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Determinants of Inefficiency in Vegetable Farms: Implications for Improving Rural Household Income in Nepal

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Abstract Improving household income is a critical issue for rural sustainable economic development in the world, particularly in developing countries. Enhancing the productive efficiency of vegetable farms help to increase farmers' income and that contribute to reduce rural poverty. This paper evaluates the productive efficiency and identifies the determinants of inefficiency in vegetable farms adopting stochastic translog production function using survey data. The results reveal that the vegetable farms are inefficient and have substantial potential to improve the efficiency levels with greater access to agricultural markets, higher levels of farmers' education, and increased number of trainings to the farmers. In addition, women empowerment in vegetable farming with incentive packages consisting of agricultural support services and superior technologies would improve productivity and efficiency in vegetable production that increase household income of the farmers.

Keywords: *vegetable farm, efficiency, women contribution, rural household income, poverty reduction*

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1. Introduction

Ending poverty and hunger as targeted by Millennium Development Goal (MDG1) by 2030 in the world, particularly in developing countries are the major and intertwining challenges. It depends on the rate of income growth and economic development [27]. Asia, where more than half of the world's poor live, has a disproportionate distribution of poor with almost three-quarters of the continent's poor residing in South Asia [12,44]. The average of the gross domestic product (GDP) per capita income in South Asia was US$1420.40 in 2012, which was more than two times higher than in Nepal (US$681.20) [12]. Furthermore, the poverty incidence in Nepal was 27.40%, which was much higher in mountain region (43.3 %) and lower in hills and terai (southern tropical plain) regions with rates hovering around 25 % of the country [12]. This indicates that Nepal has a major challenge to increase the per capita income and reduce the poverty incidence.

The majorities of the people (80 %) live in rural areas and their livelihoods depend on small scale agriculture farming system, where vegetable sector is one of the main components. Such small scale farms are the most potential to contribute for economic growth and reduce poverty [40,48,49,50]. Vegetable farming is the most potential source of rural employment that generates incomes and reduces poverty in the world [6]. In Nepalese context, this sector significantly contributes to the national economy because of comparative advantage available in labor-resource endowment. The vegetable was produced 3.3 million tonnes in 0.25 million hectares of land in 2012, where about 50 % of the products shared by summer season vegetables [30]. The growth rate of vegetables slowed down from 7.42 % during 2004-2009 to 3.07 % during 2010-2012; as a result Nepal imported vegetables (more than US$150.00 million) from neighboring countries in 2012 [30]. The diverse agroecological ranges such as terai, hills, and mountain regions, and associated climatic variations offers immense opportunities in producing varieties of vegetables throughout the year that would help for import substitution and export promotion.

In recent years, Nepalese vegetable farming has been transferring from subsistence into commercial systems, especially in the peri-urban areas or areas with road and market access [43]. But, the vegetable farmers are encountered by poor quality and inadequate quantity of improved varieties of seeds, poor access to credit, weak access to commodity markets, and rudimentary infrastructures that limit the productivity and the reduced level of efficiency. The government policies [29,31,34,35] aimed to achieve sustainable economic development and poverty alleviation, where vegetable farming identified as the prioritized sector. Despite implementing these policies, the vegetable sector lags behind expectations of the targets because of inadequate policy set-up, particularly at the operational levels. Indeed, the efficient use of productive inputs and similarly addressing farm-specific socio-economic factors would improve the productivity and the efficiency. Some studies [32,48] identified that sustainable agricultural development is embarrassed by low productivity, inefficiency, less competitiveness, and resources scarcity. Such statements cannot address in enhancing efficiency because vegetable production differs in several climatic, seasonal, soil and other natural conditions. Since the technological development is a slow process, the increase in agriculture growth depends on improving the technical efficiency [21]. There is therefore need of empirical studies that could infer policies on inputs prioritization, costs minimization and outputs optimization in vegetables production. The stochastic frontier analysis is the best approach to suggest policies that minimize the cost and optimize the outputs. Previous researches [1,10,16,39,41] estimated efficiency in agriculture in general, but ignored vegetable sector. In fact, there is a dearth of studies on the productive efficiency of vegetable farms in relation to household income and rural poverty. Therefore, we conducted this study to evaluate the productive efficiency and determine the factors affecting inefficiency of vegetable farms in agroecological and gender perspectives. The policies recommended in this study would be useful to enhance the efficiency in vegetable production and improve the rural household income in the country and also can be applied in the similar socio-economic and geo-graphical conditions in different other countries. The next section discusses materials and methods, followed by results and discussion, and conclusions and policy implications.

2. Materials and Methods

2.1. Study Areas and Sampling Design

We selected the central development region among five development regions (eastern, central, western, mid-western and far-western) in Nepal (Figure 1). This region is on the top for vegetable production, which shared 40% of the total production in the country [30]. Four districts Dhanusa, Dhading, Lalitpur and Dolakha were selected representing three agroecological regions, (terai, hill, and mountains) based on the highest quantity of production within the region. Dhanusa district represents the terai, Dhading and Lalitpur the hills, and Dolakha the mountain. Terai exist mostly low land type, majority of the farms are irrigated and hot weather, while hills and mountain regions are mostly upland, cold weather and the main sources of irrigation remain local streams, ponds,and rain. The altitude range in the study areas are: Dhanusa (150m-400m), Dhading (800m-1500m), Lalitpur (1000m–1800m), and Dolakha (2000-2600m) from the sea level. The distance of study areas from capital city (Kathmandu) are: Dhanusa (115-120km), Dhading (65-70km), Lalitpur (18-33km), and Dolakha (60-70km). Two districts, Dhading and Lalitpur were selected from the hill to represent relatively larger number of districts growing vegetables.

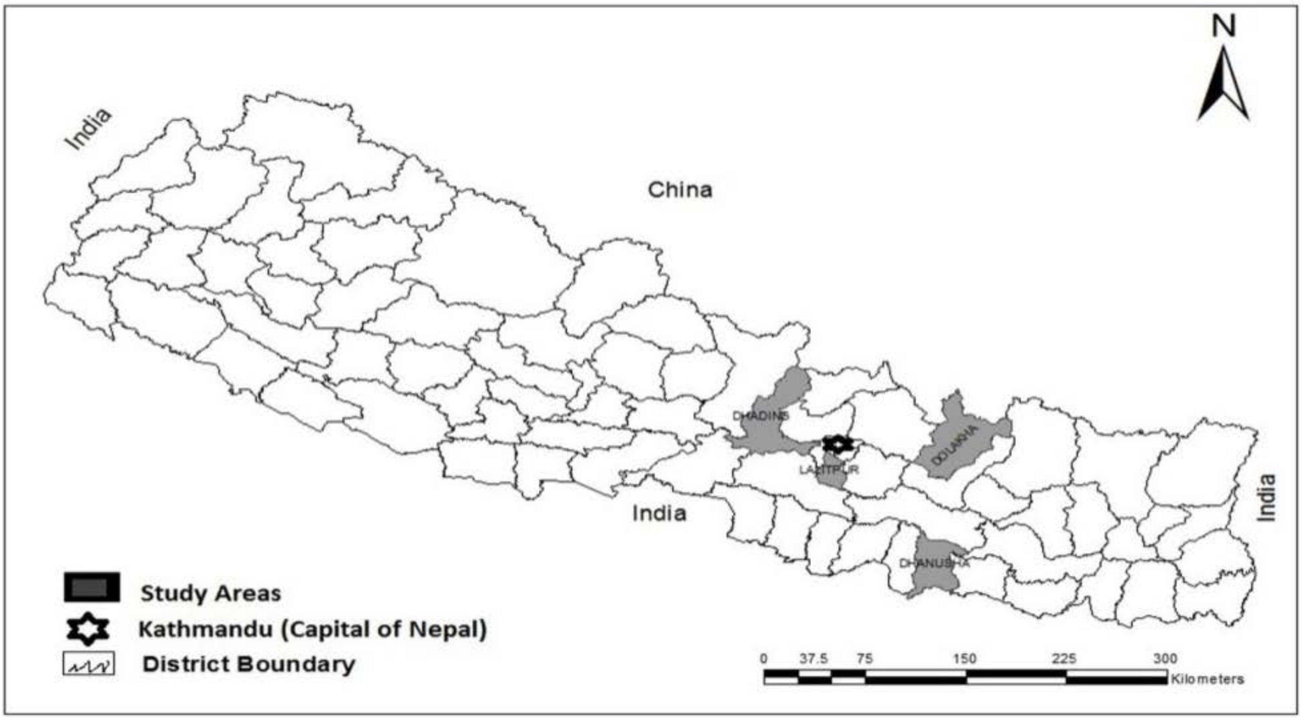

Figure 1. Map of Nepal showing study areas

Next, three villages from each district were randomly selected from the profile provided by respective District Agriculture Development Offices (DADO). The sample selected villages were: Dhalkebar, Bengadabar, and Digambarpur in Dhanusa; Jeevanpur, Benighat, and Dhusa in Dhading; Luvu, Jharuwarasi, and Devichor in Lalitpur; Boach, Bhimeshowar, and Kavre in Dolakha district. A random sampling design was adopted to select sample farms in the sampled villages among the farmers who cultivate vegetables not only for household consumption but also for sale.

Vegetable farming in Nepal is broadly classified into two seasons such as winter and summer. This study was conducted considering summer season vegetable farms, which represents about 50 % in vegetable production as our previous work [45] was for winter season vegetable farm that used non-parametric approach. The summer season is characterized by relatively sufficient rain water, irrigation facilities, and hot weather. In this study, the summer season vegetables were considered which were harvested during March to August such as bitter gourds, bottle gourds, pointed guards, pumpkin, cucumber, cowpea, tomato, and cabbage.

Data from 460 farms were collected during July and August, 2013. A farm record and recall technique were adopted to collect information related on cost share of agriculture inputs, quantity of outputs, farm gate prices, farm-specific characteristics and socio-economic variables.

2.2. Analytical Framework

Stochastic Frontier Analysis (SFA) is the popular parametric approach in applied production economics where error term is decomposed into random error and inefficiency due to the technical inefficiency in production process [3]. This approach is the most suitable for analyzing efficiency, particularly for farm level survey data that might have measurement error, missing variables, and weather effects [13]. This study therefore employed the stochastic frontier model proposed by [3] and extended by [7]. Based on the result of likelihood ratio (LR) test, we adopted stochastic frontier translog production function (STPF) (Equation 1) to estimate the productive efficiency of vegetable farms. A two stage approach was used; first step, estimate the technical inefficiency scores (1-technical efficiency) of each farms, and then second step, the technical inefficiency scores were regressed by various explanatory variables (Equation 3).

$$\ln(Y_i) = \beta_0 + \sum_{j=1}^{7}\beta_j lnX_{ij} + \frac{1}{2}\sum_{j=1}^{7}\sum_{k=1}^{7}\beta_{jk} lnX_{ij} lnX_{ik} + \varepsilon_i \quad (1)$$

$$i = 1.......n$$

$$\varepsilon_i = v_i - u_i \quad (2)$$

Where, Y_i is the vegetable output of the ith farm; X_{ij} is the inputs for ith farm; ln is natural logarithm; v_i is random variable assumed to be independently and identically distributed with $N(0, \sigma_v^2)$; u_i is a non-negative random variable that accounts for technical inefficiency in production assumed to be independently and identically distributed $N(0, \sigma_u^2)$ as truncations.

$$u_i = \delta_0 + \sum_{l=1}^{6}\delta_l Z_{il} + \omega_i \quad (3)$$

The explanatory variables represented by Z_{il} that may explain the technical inefficiency in vegetable farms; ω_i represents the truncated random variable; $\beta_0, \beta_j, \beta_{jk}, \delta_0,$ $and\ \delta_l$ are unknown parameters to be estimated.

The Maximum Likelihood Estimates (MLE) of the parameters was estimated using frontier version 4.1, developed by [14]. The technical efficiency of vegetable farms is the ratio of the observed output to the frontier output (Equation 4) that could be produced by a fully efficient farm in which the inefficiency effect is zero ($\gamma = 0$). The technical efficiency of farms exists between zeros to one, and is inversely related to the inefficiency effects [15].

$$TE_i = \frac{\exp(X_i)\beta + v_i - u_i}{\exp(X_i)\beta + v_i} = \exp(-U_i) \quad (4)$$

The variance parameters were estimated with sigma squared $(\sigma^2) = (\sigma_v^2 + \sigma_u^2)$ and gamma $(\gamma) = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$, following [8]. We hypothesized that vegetable farms were technically efficient ($\gamma = 0$) using LR test statistics (Equation 5).

$$\mathrm{LR} = -2[\ln\{\mathrm{likelihood}(\mathrm{H}_0)\} - \ln\{\mathrm{likelihood}(\mathrm{H}_0)\}]. \quad (5)$$

The LR test statistics have an approximately Chi-square distribution with the parameter equal to the number of parameters assumed to be zero in the null hypothesis (H_0), provided H_0 is true [7].

2.3. Data and Variables Specification

Vegetable production was considered as the function of land, labor, traction power, seed, organic matter, chemical fertilizer, and capital. The dependent variable, quantity of vegetable output (kg), was calculated by adding farm use as seed, household consumption, sales, and gift. All the input variables except land were estimated as expenditure in Rupees (NRs 86.93=1US$ as of 2012) and normalized divided by weighted average of respective inputs. The labor (family and hired), traction power (animal or and tractor) used for plowing vegetable farms, organic matter (compost and manure) used for plant nutrients either purchased or homemade (estimated in current market price), and chemical fertilizers used for plant nutrients. The capital was depreciated cost incurred for temporary bamboo-plastic tunnel, thatch, and simple equipment. The land was considered as the area covered by vegetable crops estimated in hectares.

The explanatory variables such as education of farm manager, number of trainings received by farm manager, credit access, market access, gender of farm manager, and women participation index were introduced to analyze the effects of these factors on the inefficiency of vegetable production. The farm manager was considered as a person in the farm household who was the main decision maker and responsible to manage vegetable farms. The years of education of farm manager believed to positively influence on the productive efficiency since educated farmers can grasp knowledge and adopt technology faster than non-educated one. We considered the number of academic years of education of farm manager to assess its effect on the inefficiency of vegetable production.

Farmer' training is one of the key extension activities to disseminate improved farming technologies to the farmers. The total number of trainings received by farm manager with regards to vegetable farming was considered to determine its impact on the efficiency of vegetable production. The vegetable farmers are embarrassed with limited financial resources, and charged higher interest rates by informal financial agents (moneylenders, relatives, and friends). About 72% of the farm households borrow credit from informal sectors despite the much higher interest rates up to 42%, while banks charges 8 to10% annually because of lack of formal financial institutions in the rural areas [20]. This situation limits the accessibility of required credit that reduces the use of inputs in vegetable farming [25], which adversely affects the outputs. Therefore, we co-opted credit access dummy considering 1 if the farmer availed credit and 0 otherwise.

The smallholder vegetable farmers are handicapped by market access, particularly in developing countries. In order to assess the effects of market access on the efficiency, we introduced market access dummy considering 1 if farmers were satisfied with accessed to markets and 0 otherwise.

Vegetable farming is labor-intensive, and women are typically the major sources of labor forces in vegetable production while they are less likely to have access to education, credit, market and extension supports that led vegetable farms to be inefficient. In recent years, it has been realized that without incorporating gender analysis, policy directions towards the productivity and efficiency in agriculture are unlikely to succeed [11]. Most of the previous researches used labor as an explanatory factor but these studies ignored to disaggregate labor force into men and women, such accounts makes faulty decision to be successful in agriculture. Therefore, gender perspective analysis in resource use efficiency is important frontage in sustainable agriculture development. To analyze the impact of women labor force on the productive efficiency in vegetable farming, two types of explanatory variables were introduced: first, gender of farm manager; and second, women participation index. The gender of farm manager was undertaken as a dummy variable considering 1 if the farm was managed by male and 0 otherwise. The women participation index was estimated considering five types of contributions in vegetable farming i. e. land preparation, vegetable plantation, crop management (irrigation, insect-pest management, fertilization, weeding), harvesting-marketing, and decision-making. Each of these contributions was indexed from one to five; less participation of women (one) and highest participation (five). Thus, the aggregated index ranges from 5 to 25.

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 average size of vegetable farms were very small (0.10 ha). The highest contribution of inputs was for labor cost, followed by capital, organic matter, and chemical fertilizer. For the farm-specific socio-economic explanatory variables, the mean of education of farm manager was 6 years and the farmers received less number of training in vegetable farming. About 31% farmer availed credit for vegetable farming and about 70% of the farmers accessed to markets. The majority of farms (75%) were managed by female farmers, and average women participation index 17 out of 25 indicated that there was a significant contribution of women labor force in vegetable farming.

Table 1. Descriptive statistics of variables used in this study

Variable	Mean	Standard deviation	Minimum	Maximum
Output (Kg, 00)	17.37	15.78	12.0	180.00
Land (Ha)	0.10	0.09	0.02	1.68
Labor cost (Rs, 00)[a]	63.11	24.34	12.50	168.75
Power cost (Rs, 00)	26.82	23.49	4.00	170.00
Seed cost (Rs, 00)	26.21	36.69	10.00	320.00
Organic matter (Rs, 00)	38.88	28.20	2.00	200.00
Fertilizer cost (Rs, 00)	27.05	21.85	2.00	125.00
Capital (Rs, 00)	54.37	35.69	4.00	250.00
Education of farm manager (Year)	6.24	3.88	0.00	16.00
Training of farm manager (No.)	1.59	1.96	0.00	9.00
Credit access (dummy)	0.31	0.46	0.00	1.00
Market access (dummy)	0.69	0.46	0.00	1.00
Gender of farm manager (dummy)	0.25	0.43	0.00	1.00
Women participation index (No.)	16.59	4.23	5.00	25.00

[a] Nepali currency (Rupees) Rs 86.93 = 1US$ as of 2012.

3.2. Estimation of Stochastic Translog Production Function

The variance parameters were found to be highly significant (Table 2). The coefficient of gamma (γ) was 0.54, revealed that more than half of the inefficiencies in vegetable farms were attributed by the technical inefficiency and rest of the inefficiencies because of random error accounted for climate, drought, and other natural calamities. The null hypothesis of technically efficient ($\gamma = 0$) was tested using the LR test. We rejected the null hypothesis at 10% level (LR statistics $2.791 > X^2_{(0.90,1)} = 2.706$), and confirmed that the inefficiency existed in vegetable farms.

Table 2. Estimation of variance parameters using stochastic translog production function

Variable	Coefficient	Standard error	
Sigma-squared (σ^2)	0.308	0.053	***
Gamma (γ)	0.543	0.153	***
Log likelihood	-283.286		
Likelihood Ratio (LR) test	2.791*		

***,**,* significant at 1, 5, and 10% levels, respectively.

The coefficients of input variables such as traction power and organic matter showed significant positive effects; while labor and seed had significant negative effects on vegetable outputs in using stochastic translog production function (Table 3). In the long-run, traction power (traction power square), seed (seed square), and capital (capital square) showed significant positive effects, implied that further increase of these inputs increases the outputs.

Table 3. Maximum likelihood estimates of stochastic translog production function

Variable	Coefficient	Standard error	
Constant	7.923	0.199	***
lnL[a]	0.232	0.270	
lnW	-0.333	0.254	*
lnP	0.288	0.158	**
lnS	-0.119	0.092	*
lnO	0.410	0.138	***
lnF	0.089	0.118	
lnC	-0.020	0.118	
lnL×lnW	-0.403	0.173	***
lnL×lnP	-0.016	0.099	
lnL×lnS	-0.126	0.065	**
lnL×lnO	0.240	0.109	**
lnL×lnF	0.011	0.081	
lnL×lnC	-0.298	0.079	***
1/2 (lnL×lnL)	0.033	0.092	
lnW×lnP	0.194	0.129	*
lnW×lnS	0.097	0.075	*
lnW×lnO	-0.107	0.135	
lnW×lnF	-0.047	0.105	
lnW×lnC	-0.102	0.112	
1/2 (lnW×lnW)	0.093	0.134	
lnP×lnS	0.001	0.043	
lnP×lnO	-0.051	0.087	
lnP×lnF	-0.058	0.065	
lnP×lnC	0.132	0.063	**
1/2 (lnP×lnP)	0.094	0.059	*
lnS×lnO	-0.031	0.052	
lnS×lnF	0.034	0.043	
lnS×lnC	0.047	0.042	
1/2 (lnS×lnS)	0.036	0.021	**
lnO×lnF	0.028	0.063	
lnO×lnC	-0.151	0.073	**
1/2 (lnO×lnO)	0.021	0.053	
lnF×*ln*C	0.002	0.051	
1/2 (lnF×lnF)	0.042	0.043	
1/2 (lnC×lnC)	0.153	0.041	***

***,**,* significant at 1, 5, and 10% levels, respectively. [a] Land = L; labor wage = W; traction power = P; seed = S; organic matter = O; chemical fertilizer = F; and capital = C.

In using the Ordinary Least Square (OLS) model, the estimated coefficients of parameters were significant for land, labor, traction power, organic matter, and capital (Table 4). The standardize coefficients for the parameters were found in decreasing order were capital, traction power, land, and labor, implied that these variables are the most effective factors to determine vegetable production.

Table 4. Ordinary least square estimates and beta value

Variable	OLS Coefficient		OLS Std. error	Standardized coefficient
lnConstant	7.821	***	0.081	
lnLand	0.282	***	0.056	0.240
lnLabor	0.231	***	0.069	0.126
lnTraction power	0.297	***	0.044	0.273
lnSeed	0.002		0.027	0.003
lnOrganic matter	0.099	***	0.046	0.085
lnChemical fertilizer	0.022		0.037	0.022
lnCapital	0.301	***	0.036	0.289

***,**,* significant at 1, 5, and 10% levels, respectively.

3.3. Factors Affecting Productive Efficiency in Vegetable Farms

In order to determine if there were underlining causes for the inefficiencies in vegetable production, various explanatory variables were regressed on the inefficiency scores of each vegetable farms. There are interesting empirical evidences on the relationship of explanatory variables and inefficiencies in vegetable farms. Results showed that all the explanatory variables except credit access were statistically significant with consistent signs (Table 5). Statistically significant negative effect of education of farm manager on the inefficiency indicated that higher levels of academic education of farmers help them to improve the productive efficiency in vegetable farms, which was consistent result of past studies [2,11,45]. Educated farmers are more proactive in adopting latest technologies, dynamic in nature, and updated information help to reduce cost per unit and eventually enhance the efficiency in vegetable production.

Table 5. Factors affecting productive inefficiency in vegetable farms

Variable	Coefficient	Standard error	
Inefficiency effect model			
Constant	0.314	0.019	***
Education of farm manager	-0.002	0.001	**
Training of farm manager	-0.004	0.002	**
Credit access	-0.004	0.009	
Market access	-0.022	0.009	***
Gender of farm manager	0.019	0.009	**
Women participation index	-0.002	0.001	*

***, **,* indicate significant at 1, 5, and 10 percent levels, respectively; values in parentheses is standard error.

The negative effect of training of farm manager on the inefficiency supported the hypothesis that larger number of training increases the levels of efficiencies in vegetable outputs. Our finding was consistent with the results of [10,17,36,46] that has important implications to make extension services more effective in the areas where extension system ispathetic.The extension and training programs disseminate technologies to improve farming practices by increasing the ability of farmers in decision-making process [4]. Farmers' field school of agriculture extension has been instrumental in developing technical competencies of farmers to improve their productive efficiency [23]. In addition, community integrated pest management (CIPM) program is the best approach for insect-pest management since CIPM minimizes the use of toxic chemical pesticides, improve the health of producers and consumers, and consequently contribute in socio-economic processes [5].

Market access was highly significant negative effects on inefficiency, implied that effective marketing facilities to farmers tend to improve the levels of the efficiencies in vegetable farming. In the developing countries, small-scale farmers are frequently constrained by weak market access because of lack of market infrastructure facilities and ineffective marketing regulations [28]. Adequate marketing infrastructures and farmer-friendly marketing regulations help farmers sell their products in more competitive condition that contribute in increasing income to the farmers. Cooperative marketing approach could increase the income of smallholder farmers by increasing the economics of scale and reducing the marketing margin [9,22,24,26]. Cooperatives and farmers' group as one of the major agricultural development approaches in Nepal, could play a potential role in inputs delivery and output marketing services. This study suggest policy in strengthening farmers' group and cooperatives in enhancing the efficiency in vegetable production.

The coefficient for gender of farm manager was statistically significant positive effect on inefficiency, which was consistent with the finding of [38,42,45,46] implied that women farm managers were more productive and efficient than that of male counterpart in vegetable farming. The coefficient of women participation index was significant negative effect on inefficiency, implied that increased the levels of women involvement in vegetable farming would improve the productive efficiency. The women participation index was found to be 17 of the total index 25 (Table 6), which was almost similar result with the finding of [18,19] where women labor shared 60 to 80% of the total labor forces in agriculture. Table 6 shows that the average index was higher in vegetable plantation followed by crop management, harvesting-marketing, land preparation, and decision-making activity. The composition of the index indicates that the women participation in decision-making activity was found to be the lowest level that could be one of the reasons to be reduced levels of efficiency in vegetable farms. Indeed, achieving sustainable rural economic development goal would be unsuccessful, unless women farmers are reached at the decision-making levels, and they are accessed to resources and opportunities.

Table 6. Women participation index in summer season vegetable farming

Variable	Average Index[a]	Rank
Land preparation	3.17	4
Vegetable plantation	3.64	1
Crop management	3.51	2
Harvesting and marketing	3.46	3
Decision-making	2.80	5
Total index	16.59	

[a]Index: 1 = minimum women participation, 5 = maximum women participation for each component in farms.

3.4. Technical Efficiency of Vegetable Farms

The technical efficiency of vegetable farms is presented in Figure 2. The average technical efficiency score was found to be 0.74 (ranged from 0.35 to 0.92) indicated that a wider ranges and greater extent of inefficiencies exists in vegetable farms. This score implied that substantial improvements (more than 25%) in vegetable production could be achieved by operating the farms at the frontier level without use of extra inputs. To reduce the levels of inefficiencies and achieve higher levels of efficiencies in vegetable production many of the farmers would have to adopt superior technologies.

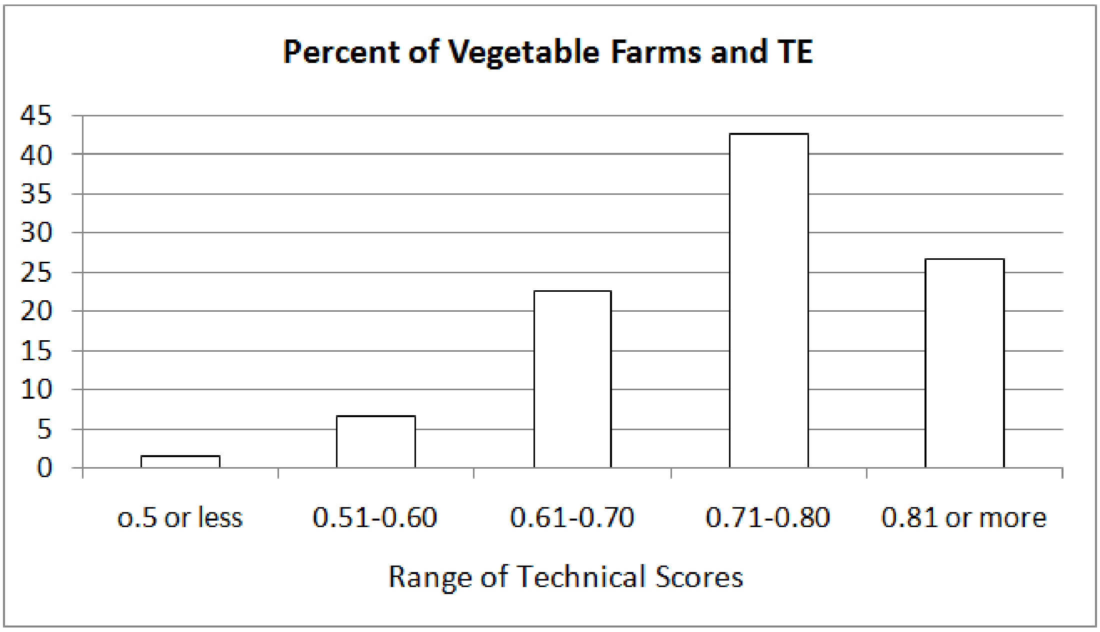

Figure 2. Technical efficiency scores in vegetable farms in summer season

The majority of the vegetable farms (92%) performed 0.61 to 0.90 efficiency scores. Limited vegetable farms (less than 1 %) performed efficiency score more than 0.91 and only 8 % showed efficiency scores less than 0.60. About 99% of the farms performed the efficiency scores below the highest level of benchmarking, implying that almost all the farms could improve efficiency levels and substantial increase outputs by learning the best inputs allocation decisions from the highest level of the efficient farms.

Nepalese agriculture is extremely heterogeneous because of its diverse geographical, agroecological and seasonal conditions. Diversities in agroecology and associated climate could be potential endowments for explaining vegetable output differential. The technical efficiency scores of vegetable farms in agroecological regions (Table 7) suggest that substantial potential increase in vegetable outputs could be achieved in all the regions given the existing technology and inputs costs. The mean of the technical efficiency scores in terai agroecological region was found to be higher than in hills and mountain. The condition if farmers operated the farms at the frontier level, they could have increased vegetable outputs in wider ranges: terai 9-43%; hill11-60%; and mountain region13-70%.

Table 7. Technical efficiency scores of vegetable farms by agroecological regions

Season	Mean	Std. dev.	Minimum	Maximum
Terai	0.75	0.084	0.57	0.91
Hill	0.74	0.089	0.40	0.89
Mountain	0.73	0.098	0.30	0.87
Mean	0.74			

Women's labor contribution is significant in agriculture, particularly in vegetable farming in developing countries [46]. While, rural women are less likely to have access to financial services, technology, education and markets that rendered them on up-scaling outputs and increasing net returns [47]. The mean of the technical efficiency score was higher for the farms which managed by women than that of men (Table 8), revealed that women farm managers were more productive and efficient. This result was consistent with previous study of [37,45,46], while contradictory with [33]. The levels of inefficiencies in vegetable farms would improve by encouraging and empowering women farmers providing them greater opportunities, access to resources and capacity building programmes. The women farmers therefore should be empowered to reach them at decision-making levels that enhance the levels of efficiencies in vegetable production and contribute to sustainable rural household income.

Table 8. Technical efficiency scores of vegetable farms by gender perspectives

Season	Mean	Std. Dev.	Minimum	Maximum
Female	0.75	0.0897	0.30	0.91
Male	0.73	0.0908	0.45	0.90

3.5. Output-losses in Vegetable Farms

The study showed surprisingly rigorous empirical evidence of inefficiency in Nepalese vegetable farms. Better understanding of the costs composition and different farm-specific and socio-economic factors with regards to vegetable farming are crucial for developing effective policies to enhance efficiency in vegetable production. The average technical efficiency, actual output, optimum output, and output-loss in vegetable farms are presented in Table 9. The optimum vegetable output is achieved by operating the farms at the frontier level, which was estimated by dividing the actual output by the technical efficiency scores of individual farms. The output-loss is the amount that have been lost due to the inefficiencies in vegetable production given prices and fixed factor endowments, which was calculated by multiplying the optimum outputs with the technical inefficiency scores.

The average output-loss was estimated about 24% because of the technical inefficiencies in vegetable farming that can be recovered by operating the farms at the frontier levels. The mean of outputs and efficiency levels were found to be higher in the vegetable farms where the level of education of farm manager was higher. The farm manager, who received large number of trainings, performed significantly higher levels of actual outputs, higher levels of technical efficiencies, while lower levels of output-loss. Those farmers, who availed credit in vegetable farming, showed higher levels of vegetable outputs than the farmers who did not availed. The farmers, who accessed to markets, performed higher levels of actual outputs and higher levels of efficiencies. Similarly, the vegetable farms managed by women, performed higher levels of outputs and higher levels of efficiencies as compared with the farms managed by the men managers. This situation suggests that women empowerment is crucial to enhance vegetable production efficiency and improve sustainable rural economy.

Table 9. Technical efficiency, actual output, optimum output, and output-loss in vegetable farms

Variable	TE[a]	Actual output (kg)	Optimum output (kg)	Output- loss (kg)	Output-loss (%)
Output-loss by education of farm manager					
Less educated (<6.24 years)[b]	0.74	1580	2078	498	23.97
More educated (≥6.24 years)	0.75	1907	2461	554	22.51
Output-loss by training of farm manager					
Less number (<1.59 times)c	0.74	1688	2202	514	23.34
Large number (≥1.59 times)	0.75	1807	2348	540	23.00
Output-loss by credit access					
Credit not availed	0.74	1690	2205	515	23.36
Credit availed	0.74	1844	2392	547	22.87
Output-loss by market access					
Market not access	0.72	1649	2176	527	24.22
Market access	0.75	1776	2300	523	22.74
Output-loss by gender of farm manager					
Female manager	0.75	1780	2314	534	23.08
Male manager	0.73	1607	2104	498	23.67
Average output-loss (%)				23.24	

[a] TE = Technical efficiency, [b] Mean of education levels of farm manager is 6.24 years; less than mean is regarded as less educated and equal or more than mean is more educated. [c] Mean of number of trainings = 1.59; less than mean is regarded as less number of training and equal or more than mean is large number of training.

4. Conclusions and Policy Implications

The vegetable farming is one of the important sources of household income for rural farmers in developing countries. This study evaluates the technical efficiency of summer season vegetable farms using stochastic translog production function with the data obtained from household survey during July to August, 2013. The technical efficiency in vegetable farms was found to be higher in terai and hills than in mountain region. A wider range and greater extent of inefficiencies existed in the vegetable farms, which could be recovered with existing technologies by operating the farms at the best farming practices.

The input variables such as labor, traction power, seed, and organic matter determined the levels of vegetable outputs. In addition to the policies suggested by [29,31], the policymakers should focus on making labor force more productive and efficient by providing them adequate trainings and extension services, increasing productivity of traction power (animal and tractor for plowing), and encouraging farmers to use improved seeds and use of organic manures in vegetable farming. The productive efficiency in vegetable farms would improve with increased levels of education to farmers, larger number of farmers' trainings, and farmers' access to agriculture markets. The trainings and extension programmes should incorporate vegetable farm management, appropriate allocation of inputs, market management, integrated pest management, and cross-cutting issues of vegetable production with income, poverty, gender, and economic development. Pluralistic extension approach consisting of government sector, non-governmental organizations, and private sectors could be the best extension strategy to provide effective training and extension services to the rural vegetable farmers.

Market access to farmers increases the efficiency by improving backward and forward linkages of vegetable production and establishing vegetable markets nearby production areas. Strong government support is required to allocate adequate resources, and endorse farmer-friendly rules and regulations to be sure that farmer's access to markets. Market infrastructures development requires more resources; thereby, a strategic cooperation and alignment with private sectors, farmers' group, cooperatives, and funding agencies is imperative. Farmers' cooperatives marketing approach would increase the economics of scale and reduce the cost per unit that increases income of the farmers.

The gender related explanatory variables (women farm manager and women participation index) are asserted to be important factors explaining efficiency in vegetable farming. Policies should encourage and empower women farmers in vegetable farming with composite incentive package consisting of education programmes, training and extension services, agriculture credit programmes, and market facilities. Such policies would certainly enhance the efficiency levels in vegetable production that increase the farmers' income and eventually improve the rural economy.

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