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1. Introduction

Nepal is an agriculturally dependent country where agriculture absorbs nearly 80% of the economically active population hence its importance is unquestionable (Prennushi [14]). Despite this fact, agricultural productivity has been very low and stagnant in Nepal over the past twenty-five years. Nepal, which used to be a food grain surplus country in the 1970s changed to a food grain deficit country in the 1990s (FAO [9]). Hence, currently there is a dearth of empirical studies on the productivity of Nepalese agriculture at either national, regional, or commodity-specific levels (Chaudhury [7]).

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. An underlying premise behind much of this work is that farmers are not making an efficient use of existing technology. Therefore efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing output (Belbase and Grabowski [5]; Shapiro [17]).

However, efficiency in agricultural production is frequently attributed to the managerial skills of the farm manager, and education is an important factor (Battese and Coelli [4]; Kalirajan [12]; Ueda [18]). Decision makers with more education can more quickly grasp changes and rapidly and accurately adjust to them (Huffman [10]). Several researchers found positive and significant effects of education on farm productivity and efficiency (Evenson and Mwabu [8]; Pudasaini [15]; Weir [19]). Extension services are also important to disseminate technology and to increase farm productivity (Kalirajan [11]). Several studies found the positive effects of agricultural extension services in agricultural yields and technical efficiency of the farms (Evenson and Mwabu [8]; Owens et al. [13]. In this context, this research focuses on the role that education and agricultural extension can play to increase agricultural productivity and thus the farm profits of rural Nepalese farmers by increasing the technical efficiency of their farms. However, most previous studies considered only one form of extension we separated extension provided by governmental and non-governmental organizations. This is because of differences in procedures, target groups, target crops, and so forth, though in terms of the extension services they provide, both organizations are similarly involved. With very few studies dealing with the role of non-governmental organization in providing agricultural extension services, this research might be useful for policy makers as well as for future researchers.

2. Methodology

This research was carried out in the relatively undeveloped far western region of Nepal because agriculture, which is the mainstay of the people, has never been rewarding. Agricultural productivity in this region is very low, and small changes can bring about drastic differences in the way farming is practiced. The purposive sampling method was used to fulfill our requirements for data collection. The far western region is divided into 9 districts, from which we selected (i) 2 hilly districts, Baitadi and Dadeldhura, and (ii) 2 terai (plain areas) districts, Kailali and Kanchanpur (Figure 1). The selected region represents average national conditions, with temperate (hill) to tropical (terai) climates. Within these areas, however, environmental production conditions are relatively similar, including soil, temperature, and rainfall. Major crops grown, mostly rice, wheat, and maize, are also similar to other regions of Nepal. A total of 25 households from Dasharath Chand Municipality (Baitadi), 26 from Amargadi Municipality (Dadeldhura), 34 from Dhangadi Municipality (Kailali), and 39 from Mahendranagar Municipality (Kanchanpur) were then purposively selected, totaling 124 samples (nearly 0.3% of total households, as of 2003). To collect data, we interviewed each household head individually, with the help of a semi-structured questionnaire, based on the recall method for the crop year 2003. This year also represents an average year with normal climatic conditions. Data were collected during the period of February and March of 2004. It comprises of household characteristics and agricultural production processes, including income and expenses from all crops cultivated by the household.

Figure 1: Map of Nepal highlighting the survey areas

The data were analyzed with the help of the maximum likelihood method of stochastic frontier production function (SFPF) for productivity analysis. The frontier production represents the maximum level of output that is possible with a given level of inputs; thus the SFPF is able to analyze the gap between farm and frontier production levels with the determining factors. The Cobb-Douglas model common among researchers is used to fit our production function, which in our case takes the following form:

$$\ln Y_i = \beta_0 + \beta_1 (\ln F\_LABOR) + \beta_2 (\ln H\_LABOR) + \beta_3 (\ln LAND) + \beta_4 (\ln CAPITAL) + v_i - u_i$$

Here, $\ln Y_i$ is the log of net crop output in terms of monetary value (net value of all crop outputs consisting mainly of rice, wheat, and maize after deducting current costs or the cost of inputs). Income is used instead of crop output because farming is diversified in Nepal with farmers growing several crops, and if different crops are aggregated in terms of output, crop-aggregation bias may occur as a result of substantial differences in price. Similarly, $\beta_{()}$s are unknown parameters to be estimated. On the other hand, *F_LABOR* represents family labor in monetary terms (number of man-days x market labor wage), and *H_LABOR* represents hired labor in monetary terms. Hired laborers are sometimes used on a daily wage basis and sometimes on a contract basis, and since for the contract basis we have no data on man-days, it is appropriate to use monetary values to remove confusion and for ease in comparison and aggregation. The use of monetary terms is preferred to omitting this variable, which could lead to an omitted variable bias. *LAND* is the area of land cultivated by the households and is in hectares. *CAPITAL* represents all other inputs summed up in terms of money used to buy them. Because of low levels of input use and some missing data on the quantity of individual inputs, we used monetary terms to aggregate all these inputs. Similarly, v_i is a random error term, and u_i is the non-negative inefficiency term, which is assumed to be half-normally distributed and given by:

$$u_i = \delta_0 + \delta_1 (AGE) + \delta_2 (S\_EDU) + \delta_3 (S\_EMP) + \delta_4 (S\_LABOR) + \delta_5 (S\_FARM) + \delta_6 (M\_FARM) + \delta_7 (TERAI) + \delta_8 (TRADITIONAL) + \delta_9 (MKT\_DIST) + \delta_{10} (GOVT\_EXT) + \delta_{11} (NGO\_EXT) + e_i$$

Here, $\delta_{()}$ are the unknown parameters to be estimated. *AGE* represents age of the head in years, and *S_EDU*, *S_EMP*, and *S_LABOR* represent shares of educated (completion of 10 years of schooling), non-agriculturally employed members, and family agricultural labor in each household, respectively. The age of the head and the share of educated members are used as proxies for management, whereas the share of agricultural and non-agricultural laborers directly determine labor availability and thus are used. We also use *S_FARM* and *M_FARM*, which represents small and medium-sized farms based on the asset levels of the households, since family wealth can affect crop choice, input use, and other farming practices. Because technical efficiency can differ between hill and terai region, we use *TERAI* as a dummy variable for capturing differences in production environment (1 = if farm is situated in the plain areas, 0 = otherwise). *TRADITIONAL* is also a dummy variable for farm technology (1 = if farmer says they prefer or are practicing traditional farming, 0 = otherwise) that may affect technical efficiency. *MKT_DIST*, which represents the distance from the farm to the nearest market in kilometers, is used because it determines the ease in access to the market for inputs as well as for the disposal of surplus. *GOVTEXT* and *NGOEXT* represent extension services provided by governmental and non-governmental organizations, respectively, and are dummy variables (1 = presence, 0 = otherwise). And e_i is a random error term. The suggested measure of technical efficiency is $TE_i = exp(-u_i)$ (Battese and Coelli [3]).

In the technical inefficiency model, if the variable has a positive sign it is said to increase technical inefficiency, or, in other words, to decrease efficiency, and vice versa. In our model, *AGE* is expected to have either a positive sign, since an increase in age is expected to increase technical inefficiency resulting from a resistance to change, or a negative sign leading to a decrease in inefficiency may be due to an increase in experience. However, *S_EDU* and *S_LABOR* are expected to have negative signs, meaning positive effects on technical efficiency. However, *S_EMP* could have either a negative sign (positive effect) because of a contribution in capital formation, or a positive sign (negative effect) because it absorbs family agricultural labor. Similarly, *S_FARM* and *M_FARM* are expected to be either negative because farmers with less land endeavor hard to get good results, or positive because of the low scale of production. *TRADITIONAL* and *MKT_DIST* are expected to have positive signs, but TERAI, which has better facilities in terms of agricultural inputs, is expected to have a negative sign. Extension is expected to have a negative sign (positive effect) because of its effect on increasing technical efficiency by improving the managerial ability of farmers.

3. Results and discussion

An analysis of levels of inputs and outputs was done to reveal the agricultural production process (Table 1). Average resource allocation per hectare of owned land was estimated for the selected households. However, borrowed land is excluded from this analysis for ease. Results showed that family labor wages and owned land rent have more than 90% shares in the resources, if included. On the other hand, if these inputs are excluded, there is a clear insight into the pattern of resource allocation for farming activities: draft power takes the largest share, followed by hired labor wages, seeds, and fertilizers. Other inputs have less than a 10% share in total resource allocation. Moreover, gross crop income shows a low value, meaning low levels of agricultural productivity, highlighting the need for crop productivity analysis in this region, which in turn may help the farming households to efficiently allocate and use the available resources.

Table 1: Factor shares in the agricultural production process (average resource allocation per hectare of own land)

Inputs	Average (NRS/ha)	Factor shares (resource allocation %)	
Family labor wages	85344.40	69.34	n.a.
Land rent	27748.46	22.54	n.a.
Draft power	5523.69	4.49	55.30
Hired labor wages	1711.43	1.39	17.13
Seed	1362.58	1.11	13.64
Fertilizers	709.80	0.58	7.11
Transportation	425.44	0.35	4.26
Miscellaneous chemicals	49.12	0.04	0.49
Irrigation water	13.45	0.01	0.13
Miscellaneous inputs	193.55	0.16	1.94
Total indirect inputs	123081.92	100.00	100.00
Total direct inputs	9989.05	n.a.	n.a.
Gross crop income / ha	27147.75	n.a.	n.a.
Net crop income / ha	17158.69	n.a.	n.a.

Note: ha = hectare; NRS = Nepalese rupees (NRS 7 = 10 yen, approximately); n.a. = not available / not applicable

An analysis of stochastic frontier production functions was done to find variables that significantly affect the agricultural productivity and technical efficiency of crop-producing households (Table 2). Results from the stochastic frontier model revealed that the highest output elasticity is for capital (0.72), which is also highly significant and positively related with farm profits, and thus with farm productivity. Hence, facilitating timely availability of these agricultural inputs may be helpful for agriculturally dependent farms. Battese and Coelli [4] also found capital to be positive and significant in the case of paddy farmers in Indian villages, but with small coefficients. Similarly, land is also highly significant and has a high contribution in the overall income of farmers. Ueda [18] also found land to be highly positive and significant while analyzing production function for Indian panel data. Adams [1] also found land to be positive and significant in the case of rice production in Pakistan. However, Ali [2] found farm size to be positive, but not significant, in the case of Nepalese wheat farmers. On the other hand, family labor is not found to be significant and also has a small positive contribution, which might be due to the excess availability of family labor in the sampled households. Moreover, hired labor is found to have negative effects, though insignificant. These findings contrast with those of Ueda [18], who found labor also to be positive and significant. Adams [1], on the other hand, found a negative relationship of labor to rice production in Pakistan. On the other hand, the sum of all input elasticities is 1.01, indicating on average nearly constant returns to scale. Furthermore, the estimated coefficients of inputs do not match the respective factor shares, suggesting that farmers face certain disequilibria in the market, most probably because of the proximity of the selected regions to urban areas.

On the other hand, the technical inefficiency model revealed that agricultural extension services provided by non-governmental organizations are among the important factors for improving the technical efficiency of farms, and it is also significant at 5%. Moreover, the negative coefficient associated with this variable implies that as farmers were able to receive extension services from these organizations, their technical efficiency in production increased compared to those obtaining none or those obtaining extension from governmental organizations. Kalirajan [11] also reported a significant positive impact of extension on rice production; however, there is no segregation for the organization involved. Similarly, results showed that with an increase in the share of educated and employed members, technical efficiency increases. The number of educated members is significant at 5%. This might be due to a better know-how of the educated members to operate the farm and also due to ease and readiness in the adoption of modern technology by households with more educated members. Education was found to be highly significant by many past researchers. Kalirajan [12] studied rice production in the Philippines and reported a significant positive effect of education of the head. Ueda [18] also found similar results, using Indian panel data. However, Battese and Coelli [4] found education of the head to be negative, though the relation was weak. Similarly, share of family agriculture labor is also found to be significantly and positively related to the efficiency of the farms. Small and medium-sized farms were found to have positive and higher efficiency compared to larger farms.

On the other hand, the age of the household head, extension provided by governmental organizations, terai, traditional farming practices, and market distance were found to increase the technical inefficiency of the farm. Age might have decreased efficiency as a result of unwillingness to change. However, government extension was unexpectedly also found to be negative, though insignificant. Most probably this occurs because government officials are usually given few incentives, reducing their interest in their work, which leads to irregular field visits and interrupted extension projects. Most cases of government extension reported revealed similar problems. Reynar and Bruening [16] also reported several problems in the case of extension provided by governmental organizations. This might have caused imperfect knowledge on the part of farmers even with the better technology they had adopted in the initial stage, making them unsuccessful to harvest the best fruit. Another reason might be that governmental organizations mostly focus on the staple crops, which is vital from the viewpoint of food security, hunger, poverty, and migration. However, this point is overlooked in this research. Similarly, if the farms are located in terai or plain regions, they are found to have significantly lower efficiency, which may be due to higher opportunities in the non-farm sector leading to negligence in farming. As is obvious, farms practicing the traditional approach have significantly lower efficiency. If farms are located far from the market, it is also found to reduce efficiency, but not significantly.

Furthermore, the estimated value of variance parameter (gamma) was close to unity and also highly significant, suggesting that technical efficiency effects are significant in explaining the levels of and variations in farm productivity on these farms.

Table 2: Stochastic production function analysis of the determinants of farm productivity

Variables	Coefficient estimates	t-value
Stochastic frontier model		
F_LABOR	0.04	1.42
H_LABOR	-0.00	-0.42
LAND	0.25	2.05**
CAPITAL	0.72	7.52***
CONSTANT	2.35	2.46**
Technical inefficiency model		
AGE	0.02	1.68*
S_EDU	-2.08	-2.44**
S_EMP	-0.70	-0.79
S_LABOR	-1.44	-1.87*
S_FARM	-1.26	-1.64
M_FARM	-1.03	-1.74*
TERAI	3.63	5.00***
TRADITIONAL	2.42	4.85***
GOVT_EXT	0.28	0.57
NGO_EXT	-1.38	-2.32**
MKT_DIST	0.07	0.95
CONSTANT	-5.16	-6.76***
Sigma square	0.71	5.03***
Gamma	0.90	34.69***
Log likelihood	-55.73	n.a.

Note: *significant at 10%, **significant at 5%, and ***significant at 1%

The gap between the production level at frontier and farm is called technical efficiency. The estimated technical efficiency scores in our case revealed that one-third of the farms are achieving efficiency near 80 to 90 percent, nearly one-quarter from 90 to 100 percent, and the rest below these ranges, with the mean efficiency of all farms near 69 percent (Table 3). This means that farms are performing on average 31 percent behind the potential level. Therefore with the better use and allocation of resources technical efficiency can be increased by more than 30 percent. Several similar studies revealed the average efficiency of farms to be well below the frontier. Bravo-Ureta and Evenson [6] found the efficiency of Paraguay farmers in producing cotton and cassava to be around 58 and 59 percent, respectively. Ali [2] found the average resource-use inefficiency to be 25 percent in Nepalese wheat farmers. Kalirajan [12] found technical efficiency of Philippine rice farmers to be around 79 percent. Thus most analyses revealed that farmers are still behind the potential production levels, and some kind of inefficiency in production exists in the real world situation.

Table 3: Categorization of farm by the level of technical efficiency achieved

Technical efficiency	Number of farms	Percentage of farm	Average efficiency (%)
00 to 50%	21.00	16.94	38.12
50 to 60%	25.00	20.16	55.60
60 to 70%	17.00	13.71	63.68
70 to 80%	2.00	1.61	72.71
80 to 90%	39.00	31.45	87.35
90 to 100%	20.00	16.13	92.25
Total	124.00	100.00	69.92

4. Conclusion

An analysis of agricultural productivity revealed that capital, that is, inputs, other than land and labor, is an important production input that is also significant. Land also has a positive and significant contribution. Family labor is positive; however, hired labor is negative, though both are insignificant. Moreover, the technical inefficiency model revealed that agricultural extension services provided by non-governmental organizations have a positive and significant contribution, and it increases technical efficiency of the farm. Therefore we recommend policy that increases the role of non-governmental organizations in providing agricultural extension services. Similarly, the share of educated persons per household is also significantly and positively related to technical efficiency, so providing educational services to these households may also be helpful. However, in contrast to our expectation, government extension is found to have a negative effect on efficiency, though it is insignificant. As we can expect, because governmental organization takes the lion's share in terms of coverage, policies should be made favorable to improve their performance in providing agricultural extension services.

An analysis of technical efficiency on farms revealed that on average they are operating well below the frontier, with the average technical efficiency being 69%; obviously there is ample room for improvement. With little changes in the production process, technical efficiency of the selected farms could be increased on average by up to 30%.

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