Agricultural Practices and Farm Income in the Kumaon Himalaya: An Empirical Study of Rural Households in Pithoragarh District, Uttarakhand

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Abstract: *The Kumaon Himalayan region, located in the state of Uttarakhand, is mostly dependent on agriculture for the livelihood of rural families. However, at the same time, agricultural features such as fragmented holdings, terraced fields, rain-fed agriculture, use of traditional techniques in agriculture, etc. are key factors of agricultural income. The objective of the present study is to study the socio-economic and agricultural characteristics of selected rural households in the area, as well as to analyse the agricultural income relationship based on selected variables, including techniques used in agriculture, irrigation facilities, fertilizers used, seeds selected, and land size. The present study is based on the analysis of households selected from 10 randomly selected villages of Gangolihat, a development block in Pithoragarh district, using both descriptive and inferential statistical tools. The outcome of the study found 76.00 percent of the households were traditionally engaged in agriculture while 61.60 percent of the households were rain-fed for agriculture. The predictive model used in the study to measure the effect on income is statistically significant but reveals limited explanatory power. Agricultural techniques used in land size were positive with monthly farm income while irrigation methods and seed selection were not statistically significant at the 5.00 percent significance level. This study makes it clear that in order to strengthen the agricultural income of households engaged in agriculture in the selected area, it will be necessary to focus on technical efficiency and overall resource management in accordance with local conditions.*

Keywords: Kumaon Himalaya, Hill Agriculture, Agricultural Income, Rural Livelihood

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Introduction

Agriculture has been considered the mainstay of livelihood in the Indian rural economy (Meena & Kumari, 2024; Singh & Ali, 2026). It is not only a means of food production but also directly related to family livelihood, income and food security as well as socio-economic stability in rural economic life (Bairwa et al., 2014; Zewudie, 2025; Singh et al., 2024). The role of small and marginal farmers is important in the Indian agricultural structure by contributing beyond production as poverty reduction, food security, and rural economic stability (Kaur & Kumar, 2026). About 86.0 percent of agriculture in the country is done on less than 2.0 hectares with an average landholding size of 0.38 hectares (Anand & Mahalakshmi, 2026; Gulati et al., 2021). In such a situation, conditions like these small holdings and traditional farming practices appear as a challenge to earn adequate income from the agricultural sector as agricultural income is affected by the size of the land as well as. The techniques used in production, means of irrigation, quality of seeds, better management of agriculture and other agriculture-related resources.

The major impact of this problem is highly complex in the hilly region as the impact of natural and geographical conditions on agriculture can be clearly seen in these areas. The agricultural system of Uttarakhand, a state located in the Indian central Himalayan region, has a distinct feature of hill region agriculture. Almost 86.0 percent of the total land in the state is used for sustenance and primitive farming (Vishleshwar, & Chanyal, 2024) and the agriculture practices done under small and marginal holdings, and not possible to operate scale economies, so that make input cost of output high due to labour-intensive (Rana & Bisht, 2023). Agriculture in this part is characterised by small and scattered holdings, terraced farming, rain-fed agriculture, limited irrigation facilities, emulation of traditional practices in agriculture, and limited use of modern technique (Sati et al., 2025; Rana et al., 2019; Chhimwal et al., 2019). Moisture stress is a significant challenge to agricultural production in this terrain as 85.0 percent of the agriculture in the hilly regions of the state is rain-fed (Meena & Maikhuri, 2025).

The structural nature of agriculture in the state of Uttarakhand is characterised by a small proportion (0.8 million hectare) of the total geographical area being available for cultivation (Indian Council of Agricultural Research [ICAR], n.d.) and the proportion of small and marginal holdings being higher than the national average having 0.95 hectares average landholding size (Udyogini, n.d.). At the same time, the structural nature of irrigation for agriculture also lags behind the plains and increases dependence on rainfall (Karn et al., 2026). Thus, these structural conditions make it difficult for families engaged in agriculture in hilly terrain to maintain stable agricultural production and farm incomes.

The methods and inputs used for production are particularly important in hill agriculture. The traditional agricultural systems of the region, which evolved in accordance with the availability of local resources and the environment, hold a special place in the local agricultural systems. But here it is also necessary to understand that due to increasing economic conditions, availability of agricultural labour and other requirements, the utility of modern agricultural techniques has also increased. In such a situation, it is necessary to understand the agricultural techniques used by the farmers of the area, the condition of the means of irrigation, the land

and the seeds used by them in terms of agricultural income. The selected study area in the state of Uttarakhand, located in the hill district Pithoragarh in the Kumaon division, presents a special study area in this regard. Agriculture plays a central role in the economic structure of a rural household and is a major means of livelihood. But the topography of the region, the limitations of agricultural holdings, agricultural dependence on rainfall, and traditional methods of cultivation can affect the agricultural productivity and income prospects of farmers. In such a situation, it is necessary to see the techniques adopted by them, the type of seeds, irrigation facilities, available land, etc. in the context of their agricultural income. The present study is an attempt in this direction.

Review of Literature

The literature review provides the conceptual basis for studies on agricultural practices and agricultural income in the study area. Related past studies indicate that the livelihood of the Kumaon Himalayan region is mainly based on agriculture, but one of its characteristics has been its subsistence-oriented and labour-intensive nature with limited resources (Yadav et al., 2017; Rana et al., 2019; Rana & Bisht, 2023). The dispersal of most holdings affects the efficiency of production, mechanization, irrigation, and marketing in agriculture (Rana et al., 2019; Kumar et al., 2020). The agricultural characteristics of the region include its rain-fed nature (more than about 85.00 per cent) and limited irrigation (Yadav et al., 2017; Lohani et al., 2026) that link agricultural productivity deeply to local topography, uncertain rainfall, and natural resource availability (Pandey et al., 2026; Shah et al., 2026; Kumar et al., 2020).

Uttarakhand's hill agriculture has been multi-cropped, based on local traditional knowledge, and rich in biodiversity. Agricultural diversity of crops 17-30 in a single field helps local people in risk management, nutrition, protection, and ecological stability (Chowdhury et al., 2025; Bisht, 2020). But dependence on agriculture alone is not enough for the local community, where 80.13 per cent of the population's dependence on diverse sources of income confirms this (Lohani et al., 2026; Pathak & K, 2024).

Past studies examined the structural characteristics, land size, rainfed nature, seed and technique selection, irrigation facilities, traditional nature of agriculture in the region but limited empirical studies give attention to household-level association with hill agriculture in the terms of farming technique, status of irrigation and selection of seeds and their association with households' farm income. The present study attempts to fill this research gap.

Objectives of the Study

- To study the socio-economic status and agrarian characteristics of the selected respondents.
- To analyse the agricultural techniques, irrigation methods, and variety of seeds used by the selected respondents.
- To examine the interplay between the socio-economic characteristics of the respondents and their agricultural decision making.
- To study the effects of selected factors in agriculture on their agricultural income.

Hypothesis

- There is no statistically significant association between respondents' socio-economic characteristics and their agricultural decisions.
- The land size, variety of seeds, and agricultural techniques have no relationship with respondents monthly agricultural income.

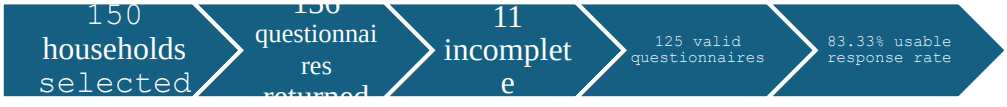
Material and Methods

5.1 Study Area: The presented study was conducted in selected rural areas of Gangolihat, a development block in Pithoragarh, a hill district in the state of Uttarakhand, in which the study area was selected based on the structural and socioeconomic characteristics of hill agriculture and locally adopted agricultural practices and the agricultural income derived from them. In which the respondent family was taken as the analytical unit.

For this study the agricultural decisions refer to the choice of adopting farming techniques, variety of seeds and arrangement of irrigation among the respondent households and their monthly agricultural income was measured by their net average monthly income which was derived from their agricultural activities during the reference period.

5.2 Sample Selection and Sample Size: A multi-stage random sampling methodology was used to select the respondents under which 10 villages under the development block Gangolihat were selected through random sampling in the first phase and 15 farming families from each selected village were selected on the basis of random sampling in the second phase.

The primary data was collected with the help of structured questionnaire which was administered through personal interviews with selected respondent households. The questionnaire was returned in full by 136 (90.66 percent) of the 150 respondent families selected for the study. Data cleaning of the questionnaire found 11 questionnaires to be incomplete that were not included for analysis in the study. Thus, the final empirical analysis of the study included 125 (83.33% of the total selected respondents) agricultural households. Secondary data was adopted from different published sources including internet.



5.3 Variables used and Data Analysis - The study included agricultural income by classifying it as a key economic outcome variable and respondents "size of farmland, irrigation conditions, choice of seeds, farming method adopted as key explanatory variables. Both descriptive and inferential statistical techniques were used for statistical analysis. The Cramér-V was used to determine the strength of the relationship between the socio-economic and educational characteristics of the respondents and the relationship of agricultural decisions with the moss

class testing method. Multiple linear regression analysis was used to analyse agricultural income relationships, using the following model:

$$MA_I = \beta_0 + \beta_1 (L_S) + \beta_2 (I_R) + \beta_3 (S_E) + \beta_4 (T_E) + \varepsilon$$

[MA_I = Monthly Agricultural Income; L_S = Size of Agricultural Land; I_R = Irrigation Status; S_E = Seed Variety; T_E = Agricultural Technique]

Since the study is based on cross-sectional primary surveys, regression analysis and correlation tests were interpreted primarily as statistical associations.

Results and Discussion

6.1 Socio-economic Status of Respondents

Table 01 presents an analysis of the socioeconomic status of the respondents. The average age of the selected respondents was found to be 50.28 years (SD=14.56) which explains the involvement of relatively older cultivators in agricultural activity in the study area. This points to the agrarian characteristic of hill agriculture, in which the involvement of the young population in agricultural work is seen to be low for various reasons. In the social category classification of the respondents, the highest number of respondents (65.60 percent) were found under the general category and the lowest under the Scheduled Tribe category (2.40 percent). The highest BPL and Antyodaya category (56.00 percent) by economic category explain the poor economic condition of the respondent farming families. Hilly farming, with limited land and rain-fed agriculture and low conditions of agro-commercialization, is a factor affecting the agricultural income potential of farmers. The highest proportion of joint families (56.00 per cent) in the respondents' family structure assumes significance in the context of the role of family labour in hill agriculture. Respondent households were found to have a monthly agricultural income of ₹22,349.60 (S.D.= ₹1739.40) and an average land holding 4.96 Nali (S.D.=5.35 Nali). The higher-than-average standard deviation in terms of land holdings illustrates the substantial heterogeneity of land ownership among the respondent farming households. Thus, taken as a whole, the large number of selected respondents in the study area explains the high age, small size of holdings, and relatively weak economic situation, which provides an important basis for studying the productivity and agricultural income of hill agriculture.

Table 1. Socio-economic profile of Respondents

S.No.	Variable/Characteristic	Classification/Metric	Value/Frequency (N)	%age	S.D.
1.	Age of Respondent	Mean/S.D. (Years)	50.28	--	14.56
2.	Social Category	General	82	65.60	--
		S.C.	40	32.00	--
		S.T.	03	2.40	--
3.	Economic Category	APL	55	44.00	--
		BPL	66	52.80	--

		Antyoday	04	3.20	--
4.	Family Type	Nuclear	55	44.00	--
		Joint	70	56.00	--
5.	Monthly Agricultural Income	Mean/S.D. (Rs.)	22349.60	--	1739.40
6.	Size of Land	Mean/S.D. (Nali)	4.96	--	5.35

Source: Primary Data

6.2 Status of Agricultural Practices and Inputs among Respondents

Table 02 presents an analysis of the selection of agricultural techniques, irrigation methods, and seed varieties by the respondents in the study area. In terms of agricultural techniques adopted, the highest percentage of 76.00 respondents practice agriculture based on traditional techniques and only 16.00 percent are using modern techniques. This reflects the slow pace of technological adoption of the respondents due to various reasons with both geographical and physical factors acting as influencing factors. Since there is no measurement of these factors in the present study, it would be appropriate to look at them as explanatory factors. A small fraction (38.40 percent) of irrigated land illustrates the dependence of a large part of agriculture in the study area on rainfall. Agricultural production in this situation, with the timeliness of the rains. Also, by sensitizing agricultural production to its quantity, it can help increase the uncertainty of crop production. Comparatively high use of local seeds by respondent (59.20 percent) farmers reflects the continuation of the use of traditional agricultural knowledge and seed systems suited to local conditions among hill farmers, as well as the state of agricultural technological change with the use of seeds improved by 40.80 percent respondents.

Table 2. Agricultural Practices and Inputs among Respondents

S.No.	Variable/Characteristic	Classification/Metric	Frequency (N)	%age
1.	Farming Techniques Adopted	Traditional	95	76.00
		Modern	20	16.00
		Mixed	10	8.00
2.	Irrigation Status of Land	Irrigated	48	38.4
		Rainfed	77	61.6
3.	Seed Variety	HYV	51	40.8
		Local	74	59.2

Source: Primary Data

6.3 Relationship between socio-economic characteristics and agricultural decisions

To understand the agrarian decision-making based on their socio-economic and educational status, Chi-Square and Cramér-V is used to find association and strength of association. Table 03 shows that, based on the social class of the respondents, no statistically significant relationship was found between their seed selection, access to irrigation facilities. But the relationship was found to be meaningful on the basis of the agricultural technique adopted in

the social category. However, the Cramér-V value 0.2234 is a clear indication that the association of strength of the relation is relatively small. Thus, while it can be assumed that social background may play a role in the choice of agricultural technique, it cannot be concluded that social class in itself is the reason for the adoption of modern agricultural technique. Seed selection, irrigation facilities, and agricultural techniques were found to be statistically insignificant based on the economic class and education of the respondents. This indicates that geographical and physical conditions may play an important role in agricultural decisions.

Table 03. Interrelation between Variables

Interrelation	χ^2 Value	p-value	d.f.	N	Cramér-V	Significant
Social Category Vs Seed Selection	1.1301	0.5683	2	125	0.0951	Not Sig.
Social Category Vs Irrigation Facility	4.5653	0.102	2	125	0.1911	Not Sig.
Social Category Vs Technique Used	12.4715	0.0142	4	125	0.2234	Sig.
Economic Category Vs Seed Selection	0.8576	0.6513	2	125	0.0828	Not Sig.
Economic Category Vs Irrigation Facility	0.5757	0.7499	2	125	0.0679	Not Sig
Economic Category Vs Technique Used	2.49	0.6464	4	125	0.0998	Not Sig
Education Category Vs Seed Selection	3.0294	0.5529	4	125	0.1557	Not Sig.
Education Category Vs Technique Used	7.4996	0.4838	8	125	0.1732	Not Sig.

Source: Primary data

6.4 Determinants of Agricultural Income

The combined role of selected factors affecting agricultural income resulted in multiple R = 0.2754 and R^2 = 0.0758. Which explains the 7.58 percentage variation in the monthly income of the respondents. Whereas the adjusted R^2 represents the limiting level. This reduction explains the variation in the impact of only selected variables under the model, while other variables (such as crop structure, loss from wild animals, weather exposure, climate impact, etc.) may also have an impact on the agricultural income of households. which were not included in this study. ANOVA's results (F=2.462035, Significance F=0.048873, $p<0.05$) with modest explanatory power make the model statistically meaningful.

There is positive association was shown by regression results between size of respondents' land; technique used in agriculture practices and monthly agricultural income. Agricultural technique shows the marginal significant positive association ($\beta = 8006.46$, $p = 0.050$). At the same time, the choice of irrigation and seed to be negative and insignificant may not be helpful in drawing a causal or policy conclusion, because even if the model is statistically significant,

the R^2 = 7.58 percentage determines that other variables may be important in interpreting agricultural income in the study area.

Regression Statistics				
Multiple R	**R^2**	**Adjusted R^2**	**Standard Error**	**Observations**
0.275397	0.075844	0.045038	18950	125

ANOVA					
	df	**SS**	**MS**	**F**	**Sig. F**
Regression	4	3.54E+09	8.84E+08	2.462035	0.048873
Residual	120	4.31E+10	3.59E+08		
Total	124	4.66E+10			

	Coff.	**Std. Err.**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	20218.91	2609.006	7.74966	3.31E-12	15053.26	25384.56
Size of land	782.8798	367.9601	2.127621	0.035415	54.34429	1511.415
Irrig.	-1973.34	4333.279	-0.45539	0.64965	-10552.9	6606.249
Seed	-7088.39	3997.263	-1.77331	0.078714	-15002.7	825.9134
Techn.	8006.457	4042.954	1.980348	0.049952	1.688002	16011.23

Conclusion and Suggestions

The findings of the presented study make it clear that small size of agricultural holdings, agriculture based on traditional techniques, dependence on rainfall, etc. are prevalent as agricultural characteristics in the selected study area. The respondents had average holdings 4.96 Nali and 76.00 percent of the respondents were cultivators adopting traditional farming techniques with majority of them depends on rain-fed agriculture. The socio-economic and educational characteristics of the respondents and the absence of statistically significant variables in agricultural decisions other than just social class and the agricultural technique adopted make it clear that agricultural decisions in the selected area are also influenced by locally generated agricultural conditions and structural factors.

The multivariate model used in the study found a positive correlation of factors such as land size and agricultural technique with farm monthly income, and seed selection and irrigation conditions were found to be statistically insignificant, explaining only 7.58 percent variation in respondents' farm monthly income based on these four selected factors. Thus, it makes it clear that in addition to these four factors, some other factors may also be important to understand the monthly agricultural income of the respondents. Thus, in addition to technological change, it will be necessary to develop agriculture according to local conditions in order to strengthen agricultural income in the study area.

The above conclusion provides some important pointers to agricultural income. First, land use efficiency and better management of fragmented holdings will be required, rather than simply

increasing the availability of agricultural inputs. It will be necessary to promote mechanization suited to mountain topography and ecological conditions. Techniques such as rainwater harvesting, rejuvenation of local water sources driven by traditional techniques can be useful to reduce dependence on rainfall for irrigation. At the same time, in order to increase the agricultural income of farmers, it will be necessary to include other important factors in agricultural policy according to local conditions along with production.

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