Resource Use Efficiency in Vegetable Production in the High Hills of Eastern Nepal

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Abstract

The main purpose of this study was to analyze the resource use efficiency and factors influencing inefficiency in vegetable production in the high hills of Eastern Nepal. This study used secondary data set of Nepal vegetable crops survey (2010) collected by the Central Bureau of Statistics, Government of Nepal, and adopted the stochastic frontier analysis (SFA). The results from the maximum likelihood estimates revealed that the mean technical efficiency score was 0.79 which indicated high potential in increasing vegetable production from the existing resources and technology. The major contributing input factors for resource use efficiency were land, labor, seeds, compost, fertilizers, pesticides, and farm capital. The farm-specific factors such as seed types, credit access, and technical support significantly affected inefficiency in vegetable production. The study recommends policies to focus on improving land, developing skilful labour, encouraging vegetable farmers to promote compost, easy access to farm capital, fertilizers, and pesticides. Policies need to focus also on innovating and adopting improved seed varieties, easy access to credit facilities, and technical supports and backstopping to farmers, and encouraging women farmers in vegetable production.

Keywords: Resource use, efficiency, inefficiency, stochastic frontier, vegetable production

JEL Codes: Q1, Q12, J43

1. Introduction

Vegetable is an important component in Nepalese economy which provides huge employment, generates income, and supplying plenty of nutrients for millions of people. Annually, the output was more than 3 million tons of vegetables in 0.24 million hectares of land with a fast growth rate (MOAD, 2012). Among the geographical regions in Nepal, the highhills are less accessed with infrastructures, markets, extension services, and public incentives in vegetable production that imply relatively low level of production and productivity of vegetables. The major concern in Nepalese vegetable farming is limited resources available with the farmers, and inappropriate and inefficient use of

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these resources leading to chronic inefficiency in vegetable production. Labor is one of the important factors in vegetable production where all the farming activities are carried out by labor manually. Nepalese farmers use compost rather than chemical fertilizers for plant nutrients since fertilizer is not available to the farmers in adequate quantity, and the quality is also not certain. Therefore, it becomes important to analyse the impact of composts and chemical fertilizers on vegetable production. Parikh, Ali, and Shah (1995); Udoh (2005); and Udoh, and Etim (2007) found that both of these inputs contributed significantly in agriculture production. Farmers use pesticide in vegetable farming which is quite expensive, not available on time, and the quality is also in doubt. Besides these inputs, other expenditures are incurred by farmers on items such as simple equipment, construction of temporary plastic-bamboo tunnels, thatch etc., considered as farm capital. Resource use efficiency is the capacity of resource to produce the highest level of output, and technical efficiency deals with the capacity of farm to produce the optimum level of output with a given level of inputs. It goes without saying that improving efficiency of resources would increase both the production and productive efficiency of vegetables.

Vegetable farming in Nepal is also strongly affected by farm-specific factors such as seed types, credit accessible to farmers, technical support, the education level of the head of household, and sex of household head. Previous studies of Bozoğlu (2007); Donkoh (2013); and Nwauwa, Rahji, and Adenegan (2013) used these variables and reported that they had a significant role in vegetable production. Therefore, these variables were also used in this study to analyse their influence on inefficiency in vegetable production. A great deal of empirical studies have been carried out using stochastic frontier analysis in vegetable production, although resource use efficiency in vegetable farm has not been conducted in Nepal. Therefore, the main purpose of this study was to analyse resource use efficiency and determine factors influencing inefficiency in vegetable production in the high hills of Eastern Nepal. This study may help in formulating policies for prioritizing inputs and making vegetable farms more efficient.

2. Materials and Methods

2.1 Study Area

The study was conducted in Sankhuwasabha district which is located in the high hill region of Eastern Nepal. The study area included Khandawari municipality and six Village Development Committees (VDCs) such as Baneshowar, Chainpur, Dhupu, Diding, Mamling, and Syabun. The elevation range of the

district is 345 - 8470 meters, while the study area ranges from 1500 to 2500 meters above the sea level. The reason for selecting this district was its high contribution in vegetable production among eastern high hill districts, where vegetable production accounted for 13,875 tons in 1,470 hectares of land with 9.44 tons/ha of productivity in 2011 (MOAD, 2012). The common vegetable crops are tomato, cauliflower, cabbage, broad - leaf mustard, onion, potato, radish, pumpkin, gourds, cucumber, chili, bean, eggplant, squash, etc. The majority of farmers cultivate vegetable in subsistence level; however, the production areas in the nearby district headquarters are commercially oriented. The study area is characterized by underdeveloped infrastructure s the seasonal road is linked to the district headquarters of Dhankuta district, are inputs; available only in the district headquarters; extension service is not effective; credit facility is not well accessed; and people sell their products only in weekly markets.

2.2 Data Set

This study used secondary datasets of Nepal Vegetable Crops Survey (2009/10) of the Central Bureau of Statistics (CBS), the Government of Nepal. A total of 956 sample vegetable farms of 150 households were used where the farm sizes were equal and larger than 0.001 hectares. The output in rupees (Rs.)[4] was as the dependent variable, calculated by adding household consumption, farm use, sales, and charity. The explanatory variables such as land, labor, seeds, compost, fertilizers, pesticides, and farm capital were considered in estimating frontier production function. L and was calculated in hectares, and labor (hired and family), seeds, compost, fertilizers, and pesticides were calculated in cost, while farm capital was estimated as aggregate expenses in plastic-bamboo temporary tunnel, thatch, equipments, etc.

Farm-specific variables used were seed type dummy 1 if improved seed adopted and 0 otherwise; credit accessed dummy 1 if the farmer accessed credit and 0 otherwise; technical support dummy 1 if the farm accessed technical support and 0 otherwise; years of education of head of household; and sex of household head dummy 1 if the farm headed by male and 0 otherwise. Alene (2008); Binam, et al. (2004); Nwauwa et al. (2013); Ojo (2009); Rahman (2003); and Tiedemann and Latacz-Lohmann (2013) used these variables in their research, and the results were consistent and significantly influencing agriculture production.

[4] Rs is Nepali currency with Rs 80.0 equalling 1 US$ in 2010.

2.3 Stochastic Frontier Analysis

The study adopted stochastic frontier analysis (SFA), version 4.1, developed by Coelli (1996). One stage procedure was adopted to measure the unknown parameter and for determining farm-specific factors influencing inefficiency in vegetable production (equation 1).

$$ln(Y_i) = \ln(X_i)\beta + v_i - u_i \qquad i = 1 \ldots \ldots n \tag{1}$$

Where, Y_i is production value of the $_i$th farm, X_i is vector of inputs for $_i$th farm, β is coefficient of unknown parameters, ln is natural logarithm. The random error (v_i) assumed to be independently and identically distributed with $N(0,\delta v^2)$ while u_i represents non-negative random error account for technical inefficiency in production, and assumed to be independently distributed as truncations at zero of the N (μi, δu^2).

The inefficiency effect model was defined as $U_i = z_i\delta$, where(z_i) for farm-specific explanatory variables that influence technical inefficiency of a farm and (δ) is unknown parameter to be estimated. Empirical model of stochastic production function was derived (equation 2), where the output of vegetables were considered as the function of land, labor, seeds, compost, fertilizers, pesticides, and farm capital (equation 2).

$$lnY_i = \beta_0 + \beta_1 lnLand_i + \beta_2 lnLabor_i + \beta_3 lnSeed_i + \beta_4 lnCompost_i + \beta_5 lnFertilizer_i + \beta_6 lnPesticide_i + \beta_7 Frm\ capital_i + v_i - u_i \tag{2}$$

Technical inefficiency was considered as a function of five farm-specific variables such as seed types, credit accessed, technical support, education level of the head of household, and the sex of household head to analyse the influence of these variables on inefficiency of vegetable production (equation 3).

$$u_i = \delta_0 + \delta_1 Seed\ type_i + \delta_2 Credit_i + \delta_3 Technical\ support_i + \delta_4 Education_i + \delta_5 Sex_i \tag{3}$$

3 Results and Discussion

3.1 Descriptive Statistics of Variables

The descriptive statistics of the variables used in this study are presented in Table 1. The farm sizes of vegetable farming were quite small (the average size 0.007 hectare). Majority of the farmers (57%) in the study area used local varieties of vegetable seeds. A limited number of farmers (40%) accessed credit facility because the financial institutions are concentrated in the city areas. The

large number of farmers (87%) accessed technical support provided by the government or non-governmental institutions. This indicated that farmers are getting technical services, although it is not effective in disseminating technology. Additionally, the level of education of vegetable farmers was quite low; the mean duration of the education of sample farmers was 3 years; and about 30 percent of the farmers had a zero level of education. Moreover, the majority of vegetable farms (93%) were headed by male.

Table1: Descriptive statistics of variables of vegetable farms

Variables	Mean	Standard Deviation	Minimum	Maximum
Farm size	0.007	0.000	0.001	0.161
Labor cost (Rs)	234.198	139.323	70.000	990.000
Seed cost (Rs)	106.856	97.118	5.000	750.000
Compost cost (Rs)	124.095	79.089	10.000	700.000
Fertilizer cost (Rs)	48.222	136.574	0.000	1200.000
Pesticide cost (Rs)	29.984	91.571	0.000	800.000
Farm capital (Rs)	129.555	86.935	10.000	800.000
Seed type	0.429	0.495	0.000	1.000
Credit accessed	0.394	0.489	0.000	1.000
Technical support	0.873	0.333	0.000	1.000
Education (year)	3.409	2.800	0.000	9.000
Sex of household head	0.934	0.248	0.000	1.000

3.2 Maximum Likelihood Estimates of Vegetable Farms

The results of maximum likelihood estimates (MLE) are presented in Table 2. The mean of technical efficiency was 0.79, which indicated that there was more scope in increasing vegetable production without increasing additional input resources. The variance parameters were highly significant, and indicated that vegetable production was effective although technical inefficiency remainder Gamma (γ) was highly significant and estimated coefficient 0.69, revealing that a large portion of inefficiency (69%) was a result of technical inefficiency which can be improved by proper vegetable production management practices. The result of likelihood-ratio (LR) test[5] revealed that the null hypothesis of technical

[5] The likelihood-ratio test statistic, $\lambda = -2\{\ln[likelihood\ (H_0)] - \ln[likelihood\ (H_1)]\}$, has an approximately Chi-square distribution with parameter equal to the number of parameters assumed to be zero in the null hypothesis (H_0), provided.

efficiency was strongly rejected, underscoring technical inefficiency.

The estimated coefficients of all the independent input variables were highly significant with consistent signs (Table 2). The elasticity of parameters were 0.038, 0.327, 0.147, 0.156, 0.036, 0.044, and 0.223 for land, labor, seed, compost, fertilizer, pesticide, and farm capital, respectively, with the highest elasticity observed in labor, farm capital, compost, and seed. The sum of the elasticity was 0.97, indicating decreasing returns to scale in vegetable production.

Among the farm-specific variables, seed type negatively affected inefficiency of vegetable production which indicated that improved seed would have a positive impact on the production efficiency of vegetables. Credit access to the vegetable farmers negatively affected inefficiency in vegetable production which was significant at 10 percent level, indicating that access of credit to the vegetable farmers would have a positive impact on production efficiency. A similar result was found by Bozoğlu (2007) for vegetable production in Turkey, and Binam et al. (2004) for groundnut and maize in Cameroon. The negative effect of technical support in inefficiency of vegetable production revealed that providing technical support would improve production efficiency in vegetables farming. The education and sex of household head were insignificant in influencing vegetable production, although the sex of household head showed a consistent expected sign. The negative effect of sex on inefficiency indicated that women farmers were more efficient than men.

Table 2: Results of maximum likelihood estimates of vegetable farms

Variable	Coefficient	Standard Error	t-ratio
Production function			
Constant	0.287	0.188	15.286***
Ln (land)	0.038	0.013	2.941***
Ln (Labor)	0.327	0.0201	16.222***
Ln (Seed)	0.147	0.014	10.211***
Ln (Compost)	0.156	0.014	10.87***
Ln (Fertilizer)	0.036	0.014	2.464***
Ln (Pesticide)	0.044	0.0162	2.723***
n (Farm capital)	0.223	0.015	15.312***
Sum of elasticity	0.971		
Variance parameters			
Sigma-square	0.142	0.0109	13.026***
Gamma	0.692	0.0456	15.188***

Variable	Coefficient	Standard Error	t-ratio
LR test	37.131		
TE	0.795		
Inefficiency effect model			
Seed type	-0.049	0.021	-2.377***
Credit accessed	-0.045	0.0209	-2.171**
Technical support	-0.046	0.029	-1.597*
Education level of head of household	0.004	0.003	1.229
Sex of household head	-0.042	0.037	-1.131

***, **, *, NS indicates significant at 1%, 5%, 10%, and non-significant levels respectively.

4. Conclusion and Policy Implications

The main purpose of this study was to analyze resource use efficiency and factors influencing inefficiency in vegetable production in the high hills of Eastern Nepal. The result of maximum likelihood estimates revealed the average technical efficiency of 0.79, which indicated that there was good opportunity to increase vegetable production within the existing level of input resources. The variance parameter, particularly the coefficient of gamma 0.69, indicated that more than half of the inefficiency was due to technical inefficiency, implying that production could be increased by improving farm management practices.

Input variables such as land, labor, seeds, compost, fertilizers, pesticides, and farm capital were highly significant, and the expected signs were consistent. Meanwhile, higher elasticity was found in labor, farm capital, compost, and seed. Therefore, the study recommends policies to be focused on capacity development of agriculture labor to make them skilful; easy access of farm capital to vegetable farmers; vegetable farmers to be encouraged for using compost for plant nutrients; innovation and dissemination of improved seed varieties of vegetables that are insect-pest resistant and high yielding; improvement of land quality; and easy availability and affordability of pesticides, and fertilizers to the farmers.

In the inefficient effect model, the negative effect of seed type on the inefficiency of vegetable productions suggested that policy needs to be focused on developing improved seeds of vegetables that can increase vegetable production efficiency. Credit access was significant in influencing vegetable production, implying that financial institutions need to be established in rural areas that would help farmers in providing the credit necessary for vegetable production. One of the important results was the negative effect of technical

support in the inefficiency of vegetable production, indicating that providing technical support to vegetable farmers would help to increase the total value of vegetable production. This implied that policies should focus on dissemination of technology by providing training and observation tour, and regular visits of technicians to the vegetable farms. Furthermore, the consistency in the expected sign of the sex of the household head implied that women farmers need to be encouraged in vegetable farming by providing them necessary training, technical backstopping, and policy incentives that would help to increase vegetable production.

REFERENCES

Alene, A. D. et al. 2008. "Economic Efficiency and Supply Response of Women as Farm Managers: Comparative Evidence from Western Kenya." *World Development,* 36 (7), 1247-1260.

Binam, J. N. et al. 2004. "Factors Affecting the Technical Efficiency Among Smallholder Farmers in the Slash and Burn Agriculture Zone of Cameroon." *Food Policy,* 29 (5), 531-545. doi: 10.1016/j.foodpol.2004.07.013

Bozoğlu, M. and C. Vedat. 2007. "Measuring the Technical Efficiency and Exploring the Inefficiency Determinants of Vegetable Farms in Samsun Province, Turkey". *Agricultural Systems,* 94 (3), 649-656.

Coelli, T. J. et al. 2005. "An Introduction to Efficiency and Productivity Analysis". Second Edition. *Springer*.

DDC. 2011. District Climate and Energy Plan, Ilam. District Development Committee, Government of Nepal, UKaid, and SNV.

Donkoh, S. A., M. Tachega, and N. Amowine. 2013. "Estimating Technical Efficiency of Tomato Production in Northern Ghana". *American Journal of Experimental Agriculture,* 3 (1).

Ibrahim, H. and A. Omotesho. 2010. "Technical and Scale Efficiency in Vegetable Crops Production under Fadama in North Central Nigeria." *Journal of Agriculture Research*.

MOAD. 2012. Statistical Information on Nepalese Agriculture. Ministry of Agricultural Development, Kathmandu, Nepal.

Nwauwa, L. O. E. et al. 2013. "Determinants of Profit Efficiency of Small-Scale Dry Season Fluted Pumpkin Farmers Under Tropical Conditions: A Profit Function Approach." *International Journal of Vegetable Science,* 19 (1), 13-20. doi: 10.1080/19315260.2012.662582

Ojo, M. A. et al. 2009. "Return to Scale and Determinants of Farm Level Technical Inefficiency among Small Scale Yam-Based Farmers in Niger State, Nigeria: Implications for Food Security." *International Journal of Agricultural Economics and Rural Development,* 2 (1).

Parikh, A., F. Ali, and M. K. Shah. 1995. "Measurement of Economic Efficiency in Pakistani Agriculture." *American Journal of Agricultural Economics,* 77 (3).

Rahman, S. 2003. "Profit Efficiency Among Bangladeshi Rice Farmers." *Food Policy, 28* (5–6), 487-503. doi: http://dx.doi.org/10.1016/j.foodpol.2003.10.001

Tiedemann, T. and U. Latacz-Lohmann. 2013. Production Risk and Technical Efficiency in Organic and Conventional Agriculture: The Case of Arable Farms in Germany. *Journal of Agricultural Economics,* 64 (1), 73-96. doi: 10.1111/j.1477-9552.2012.00364.x

Udoh, E. J. 2005. "Technical Inefficiency in Vegetable Farms of Humid Region." *Journal of Agriculture and Social Science*.

Udoh, E. J. and N.A. Etim. 2007. "Estimating Technical Efficiency of Waterleaf Production in a Tropical Region." *Journal of Vegetable Science,* 12 (3), 5-13.

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