of significance ** Significant at 1 % level of significance
*** Significant at 0.1 % level of significance

reported in a study on vegetable growers in Himachal Pradesh, India (52).

Occupation (X4) (b=-2.035*, p=0.045) and land holding size (X5) (b=-3.508**, p=0.010) had a negative and significant association with knowledge, suggesting that farmers who practiced cabbage farming may not necessarily have a higher level of knowledge on cabbage cultivation and that farmers with large land holdings had lower knowledge levels (39). Age (X1) (b=3.009*, p=0.047) had a marginally significant and positive influence on knowledge. This can be attributed to the long exposure of older farmers to farming practices, thus providing them with better familiarity and knowledge on cabbage cultivation technology. On the other hand, variables like family size (X3), extension contact (X7) and mass media exposure (X10) did not show any significant influence on the knowledge level of respondents. The previous findings obtained are in alignment with the current findings (53).

The multiple linear regression analysis of the data revealed a strong relationship, specified by an R^2 value of 0.621, indicating that approximately 62.1 % of the variation in farmers' knowledge can be explained by the set of independent variables. The model is statistically significant as indicated by an F-value of 16.1 and a p-value of <0.001.

To further substantiate the findings, stepwise multiple regression was conducted to systematically identify the most influential predictors of the knowledge level of respondents (Y1) by sequentially adding variables based on their statistical significance. Table 7 presents the stepwise multiple regression analysis for the data.

As revealed from the findings in Table 7, innovativeness (X11) was the greatest predictor of the knowledge level of farmers (β =2.988, p<0.001) and alone explained 48.8 % of the variance (R^2=0.488). This highlights the importance of innovativeness in enhancing knowledge. Educational qualification (X2) significantly boosted the model's explanatory power to 56.2 % (R^2=0.562). Its positive coefficient (β=3.045, p<0.001) underscores the importance of formal education in improving knowledge. Annual family income (X6) (β=0.000034) was highly significant (p<0.001), suggesting that even slight variations in income have an impact on knowledge levels.

Further steps incorporated social participation (X9), land holding size (X5), age (X1), experience in cabbage cultivation (X8) and occupation (X4), each improving the model fit. Notably, land holding size and occupation had negative coefficients (β=-3.508 and β=-2.035 respectively), implying that larger land holdings and certain occupations may hinder knowledge acquisition. The final model, with all significant variables included, achieved an adjusted R^2 of 0.607, explaining 60.7 % of the variance while maintaining statistical robustness (F-value=12.85, p<0.001).

Finally, path analysis was conducted for the study and the results are presented in Table 8, followed by a diagrammatic representation in Fig. 4, providing detailed interpretation of the direct, indirect and substantial effects of selected independent variables on the knowledge level of respondents.

As revealed from Table 8 and Fig. 4, among all the independent variables, annual family income (X6) exhibited the highest positive direct effect (3.405***) on the knowledge level of respondents, suggesting that farmers with higher income were better able to access inputs, information and services needed to adopt cabbage cultivation technologies.

Annual family income also functioned as a crucial mediating variable through social participation (X9), educational qualification (X2) and innovativeness (X11), contributing to significant indirect effects on knowledge. Likewise, educational qualification (X2) and innovativeness (X11) had substantial positive direct effects (3.045*** and 2.988*** respectively), underlining the importance of cognitive empowerment and openness to change in the technological learning process. Social participation (X9), while also directly significant (1.663**), further emerged as a key conduit through which variables such as educational qualification and innovativeness influenced knowledge levels, highlighting the role of peer learning, farmer groups and community exposure in enhancing the knowledge of farmers. Age also had a significant and positive direct effect (3.009*) on the knowledge level of respondents, thus solidifying the influence of age on the knowledge level.

Conversely, land holding size (X5) and occupation (X4) showed negative direct effects (-3.508** and -2.035* respectively) on knowledge, possibly indicating that larger landowners or those with less adaptable occupational roles may be either risk-averse or more dependent on traditional practices, thus demonstrating resistance to acquiring knowledge on newer technologies of cabbage cultivation like hybrid cabbage varieties or integrated pest management practices. Additionally, experience in cabbage cultivation (X8) had a moderate but positive direct effect (0.486*),

Table 7. Stepwise multiple regression analysis between independent variables (X1, X2, X3,……, X11) and knowledge level of respondents on cabbage cultivation technology (Y1) (n=120)

Steps	Variable entered/Removed	Coefficient *(b)*	Std. Error	*t*-value	*p*-value	R^2	Adj. R^2	*F*-value
1	Innovativeness (X11) (+)	2.988***	0.465	6.427	<0.001	0.488	0.478	41.30
2	Educational qualification (X2) (+)	3.045***	0.837	3.637	<0.001	0.562	0.543	32.15
3	Annual family income (X6) (+)	0.000034***	0.00000966	3.522	<0.001	0.601	0.577	25.02
4	Social participation (X9) (+)	1.663**	0.579	2.874	0.005	0.618	0.589	20.45
5	Land holding size (X5) (-)	-3.508**	1.333	-2.632	0.010	0.630	0.596	17.32
6	Age (X1) (+)	3.009*	1.494	2.014	0.047	0.639	0.600	15.21
7	Experience in cabbage cultivation (X8) (+)	0.486*	0.202	2.400	0.018	0.647	0.604	13.87
8	Occupation (X4) (-)	-2.035*	1.006	-2.024	0.045	0.653	0.607	12.85
-	**Excluded variables**	-	-	-	>0.05	-	-	-

Table 8. Path analysis showing direct, indirect and substantial effects of independent variables (X1, X2, X3, ……., X11) on the knowledge level of respondents on cabbage cultivation technology (Y1) (n=120)

Sl. No.	Independent variables	Direct effect	Indirect effect	Substantial effect		
				I	II	III
1.	Age (X1)	3.009*	-0.210	0.105 (X6)	0.072 (X9)	0.048 (X11)
2.	Educational qualification (X2)	3.045***	0.180	0.120 (X11)	0.090 (X6)	0.060 (X9)
3.	Family size (X3)	-3.094 (NS)	-0.085	-0.042 (X5)	-0.030 (X9)	-0.020 (X6)
4.	Occupation (X4)	-2.035*	-0.150	-0.098 (X5)	-0.064 (X11)	-0.042 (X9)
5.	Land holding size (X5)	-3.508**	-0.220	-0.115 (X6)	-0.088 (X9)	-0.055 (X2)
6.	Annual family income (X6)	3.405***	0.310	0.208 (X9)	0.155 (X2)	0.102 (X11)
7.	Extension contact (X7)	-0.103 (NS)	-0.020	-0.012 (X9)	-0.008 (X11)	-0.005 (X6)
8.	Experience in cabbage cultivation (X8)	0.486*	0.095	0.062 (X9)	0.040 (X6)	0.025 (X11)
9.	Social participation (X9)	1.663**	0.275	0.185 (X11)	0.132 (X6)	0.088 (X2)
10.	Mass media exposure (X10)	-1.312 (NS)	-0.045	-0.030 (X9)	-0.022 (X4)	-0.015 (X11)
11.	Innovativeness (X11)	2.988***	0.195	0.128 (X9)	0.095 (X2)	0.063 (X6)

*Significant at 5 % level of significance **Significant at 1 % level of significance
***Significant at 0.1 % level of significance

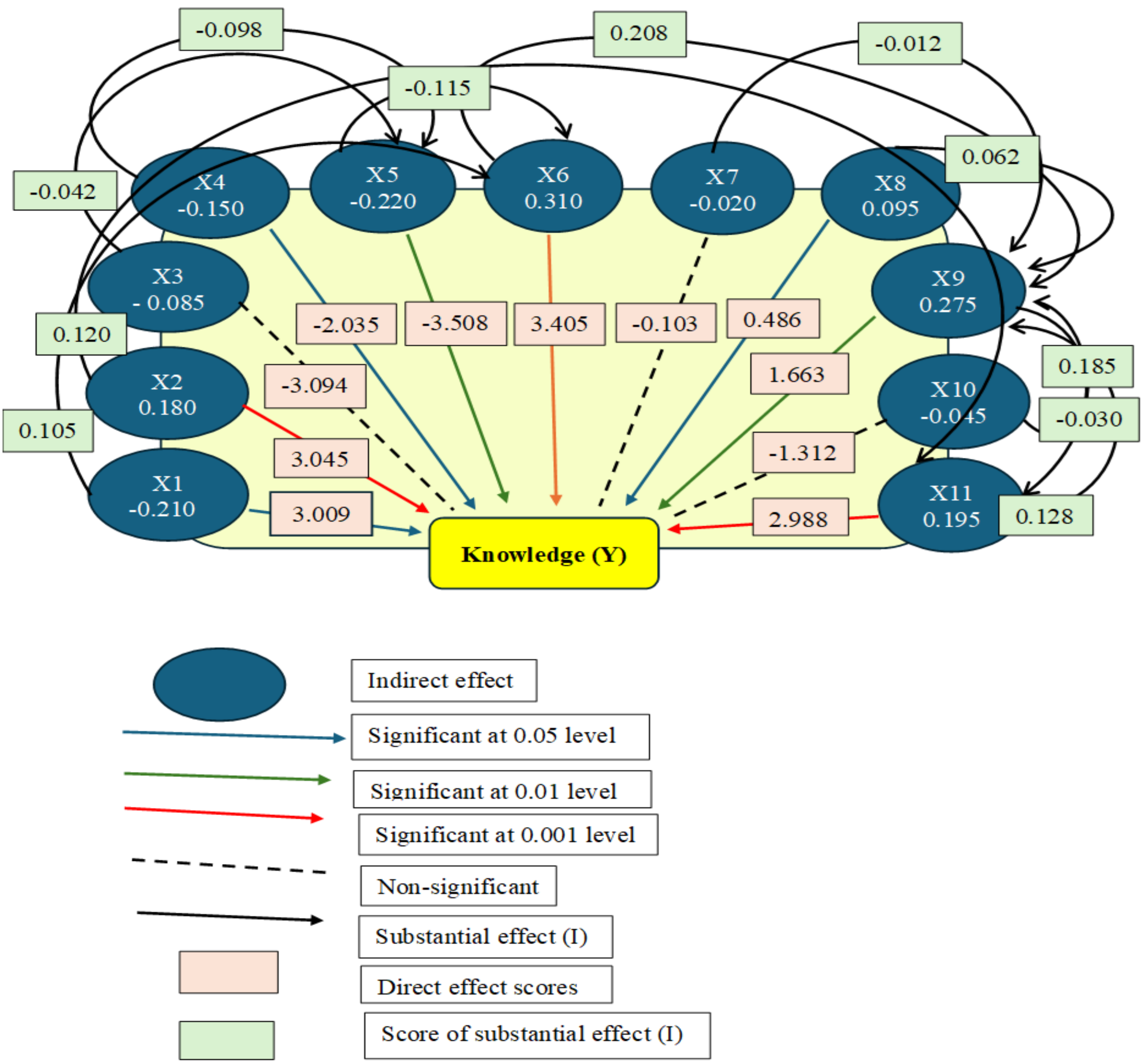

Fig. 4. Path analysis diagram of knowledge level of respondents on cabbage cultivation technology (Y1) in relation with socio-economic attributes (X1, X2,…, X11).

indicating that practical farming exposure does enhance knowledge, but not as much as educational qualification or income.

Variables like extension contact (X7), mass media exposure (X10) and family size (X3) showed statistically non-significant direct effects, implying that the mere presence of these factors does not guarantee knowledge improvement unless accompanied by quality interaction and targeted content. The substantial effects further illustrated that variables, such as annual family income and social participation act as interlinking bridges, transferring influence from other variables across the system; e.g., educational qualification (X2) substantially affects knowledge via innovativeness (X11) and social participation (X9), while experience in cabbage cultivation (X8) finds its path through annual family income (X6) and innovativeness (X11).

This study emphasises the need for holistic extension interventions. For example, promoting farmer-led innovation platforms, encouraging active engagement in social organisations and boosting farmer income through diversified livelihood initiatives can all have direct and indirect effects on knowledge enhancement. For policymakers and extension agents looking to create scalable, farmer-centric cabbage adoption programs in rural agricultural contexts, this comprehensive understanding is highly essential.

Conclusion

The study provides valuable insights into the knowledge levels of cabbage farmers in Khordha district of Odisha, focusing on their knowledge of recommended cabbage cultivation technology and the socio-economic factors influencing their knowledge levels. The results showed that only 3.4 % of farmers had a high level of knowledge, 18.3 % had a low level of knowledge and 78.3 % had a medium level of knowledge on cabbage cultivation technology. This emphasises the necessity of focused efforts to bridge knowledge gaps and encourage the adoption of improved technology. Knowledge was significantly influenced by socio-economic variables such as age, educational qualification, experience in cabbage cultivation and innovativeness. The most significant factors among these were innovativeness and educational qualification, underscoring the significance of education and openness to change in raising awareness and adoption. The study also highlighted the importance of regular farmer-extension interactions and efficient communication in enhancing the quality and accessibility of extension services. Knowledge levels were also significantly shaped by social participation and financial stability, highlighting the necessity of inclusive, community-based learning platforms and group credit financing through Farmer Producer Organisations (FPOs) and Commodity Interest Groups (CIGs). Thus, improving the knowledge of cabbage farmers requires a multifaceted approach. Educational opportunities, income diversification, innovativeness, social participation and access to effective advisory services should be given top priority by policymakers and extension agencies. Better technology adoption and increased productivity can be achieved by creating farmer-centric, need-based extension programs, especially for marginal and smallholder farmers. Overall, strengthening farmers' knowledge and capacity can significantly enhance the productivity, profitability and sustainability of cabbage cultivation in Khordha, contributing to broader agricultural development and rural livelihood advancement.

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Authors' contributions

KSD carried out conceptualisation, research design, literature review, data collection, data analysis and interpretation. BM contributed towards conceptualisation, supervision, review and editing of the manuscript. SB, AN, DKJ, SKS and AD contributed to literature review, data analysis, reviewing and editing. All authors read and approved the final manuscript.

Compliance with ethical standards

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