Effect of adopting agricultural technology on farm income of commercial vegetable growers in Bagamati province of Nepal

ABSTRACT

Improved agricultural technologies are being promoted among commercial vegetable growers to improve yield and income in Nepal. However the rate of adoption of agricultural technologies is low. This study aims to assess the magnitude of the adoption of selected agricultural technologies and their effect on farm income in Bagamati Province, Nepal. We adopted a multi-stage sampling method and surveyed 180 randomly selected households. We used multiple ordinary least square regression model to measure the effect of the adoption of agricultural technology on farm income in the study area. The results indicate that the most adopted technologies in the study area are improved varieties, mini tillers, sprayers, water pumps, and integrated pest management whereas the least adopted are plastic tunnel, drip irrigation, agriculture mobile application, plastic mulching, and rainwater harvesting. Few households have adopted more technologies. The results also revealed that if the number of technology adopted increases by one unit, the farm income increases by 20.6%. This is significant at the 1% level. The result showed that farm size (p=0.008), and membership in farmer's group/cooperative (p=0.01) also have a significant positive impact on farm income. Promoting broader adoption of appropriate technologies among farmers helps to boost income generation. Policymakers and 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, policymakers, regression

1. INTRODUCTION

Vegetable farming is one of the major economic activities of both rural and urban farmers in Nepal [1]. The contribution of vegetables to agriculture gross domestic product (AGDP) is 13.43% [2]. In comparison to cereal crops, vegetables have a faster rate of commercialization and a higher cost-benefit ratio [3]. As vegetables are preferred cash crops, vegetable farming is likely to support livelihood largely through food provision, revenue generating, and employment [4]. The total area, production and productivity of vegetables in Nepal in fiscal year 2021/22 are 2,84,121 ha, 3,993,167 mt, and 14.05 mt/ha, respectively [2].

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 [5]. Improved agricultural technologies are critical for achieving development goals such as poverty reduction and maintaining food security for impoverished farming households [6]. 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 [7].

In comparison to neighboring countries, Nepal has a considerably lower rate of adoption of modern technology in vegetable production [8]. Adoption rate refers to the speed or pace at which individuals or entities adopt new technology, product, or innovation within a specific population or market. The lack of awareness among rural farmers about modern technologies and delay in the introduction of foreign-developed technologies in Nepal, have lowered the adoption rate. Some of these technologies, introduced without proper local adaptation studies are found to be unsuitable and expensive for farmers [6]. As a result, there is a shortfall in the expected improvements in vegetable production and farmers' income. Previous studies carried out in Nepal have mainly focused on the impact of adoption of one agriculture technology on farm income such as rainwater harvesting [9], plastic tunnel [10], and improved varieties [11]. However, these studies paid less attention to the effect of agriculture technology adoption on farm income, considering many technologies simultaneously.

This study includes the major agriculture technologies adopted by 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 [12]. The various kinds of technologies are interconnected and don't operate in isolation; they impact and collaborate with each other. To unleash the complete potential of different technologies and reap the rewards of technological advancements, it's essential to adopt a combination of interconnected technologies simultaneously [13]. In contrast to previous studies, this article discusses how the different agricultural technologies such as plastic tunnel, drip irrigation, improved varieties, agriculture mobile application, mini tiller, sprayer, water pump, Integrated Pest Management (IPM), plastic mulching, and rainwater harvesting effect the farm income. In this study, vegetables such as potato, asparagus bean, okra, radish, capsicum, cauliflower, chilli pepper, and cabbage were considered as they are major vegetables grown in the study area.

The objective of this research was to provide valuable insights into the magnitude of technology adoption and measure the effect of agricultural technology adoption on farm income. Understanding the status of technology adoption and its effect on farm income is a vital issue for technologies intervention. The research finding will generate valuable information assisting policy makers in the field of agriculture to design and implement the policies targeting to improve the farm mechanization, modernization and income.

2. LITERATURE REVIEW

Technology is the knowledge/information that allows some tasks to be completed more quickly, a service to be provided, or a product to be manufactured [14]. The new technology is either new to a specific location or group of farmers, or it reflects a novel application of technology that is already in use in that location or group of farmers. The new technology enables the applicant to complete tasks more quickly and efficiently than he would have been able to accomplish without the technology, therefore saving time

and effort [15]. Adoption is the process of integrating new technology into an existing practice, which is usually preceded by some 'trying' and adaptation [14].

Over the years, the integration of modern technology among farmers in developing nations has been perceived as the remedy for reducing agricultural income disparities [16]**.** According to the country's economic growth history, agricultural productivity has been a major source of advances in rural livelihoods in Nepal. The introduction of technologies related to the use of tradable inputs, especially improved seed varieties and chemical fertilizers, is seen as signaling a shift in agriculture towards commercialization. The development of improved technology such as improved seeds, fertilizers, pesticides, cultivation techniques, agriculture tools and equipment, and trained personnel have greatly contributed to agriculture production [6]. Similarly, increased production lowers prices, improves food access, creates employment, and stimulates growth linkages [16].

Many studies have reported an increase in farm income with the adoption of new agricultural technologies. In China, the adopters of agricultural technologies like new varieties, machinery, chemical fertilizers, pest control methods, production methods, and management methods had a significant increase in farm income by 44.84% [12]. Adopters of rainwater harvesting technology had 50% more farm income than non-adopters in the Makwanpur district of Nepal [9]. The adopters of tunnel technology in Nepal had increased annual net income by 1700$ and 2100$ using the treatment and OLS model respectively in 1 ha of land in comparison to non-adopters [10]. It was reported that farmers adopting chemical fertilizers and improved varieties in Northern Ethiopia earned 339.5$ and 240.08$ more respectively in comparison to non-adopters. Farmers who embrace agricultural technology can effectively cultivate high-value and desirable crops, leading to increased income and a continuous cycle of motivation for further technology adoption within farm households [17]. A study in rural Nigeria showed that the adoption of improved varieties resulted in higher rice income per hectare, higher rice income per capita, greater total farm income per capita, and better average yield than non-adopters [18].

A study on the impact of improved vegetable farming technology on farmers' livelihood in Thailand showed that the adoption of hybrid varieties resulted in a positive net improvement in income per hectare. These crops offered farmers employment options and were a critical supplemental source of income for struggling farmers. Due to their superior qualities and huge potential for output, farmers favored hybrid types [19]. A study on an economic analysis of tunnel farming in enhancing the productivity of off-season vegetables in the Peshawar district showed that for tunnel adopters, productivity and net revenue per hectare were two to three times greater than non-adopters [20]. The study on the impact of adopting water pump technology on smallholder farmers' income showed that the adoption of a motor pump significantly increased household income. Due to their access to sufficient groundwater that can be easily lifted to their field at any necessary time, motor pump adopters could increase the amount of irrigated land as well as the utilization of fertilizer and chemicals [21].

3. METHODOLOGY

3.1 Study area, sampling process, and data collection

The research was carried out in the Bagamati Province of Nepal, selecting Makwanpur, Kavrepalanchok, and Dhading districts. The selection of respondents followed a multistage sampling technique. These three districts were purposefully chosen due to their significance in commercial vegetable farming within the Bagamati 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.

3.2 Data analysis tools and techniques

3.2.1 Ordinary least square regression model

To measure the effect of agricultural technology adoption on farm income Ordinary least square (OLS) regression model was used. This model was used because farm income is a continuous variable. Additionally, as outlined by Gujrati [23], when considering the classical linear model assumption, the estimators derived from Ordinary Least Square (OLS) exhibit unbiased linearity while maintaining the lowest variance. This characteristic qualifies them as the most optimal and unbiased linear estimators, commonly referred to as best linear unbiased estimators [23]**.** An ordinary least square regression model was used by [17] to measure the effect of technology adoption on 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 dependent variable (natural log of farm income), β_0 is a constant, β_i is the regression coefficient of the independent variable, X_i is a vector of the estimated coefficient of the independent variable, and ε a random disturbance term which is believed to meet all the assumptions of OLS.

The list of dependent and independent variables used in OLS regression is shown in Table 1.

Table 1: Description of the variables for the OLS regression

Variables	Description	Type of measures	Expected sign
Dependent variable	Natural log of farm income		
Explanatory variables			
i. Continuous variables	Number of technology adopted	Count	+
	Education of the household head	Years of schooling	+
	Farm size	Hectare (ha)	+
	Distance to the nearest market	Kilometer(km)	-
ii. Categorical variables	Membership in farmer's group/cooperatives	=1 if yes; 0 = no	+
	Extension worker's visits	=1 if yes; 0 = no	+

4. RESULTS AND DISCUSSION

4.1 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 [24]. Within the study area, the average education of household head was 6.04 years. On average, the distance from the fields to the nearest market was 1.81 km (Table 2). The results indicated that farmers in the area had convenient access to market.

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
Education of household head (years)	5.63	6.28	6.21	6.04
Distance to the nearest market (km)	1.55	2.040	1.85	1.81
Categorical variables				
Membership in farmer's group/cooperative	55(91.67)	40(66.67)	56(93.3)	151(83.89)
1= yes	5(8.33)	20(33.33)	4(6.7)	29(16.11)
0= no				
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 84% of total sampled households had membership in farmer's groups or co-operatives 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 [25].

4.2 Magnitude of technology adoption

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 in fiscal year 2021/22.

The result showed that farmers preferred affordable technologies with low technical difficulties like improved varieties, sprayers, water pumps, mini tillers, and IPM was mostly adopted. 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.

The improved connectivity of roads in rural areas has increased the use of tractors, power tillers, and pump sets [26]. These kinds of equipment are becoming more popular because farmers have identified the distinct advantages of utilizing them, which include time, resources, and labor efficiency.

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

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

4.3 Number of technologies adopted

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. A 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 a 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 the finding of Kumar et al. [27].

Table 4: Distribution of adopters by the number of technologies adopted

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*

4.4 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 the coefficient of multiple determinations (R^2 = 0.266) indicated that 26.6% of the variation in the income is explained by the independent variables included in the model. The F statistics (8.917) confirm the stability of the overall regression equation and joint significance at 1% level. The Breusch-pagan test for heteroscedasticity showed a constant variance of errors and the model has no heteroscedasticity. Variance Inflation Factor (VIF) presents results according to expectation, mean VIF of 1.68 is and none of the variables 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 effect of agricultural technology adoption on farm income

Variables	Coefficient	S.E	T value
Number of agricultural technology adopted	0.206***	0.06	3.524(.00)
Education level of household head (years)	-0.008	0.018	-0.432(.66)
Farm size (ha)	0.719***	0.267	2.692(.008)
Distance to the nearest market	-0.074	0.153	-0.484(.62)
Extension work visit(1)	0.139	0.148	0.936(.35)
Membership in farmer's group/ cooperatives(1)	0.513**	0.196	2.622(.01)
constant	10.836***	0.541	20.046(.00)
Number of observation	180		
R square	0.266		
Adjusted R-square	0.236		

F-value	6.528(0.00)

*Significant at 10% level of, ** significant at 5%, *** significant at 1% level
Note: Figure in parenthesis indicates P value Source: Field survey, 2022

Regression results showed that the number of agricultural technology adopted had a positive impact on farm income. If the number of technology adopted increases by one unit, the farm income increases by 20.6%. This is significant at the 1% level (p = 0.00). Thus, the adoption of agriculture technology has a great impact on farm income. Wu 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% [12]. Pasa 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 [6]. 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 [28].

The farm size has a positive impact on farm income. If the farm size is increased by 1 ha, then the farm income is increased by 71.9%. This is significant at the 1% level (p = 0.008). The large farm size produces more vegetables and can sell more to the market which increases revenue and profits [29]. 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 [30].

Membership in groups/cooperatives has positive impact on farm income. The household with group membership has 51.3% more farm income than household without group membership. This is significant at the 5% level (0.01). 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 the work of Zou and Wang [31].

5. CONCLUSION AND RECOMMENDATIONS

This study assessed the effect of adopting agricultural technology on farm income of commercial vegetable growers in Bagamati Province of Nepal. Farmers have mostly adopted affordable technologies with low technical difficulties such as improved varieties, mini tiller, sprayer, water pump and IPM. Fewer numbers of households were adopting more technologies. The adoption of more number of agricultural technologies has significantly contributed to the economic well-being of farmers. It is necessary to take effective measures to promote the adoption of technologies among commercial vegetable farmers.

The outcomes of our research carry significant policy implications for fostering the adoption of the technology in the Bagamati province. Prior to introducing new technologies, the requirements of the farmers should be thoroughly studied so that their need is addressed. 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 smallholder farmers.

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