

Original Research Article
**Effect of agricultural technology adoption on farm
income of commercial vegetable growers in
Bagamati province of Nepal**

ABSTRACT

Aims: To assess the present situation of technology adoption and effect of technology adoption on farm income in Bagamati Province, Nepal.

Study design: Survey research design

Place and duration of study: Ward 2 of Thaha municipality of Makwanpur district, Ward 3 of Panchkhal municipality of Kavrepalanchok district and Ward 7 of Benighat Rorang rural municipality of Dhading district of Bagamati Province of Nepal, between June and August of 2022

Methodology: We adopted a multi-stage sampling method and surveyed 180 randomly selected households. We used multiple linear regression to measure the effect of adoption of agricultural technology on farm income in the study area

Results: As the number of technologies increases, there is a declining trend in adoption with few households adopting more number of technologies. Number of technology adopted ($p=0.00$), household headed by female ($p=0.00$), farm size ($p=0.06$), family members involved in agriculture ($p=0.02$), years of farming ($p=0.06$) and membership in farmer's group/cooperative ($p=0.03$) were the major variables having positive impact on farm income.

Conclusion: Promoting broader adoption of appropriate technologies among farmers helps to boost income generation. Policy makers and the stakeholders are suggested to encourage technology adoption among commercial vegetable growers through training, access to inputs and technologies, and organizing them in groups or cooperatives.

Key words: adopters, economic activity, multistage sampling, policy makers, regression

1. INTRODUCTION

In low-income nations like Nepal, increasing agricultural productivity through the adoption and diffusion of improved agricultural technologies and practices has been seen as one of the most practical ways to achieve economic growth and agricultural transformation. [1]. Improved agricultural technologies are critical for achieving development goals such as poverty reduction and maintaining food security for impoverished farming households [2]. The adoption of improved agriculture technology could increase the market share of agricultural production, empowering smallholder farmers' decisions on resource use and production diversification towards the goal of maximizing profits [3].

In comparison to neighboring countries, Nepal has a considerably lower rate of adoption of modern technology in vegetable production [4]. Adoption rate refers to the speed or pace at which individuals or entities adopt a new technology, product, or innovation within a specific population or market. The low adoption of modern technologies among Nepalese farmers in rural areas is largely attributed to their lack of awareness, time-consuming foreign technology introduction, inadequate local adaptation studies, and the unsuitability and high costs of some technologies [2]. Previous studies carried out in Nepal has mainly focused on the impact of adoption of individual agriculture technology on farm income [5] [6]. However, these studies paid less attention to the effect of agriculture technology adoption on farm income, considering many technologies simultaneously.

Nepalese government has prioritized the implementation of technology-driven interventions strategies in vegetable farming as it is one of the major economic activity of both rural and urban farmers in Nepal [7]. In comparison to cereal crops, vegetables have a faster rate of commercialization and a higher cost-benefit ratio [8]. Because vegetables are preferred cash crops, vegetable farming is likely to support livelihood largely through food provision, revenue generating, and employment [9]. Total area, production and productivity of vegetables in Nepal are 2,84,121 ha, 3,993,167 mt and 14.05 mt/ha, respectively [10].

This study includes the major agriculture technologies adopted by the commercial vegetable growers in the study area. This is because, in practice, farmers typically employ a combination of agricultural technologies rather than relying on a single one [11]. The agriculture technologies considered in this study are plastic tunnel, drip irrigation, improved varieties, agriculture mobile application, mini tiller, sprayer, water pump, Integrated Pest Management (IPM), plastic mulching and rainwater harvesting. In this study, potato, asparagus bean, okra, radish, capsicum, cauliflower, chilli pepper, and cabbage were considered.

The objective of this research was to provide valuable insights into the present situation of technology adoption and measure the effect of agricultural technology adoption on farm income. The findings will guide agriculture development policies, strategies as well as technology intervention to be taken by all levels of government.

2. METHODOLOGY

2.1 Study area, sampling process, and data collection

The research was carried out in the Bagmati Province of Nepal, specifically in the districts of Makwanpur, Kavrepalanchok, and Dhading. The selection of respondents followed a multistage sampling approach. These three districts were purposefully chosen due to their significance in commercial vegetable farming within the Bagmati Province. In the initial stage, one municipality was purposefully selected from each district based on its higher number of commercial vegetable growers compared to other municipalities in the district. Subsequently, one ward was purposively chosen from each municipality using the same criteria. Within each selected ward, households were randomly sampled using a simple random sampling technique. Therefore, the study was conducted in Ward 2 of Thaha Municipality in Makwanpur district, Ward 3 of Panchkhal Municipality in Kavrepalanchok district, and Ward 7 of Benighat Rorang Rural Municipality in Dhading district.

In this research, commercial vegetable growers were defined as individuals who cultivated vegetables for at least two seasons within a year, covering an area of more than 0.1 hectares, and contributing at least 20% to their annual household income. The study included a total of 180 households involved in commercial vegetable farming, with 225 households from Panchkhal-3 in Kavreplanchok, 208 households from Thaha-2 in Makwanpur, and 195 households from Benighat Rorang-7 in Dhading. To achieve an equal sample, 60 households were randomly selected from each ward, making a total of 180 households for the study. The data collection took place between June and August of 2022, and face-to-face interviews were conducted with the respondents using a semi-structured questionnaire.

2.2 Data analysis tools and techniques

2.2.1 Multiple regression model

To measure the effect agricultural technology adoption in farm income and identify the factors effecting farm income multiple linear regression was used. A multiple linear regression model is a highly effective and valuable tool that allows researchers to gain deeper insights into the connections among the data they are investigating, particularly with regards to the interrelationships between multiple independent variables and a dependent variable [12]. Multiple linear regression was used by [13] [14] to assess factors influencing farm income.

The specific structure of the model is as follows:

$$Y = \beta_0 + \sum_{i=1}^n \beta_i X_i + \varepsilon$$

Where, Y is the natural log of farm's income, β_0 is a constant, β_i is the regression coefficients of the independent variable, X_i is the independent variable and ε a random disturbance term.

The list of dependent and independent variables used in multiple linear regression is shown in table 1.

Table 1: Description of the variables for the multiple linear regression

Variables	Description	Type of measures	Expected sign
Dependent variable	Natural log of farm income		
Explanatory variables			
i. Continuous variables	Age of the household head	Years	-
	Education of the household head	Years of schooling	+
	Members involved in agriculture	Number	+
	Farm size	Hectare(ha)	+
	Farming experience	Years	+
	Distance to the nearest road	Kilometer(km)	-
	Distance to the nearest market	Kilometer(km)	-
	Number of technology		

	adopted	Count	+
ii. Categorical variables	Gender of household head	=1 if female; 0 = male	+
	Membership in farmer's group	=1 if yes; 0 = no	+
	Training received	=1 if yes; 0 = no	+
	Extension worker's visits	=1 if yes; 0 = no	+
	Credit received	=1 if yes; 0 = no	+

3. RESULTS AND DISCUSSION

3.1 Socio-demographic characteristics

The study's findings revealed that the average farm size among the surveyed households in the study area was 0.42 ha smaller than the national average of 0.68 ha [15]. Within the study area, the average number of family members engaged in agricultural activities was 2.23. Similarly, the average age of household heads was 50.17 years, and their average farming experience was 18.66 years. On average, the distance from the fields to the nearest market was 1.81 km, while the distance to the closest road was 0.54 km (Table 2). The results indicated that farmers in the area had convenient access to both roads and markets.

Table 2: Socio-economic and demographic characteristics of the sampled household in the study area

Variables	Dhading (n=60)	Makwanpur (n=60)	Kavrepalanchok (n=60)	Total (n=180)
Continuous variables				
Farm size (ha)	0.47	0.35	0.37	0.42
Age of household head (years)	51.45	50.45	48.78	50.17
Education of household head (years)	5.63	6.28	6.21	6.04
Members involved in agriculture	2.14	2.43	2.02	2.23
Distance to nearest market (km)	1.55	2.040	1.85	1.81
Distance to nearest road (km)	1.44	0.19	0.16	0.54
Farming experience (years)	18.37	21.43	16.45	18.66
Categorical variables				

Gender HH				
Male=0	53(88.33)	44(73.3)	49(81.7)	113(62.77)
Female=1	7(11.67)	16(26.7)	11(18.3)	67(37.22)
Membership in farmer's group				
1= yes	55(91.67)	40(66.67)	56(93.3)	151(83.89)
0= no	5(8.33)	20(33.33)	4(6.7)	29(16.11)
Training received				
1= yes	37(61.67)	18(30)	46(76.7)	100(55.56)
0= no	23(38.33)	42(70)	14(23.3)	80(44.44)
Extension worker's visits				
1= yes	16(26.67)	11(18.33)	30(50)	58(32.22)
0= no	44(73.33)	49(81.67)	30(50)	122(67.77)

Note: Figure in the parenthesis represents percentage

Source: Field survey, 2022

The study revealed that most of the households (62.77%) are headed by male members. Members from 84% of total sampled households had membership in farmer's groups or co-operatives and 55.56% of household heads had received at least one training related to commercial vegetable farming in the past five years period (Table 3). Only 32.22% of respondents reported that the extension agents visited their farms which is higher than the national average of 25% extension coverage in Nepal [16].

3.2 Status of technology adoption

3.2.1 Number of adopters

In the study area, all households have been using improved varieties and sprayers. However, the mini tiller was used by 93.33%, IPM by 47.67%, and the water pump by 43.33%. Each other technology was adopted by less than 20% of the sampled households (Table 3). This study has included the adoption status of these technologies for the past five years (from 2017 to 2021).

The result showed farmers preferred affordable technologies with low technical difficulties like improved varieties, sprayers, water pumps, mini tillers, and IPM were mostly adopted ones. However, expensive technologies like plastic tunnels and drip irrigation and newly developed technologies like plastic mulching, mobile application, and rainwater harvesting were adopted by less number of vegetable farmers.

Gauchan and Shrestha [17] reported that with the improved connectivity of roads in rural areas, there is increase in use of tractors, power tillers, and pump sets. These kinds of equipment are becoming more popular because farmers have identified the distinct advantages of utilizing them, which include time, resource, and labor efficiency.

Table 3: Number of adopters of the major agricultural technologies in the study area

Agricultural technologies	Makwanpur	Kavrepalanchok	Dhading	Total
	(N=60)	(N=60)	(N=60)	(N=180)

Plastic tunnel	18(30)	10(16.7)	5(8.33)	33(18.33)
Drip irrigation	4(8.3)	4(6.7)	2(3.33)	10(5.55)
Improved varieties	60(100)	60(100)	60(100)	180(100)
Electric water pump	35(58.3)	38(63.3)	5(8.33)	78(43.33)
Sprayer	60(100)	60(100)	60(100)	180(100)
Mini tiller	60(100)	60(100)	48(80)	168(93.33)
Mobile application	3(5)	12(20)	3(5)	18(16.67)
Plastic mulching	9(15)	14(23.3)	6(10)	29(16.11)
IPM	4(6.7)	32(53.3)	21(35)	57(47.67)
Rainwater harvesting	2(3.3)	8(13.3)	2(3.33)	12(11.11)

Note: Figure in parenthesis represents percentage

Source: Field survey, 2022

3.2.2 Statistics on the number of agricultural technologies adopted by farmers

In the study area, out of 10 agricultural technologies, the technology adoption ranged from 2 to 8 (Table 4). Results indicated that the highest number of households (31.67%) are adopting four technologies. Number of technology adopted vary widely across districts.

In Makwanpur and Kavrepalanchok, the highest number of households (35% and 30% respectively) adopted four of the selected technologies. In Dhading, the highest number of households (35%) have adopted three technologies. Results showed the decreasing trend in adoption percentages as the number of technologies increases, with a lower percentage of households adopting more technologies. This finding is consistent with finding of Kumar et al [18].

Table 4: Number of agriculture technologies adopted by sampled household

Number of technologies	Makwanpur	Kavrepalanchok	Dhading	Total
2			12(20)	12(6.67)
3	19(31.67)	8(13.33)	21(35)	48(26.67)
4	21(35)	18(30)	18(30)	57(31.67)
5	9(15)	11(18.33)	5(8.33)	25(13.88)
6	7(11.67)	16(26.67)	1(1.67)	24(13.33)
7	4(6.67)	6(10)	2(3.33)	12(6.67)
8		1(1.67)	1(1.67)	2(1.11)

Note: Figure in parenthesis represents percentage

Source: Field survey, 2022

3.3 Effect of technology adoption on farm income

Table 5 presents the effect of agricultural technology adoption on farm income in the study area. The value of coefficient of multiple determinations ($R^2 = 0.302$) indicated that 30.2% of the variation in the income is explained by the independent variables included in model. The F statistics (6.528) confirms the stability of the overall regression equation and joint significant at 1% level. The Breusch-pagan test for heteroscedasticity showed constant variance of errors and model has no heteroscedasticity. Variance Inflation Factor (VIF) presents results according to expectation, mean VIF 1.68 is and none of the variable has VIF higher than 2.5, which means that there is no multicollinearity among independent variables included in the model.

Table 5: Measure of the impact of agricultural technology adoption on farm income

Variables	Coefficient	S.E	T value
Number of agricultural technology adopted	***0.252	0.06	4.205(.00)
Gender of the household head(1)	***0.522	0.143	3.640(.00)
Age of the household head (years)	-0.009	0.007	-1.367(.17)
Education level of household head (years)	-0.016	0.020	-0.807(.42)
Family members involved in agriculture	**0.158	0.070	2.251(.02)
Farm size (ha)	*0.505	0.262	1.931(.06)
Distance to nearest market	-0.144	0.153	-0.941(.34)
Distance to nearest road	-0.015	0.596	-0.026(.97)
Years of farming	*0.014	0.008	1.867(.06)
Participation in training(1)	0.013	0.152	0.086(.93)
Subsidy received(1)	0.162	0.162	1(.31)
Extension work visit(1)	0.124	0.156	0.797(.42)
Membership in farmer's group / cooperatives(1)	**0.420	0.197	2.129(.03)
constant	***10.784	0.677	15.938(.00)
Number of observation	180		
R square	0.356		
Pseudo R-square	0.302		
F-value	6.528(0.00)		

*Significant at 10% level of, ** significant at 5%, *** significant at 1% level

Regression results showed that the number of agricultural technology adopted had positive impact on farm income. If the number technology increases by one unit, the farm income increases by 25.2%. This is significant at 1% level ($p = 0.00$). Thus, adoption of agriculture technology has great impact on farm's income. This is in agreement with the work of Wu [11] who reported that if the farms that currently have not adopted the new technologies start using them, the total income generated from agricultural operations will increase by 44.85%. Pasa [2] reported that the introduction of modern technology in farming systems including both mechanical and methodological advancements, has resulted in a substantial increase in family earnings. The adoption of agricultural technology reduces input costs and increases crop yield and productivity which increases farm income. Similarly, the adoption of more agriculture technology helps farmers to manage risk and improve decision-making on planting, harvesting, and crop management and reducing the risk of crop failure and losses [19].

Gender of the household has positive impact on farm income. The female headed household had 52.2% more farm income than male headed household. This is significant at 1% level ($p = 0.00$). Result indicated that men are engaged in income-generating activities outside the farm, which limits their availability for farm management. The finding is in consistent with KC et al [6].

The farm size has positive impact on farm income. If the farm size is increased by 1 ha, then the farm income is increased by 50.5%. This is significant at 10% level ($p = 0.06$). The finding is in line with Mukaila et al [20] who reported the large farm size produces more vegetables and can sell more to the market which increases revenue and profits. As the size of vegetable farms increases, it becomes easier to take advantage of economies of scale. Larger farms can buy inputs in bulk which can lead to lower costs per unit. In large farms, there is more diversified production which also increases farm income. Similarly, large farm size can benefit from better management practices and technology which improves efficiency, yield, and income Fadipe et al [21].

The family members involved in agriculture have positive impact on farm income. If the member increases by 1, then farm income increases by 15.8%. This is significant at 5% level (0.02). Result indicated that having a more members involved in agriculture can contribute the necessary amount of labor for agricultural activities, leading to a decrease in expenses related to hiring external labor. This finding is consistent with Adhikari et al [5].

The years of farming experience has positive effect on farm income. If the years of farming is increased by 1 year, then farm income is increased by 1.4%. This is significant at 10% level ($p=0.06$). Result indicated that, if vegetable growers are experienced, they can make better decisions in various aspects of vegetable production such as seed selection, planting techniques, fertilization, pest control, and harvesting resulting in lower production costs and increase yield. Similarly, experienced farmers are more likely to develop relationships with buyers and suppliers which can lead to more consistent and profitable sales over time. This finding is consistent with Djomo and Sikod [22].

The membership in group/cooperatives has positive impact on farm income. The household with membership in group has 42% more farm income than household not having membership in group. This is significant at 5% level (0.03). Results indicated that group/cooperative membership offers advantages like access to resources, exchange of knowledge and information about agricultural technologies and enhanced market opportunities. This finding is consistent with Zou and Wang [23].

4. CONCLUSION AND RECOMMENDATIONS

This study assessed the effect of the agricultural technology adoption on farm income of commercial vegetable growers in Bagmati Province of Nepal. Less numbers of households were adopting more number of technologies. The adoption of more number of agricultural technologies have contributed to the economic wellbeing of farmers. The gender of household headed by female, farm size, family members involved in agriculture, farming experience, membership in farmer's group and cooperatives have positive effect on farm income.

The outcomes of our research carry significant policy implications for fostering the adoption of the technology in the Bagmati province. Hence, policymakers and stakeholders are advised to encourage technology adoption by providing training, facilitating access to necessary inputs and technologies, and fostering the formation of groups or cooperatives focusing on small holder farmers.

UNDER PEER REVIEW

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