



Women's Labor Contribution on the Efficiency of Smallholder Vegetable Farms: Evidence from Mountain Region of Nepal

Rudra Bahadur Shrestha¹; Wen-Chi Huang^{2*} & Upasana Pradhan³

¹Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, 1, Shuefu Road, Neipu, Pingtung 91201, Taiwan.

Email: shrestha_rud1998@yahoo.com, Phone: +886-988849070, Fax: +886-8-7740446.

²Department of Agribusiness Management, National Pingtung University of Science and Technology, 1, Shuefu Road, Neipu, Pingtung 91201, Taiwan.

Phone: +886-8-7703202-7824, Fax: +886-8-7740190

* **Corresponding Author's e-mail:** wenchi@mail.npust.edu.tw

³International Finance Corporation, The World Bank Group, Kathmandu, Nepal.

Phone: +977-1-4226792- 6103, Email: upradhan013@gmail.com

Abstract

Enhancing the efficiency in vegetable farms helps farmers to increase their income and improve livelihoods. Vegetable farming is labor-intensive and the role of women is dominating in vegetable production and food systems in the developing countries. However, there is an enduring debatable issue on women labor contribution and their discrimination in relation to efficiency. This paper analyses the contribution of women labor on the efficiency of smallholder vegetable farms in mountain region of Nepal adopting the output oriented data envelopment analysis (DEA) model using survey data collected during July-August, 2013. Results revealed that there is great extent of inefficiencies in vegetable farms that can be improved through gender perspective vegetable farming practices, and by operating the farms at the frontier level. We recommend policies to encourage and to empower women farmers in vegetable farming with integrated incentive packages consisting of education, agriculture extension and training, market access, and women focused programs that enhance the efficiency levels in vegetable production.

Keywords:

Vegetable Farm; Efficiency; Women Labor; DEA; Mountain Nepal

JEL classification: D2, J7, Q1.

Introduction

The Millennium Development Goal (MDG 3) of the United Nations promote gender equality and empower women has target to eliminate gender disparity. Poverty and hunger are intertwined challenges and enduring issues for women, poor and small-scale farmers in the developing countries. The poverty incidence is more pronounced in the South Asia where average poverty incidence head count ratio (HCR) is 23.1 % in 2012. Particularly, Nepal is more vulnerable in poverty incidence (HCR) estimated at 25.5 %; the mountain region 43.3 %, hill 24.3 % and terai (tropical plain area) 23.4 %, and those who depends on agriculture estimated at 47.3 % in 2012 (SAARC, 2014).

Rural women play a positive role in reducing poverty and achieving food security by generating income through agriculture farming (UN, ITC and IFAD, 2012). Rahman (2010) and ILO (2008) argued that there is considerable contribution of women labor to

enhance productivity and efficiency in agriculture. Women contribution in agriculture exists between 60 and 80 % in developing countries, and the South Asian countries hovering at 63% (FAO, 2011, 2013). In Nepalese context, an average share of women labor force in agriculture estimated at 63 % versus 27% men, and in terms of working hours, 10.8 hours/day women versus 7.5 hours/day men (FAO, 2000). Furthermore, women are responsible to carry out most of household works, which are not accounted in household economy. While one of the common questions is whether they are as efficient as men, is a hotly debated issue. Meanwhile, women are facing several gender discriminating problems in agriculture and rural economic activities that affects them to be inefficient and less productive. Gender discrimination exists on accessed to energy, technology, education and health service that effects to decreases women's productivity (Warth and Koparanova, 2012). Heath (2014) argued that less bargaining power of women face increased risk of domestic violence, and low rates of land ownership that obstruct them access to financial assets. According to Alkire et al. (2013), women can be empowered by giving them opportunities in controlling resources and involve them in decision making process. Thus, gender-perspective planning would empower women and enhance efficiency in vegetable production. To this end, an appropriate labor division system among women and men on the basis of their labor productivity in each farming activity would gain higher levels of efficiencies in vegetable production.

Vegetable can offer good opportunities for poverty reduction because it generates huge number of employment opportunities and increases income (Weinberger and Lumpkin, 2007). Tiwari et al. (2008) reported

that rural farmers improved their income, and reduced poverty by vegetable farming. Furthermore, vegetable is the most important sustainable source of food and nutrition security for billions of people in the world (AVRDC, 2010). The government policies in Nepal (MOAD, 2004; MOAD, 2014; NPC, 2014) aimed to reduce poverty and ensure food and nutrition security by promoting agriculture, and the vegetable crops are in priority. As the vegetable farming is comparative advantage in terms of domestic labor-resource endowment, there is higher potentiality to increase vegetable outputs. In 2012, Nepal produced 3.3 million tonnes in 0.25 million hectares of land (MOAD, 2013).

Most of the Nepalese farmers (more than 80 %) are smallholders (less than 2 ha), and they are frequently constrained with resources such as quality of seeds, inadequate fertilizers, less access to markets, and low levels of education (Shrestha, Huang and Pradhan, 2014). The relationship between variable inputs, women participation, and productive efficiency infer policies that substantial increase in vegetable production. In this milieu, we conducted this study to assess the contribution of women labor force on the efficiency of vegetable production and infer policies to increase vegetable outputs that would contribute to increase income, reduce poverty, and improve livelihood of smallholder farmers.

Materials and Methods

Study area

We selected Dolakha district (Figure 1) in the central development region (one among five regions), which is on the top rank in terms of vegetable production among the districts in mountain region in Nepal. The study area is characterized by higher altitude ranges 2000m-2600m, cold weather, and steep

land type, lack of irrigation, poor road network and poor market infrastructure facilities and weak access of extension services. Three Village Development Committees (grass root level of geopolitical administrative organization in Nepal) such as Boach, Bhimeshowar, and Kavre were randomly selected among the major vegetable producing areas in the district. Next, using the profile of District Agriculture Development Offices (DADO), we randomly selected sample vegetable farms among the farmers who grow vegetables for household consumption and for sale of surplus quantities. A survey data on production costs, quantity of outputs, farm gate price and farm-specific information were collected from 90 farms during July and August, 2013.



Figure 1. Map of Nepal showing study area

Vegetable farming system is broadly classified into two seasons in Nepal: winter and summer. We considered winter season vegetables, which are harvested during September to February, because most of the farmers cultivate vegetables in this season. The major vegetable crops considered in this study were cauliflower, tomato, cabbage, radish, bean and cowpea.

Theoretical and empirical insights

We employed non-parametric approach, which is deterministic mathematical linear programming as developed by Farrell (1957) that attributes all the deviations from the frontier technology to the inefficiency. It does not require any specific functional forms and does not impose priori parametric restrictions on the underlying technology. Furthermore, this approach can be used to estimate technical and scale efficiency. The efficiency is the ratio of weighted outputs to weighted inputs given the condition that the similar ratios for every decision making unit (DMU) are less than or equal to unity (Cooper et al., 2011). The technical efficiency (TE) refers to the ability of a farm to either produce the optimum level of outputs from a given bundle of inputs and a given technology, or to produce the given level of outputs from the minimum quantity of inputs for a given technology.

We used the output-oriented DEA model (Ali and Seiford, 1993) for a single output to estimate technical and scale efficiency of small scale vegetable farms. Decision making units (DMUs), n producing single output by using different inputs, m . The i th DMU uses x_{ki} units of the k th input in the production of y_i units of output. A separate linear programming (LP) problem can be solved for each DMU. Based on the nature of data and returns to scale in the vegetable farms, the output-oriented DEA model with variable returns to scale (VRS) assumption for the i th DMU was developed (Equation 1), which is the objective function of linear programming model.

$$\begin{aligned} \max \quad & \phi_i \\ & \phi_i \lambda_i \\ \text{Subject to:} \end{aligned} \quad (1)$$



$$\sum_{j=1}^n \lambda_j y_j - \phi_i y_i - s = 0$$

$$\sum_{j=1}^n \lambda_j x_{kj} + e_k = x_{ki} \quad k$$

$$= 1, \dots, m \text{ inputs;}$$

$$\sum_{j=1}^n \lambda_j = 1$$

$$= 1, \dots, n \text{ DMUs;}$$

$$\lambda_j \geq 0; s \geq 0; e_k \geq 0$$

$$TE_i = \frac{y_i}{\hat{y}_i} = \frac{1}{\phi_i} \quad (3)$$

The technical efficiency score of the i th DMU in the CRS ($TE_{i,CRS}$) is less than or equal to that in the VRS ($TE_{i,VRS}$) because VRS is more flexible and envelops the data in a tighter way than the CRS frontier. The scale efficiency, SE_i , is defined as the ratio of technical efficiency from CRS to the technical efficiency from VRS DEA assumption (Equation 4) of the i th DMU, (Favero and Papi, 1995; Bjurek et al., 1990).

$$SE_i = \frac{TE_{i,CRS}}{TE_{i,VRS}} \quad (4)$$

Where, ϕ_i is the proportional increase in output for the i th DMU; s is the output slack; e_k is the k th input slack; and λ_j is the weight of j th DMU. The output-oriented constant returns to scale (CRS) model is obtained by eliminating the constraint $\sum_{j=1}^n \lambda_j = 1$ in equation (1).

The single output-oriented DEA model seeks to maximize the proportional increase in output within the production possibility set when output slack, s , becomes zero. If the value of ϕ in equation (1) is 1, $\lambda_i = 1$, and $\lambda_j = 0$ for $j \neq i$, the i th DMU lies on the frontier and is efficient. For the inefficient units, if $\phi > 1$, $\lambda_i = 0$, and $\lambda_j \neq 0$ for $j \neq i$. The frontier production level for the i th DMU is denoted by \hat{y}_i (Equation 2).

$$\hat{y}_i = \sum_{j=1}^n \lambda_j y_j = \phi_i y_i \quad (2)$$

The output-oriented technical efficiency of the i th DMU, denoted by TE_i , can be computed by Equation (3), which is consistent with the technical efficiency can be obtained under the stochastic production frontier.

Where, $SE_i = 1$ indicates the scale efficiency and $SE_i < 1$ indicates the scale inefficiency of the i th DMU. The scale inefficiency exists due to either increasing or decreasing returns to scale, which can be determined by the sum of weights, $\sum_{j=1}^n \lambda_j$, under the CRS assumption (Banker, 1984). If $\sum_{j=1}^n \lambda_j = 1$, shows the constant returns to scale (optimal scale), if $\sum_{j=1}^n \lambda_j < 1$, indicates the increasing returns to scale (sub-optimal scale), and if $\sum_{j=1}^n \lambda_j > 1$ that indicates decreasing returns to scale (super-optimal scale) (Førsund and Hærnæs, 1994).

Tobit analysis

We adopted a two-limit Tobit model (Equation 5) to determine the effects of explanatory variables on the efficiencies in vegetable farms (Maddala, 1985) using the maximum likelihood approach (Tobin, 1958).

$$EE_i^* = \beta_0 + \sum_{m=1}^M \beta_m W_{im} + \varepsilon_i, \quad \varepsilon_i \sim ind(0, \sigma^2)$$

$$EE_i = 1 \text{ if } EE_i^* \geq 1$$

$$EE_i = EE_i^* \text{ if } 0 \leq EE_i^* \leq 1$$

$$EE_i = 0 \text{ if } EE_i^* \leq 0$$

Where, EE_i^* is a latent variable represents the efficiency index for the i th farm that expressed in terms of the observed variable EE_i (efficiency score estimated from DEA); β_0 and β_m are unknown parameters to be estimated; W_{im} are explanatory variables associated with vegetable farms; and ε_i is an error term that is independently and normally distributed with zero mean and constant variance $(0, \sigma^2)$.

Usually cross-section data is suffered with heteroskedasticity problem (Hill, Griffiths, Lim, 2011); thus we tested heteroskedasticity with White's test in the data set. The estimated value was found to be less than critical value [$56.20 < \chi^2_{(0.99,35)} = 57.342$], and confirmed that there is no heteroskedasticity problem in the data set.

Data and variables specification

We disintegrated inputs into seven categories such as land, labor, traction power, seed, organic matter, chemical fertilizer and other variable costs. The dependent variable was quantity of vegetable output (Kg), and independent variables were: land (hectare), labor and traction power (man-days), organic matter (kg), seed, fertilizer, and other input costs estimated in Rupees (Rs 86.96 = 1USD) on the basis of prices paid by farmers. In the analysis of VRS DEA, we used the data set both in quantity and value; so the land rent was estimated assuming of 20% of vegetable value, labor (Rs), traction power (Rs), organic matter (Rs), seed (kg), and fertilizer (kg).

(5) Rural women farmers are discriminated and less likely than men to have access to technology, education, financial services and markets (Spielloch, 2011). Such discrimination limits the economic growth and diminishes the effectiveness of poverty reduction programs and policies (Bozoğlu & Ceyhan, 2007). The production efficiency is depends on the allocation of resources across farm plots, which is affected by intra household decision-making processes. In this study, we introduced gender of household head as a dummy variable (who makes decision in vegetable farming), considered 1 if the household head was a male and 0 otherwise.

Most of the studies use gender of household head as an explanatory variable, which is inadequate to represent the contribution pattern of women and men under gender perspective in each vegetable farming activity. For instance, although the household head is male, most of the farming activities have done by women and vice versa; thus that lead misleading in policy formulation. Therefore, two types of explanatory variables were regressed on the technical efficiency (TE from VRS DEA) of vegetable farms. The first, we introduced major activities where women have been involving in vegetable farming such as women participation in land preparation, women participation in vegetable plantation, women participation in crop management (irrigation, insect-pest management, fertilization and weeding), women participation in harvesting and marketing, and women participation in decision-making. Each of these five components were indexed from one (minimal participation of women) to five (the highest participation) in each DMU in our Tobit regression model. The second, socio-economic variables such as years of education of farm manager, number of training received



by farm manager, and distance of farms from markets were introduced in the regression model to determine the effects of these variables on the technical efficiency.

Descriptive statistics of variables

The descriptive statistics of the variables used in this study (Table 1), showed that the average farm size is quite small (0.118 ha), and the mean of vegetable output was more than 2 tonnes per farm. The composition of costs share was higher in other variable cost, seed cost, chemical fertilizer cost, and traction power cost. The mean of quantity of organic matter was 274 kg per farm, and the

number of labors used in the farm was found to be 24 per farm. A majority of farms (57%) were managed by female farmers, and women participation index in all the farming activities such as land preparation, vegetable plantation, crop management, harvesting and marketing, and decision making found to be more than 68% in each index. The composition of indexes indicates that on average, there was considerable level of women involvement in each vegetable farming activity. In the study area, the average education level was found to be 6 years, number of trainings 3, and the distance of farm to market was 20 kilometers.

Table 1: Descriptive statistics of variables used in this study

Variables	Units	Mean	Std. dev.	Min.	Max.
Output	Kg/farm	2044.40	1110.23	1000	8000
Land	Ha/farm	.12	.07	.025	.36
Labor	Man-days/farm	24.04	12.09	10	67
Power cost	Rs./farm	2130.56	1033.96	1000	5000
Seed cost	Rs./farm	2421.67	1278.98	1000	6000
Organic matter	Kg/farm	274.14	137.41	102	746
Chemical fertilizer cost	Rs./farm	2223.33	1173.51	1000	5000
Other variable cost	Rs./farm	4276.22	1321.98	1600	7500
Gender of farm manager	Dummy	0.43	0.49	0	1
Land preparation	Number	3.44	1.02	1	5
Planting vegetable	Number	3.50	.77	1	5
Crop management	Number	3.79	.99	1	5
Harvesting and marketing	Number	3.70	1.12	1	5
Decision making	Number	3.38	1.29	1	5
Education levels of manager	Year	5.57	3.23	0	13
Training of manager	Number	2.71	2.81	0	10
Distance of farms to market	Km	19.47	8.66	7	38

Ordinary least square estimation

All the variables for the exception for land and traction power were found to be significant in determining vegetable outputs using ordinary least square estimates (OLS) (Table 2). The output elasticities of parameters were higher and positive for

labor, other variable cost, organic matter, and seed, and negative for chemical fertilizer. The sum of elasticities was found to be 0.69, which was less than unity, indicated that there was decreasing returns to scale in vegetable farming that led us to use variable returns to scale (VRS) approach. We also



tested standardized coefficients of the parameters to identify the major effective factors that effect on vegetable outputs; the coefficients showed that the inputs like labor,

organic matter, seed, other variable input costs, and chemical fertilizer had greater effect on vegetable outputs (Table 2).

Table 2. Ordinary least square estimation in vegetable farms

Variables	Coefficient	Std. error	Beta value	Rank
Constant	3.523***	1.616	-	-
lnLand	-0.056	0.116	-0.092	6
lnLabor	0.340**	0.167	0.403	1
lnTraction power	-0.057	0.110	-0.068	7
lnSeed	0.186***	0.077	0.232	3
lnOrganic matter	0.205**	0.103	0.242	2
lnChemical fertilizer	-0.134*	0.085	-0.157	5
lnOther variable input	0.207**	0.112	0.172	4
Sum of elasticity	0.691	-	-	-

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

Technical and scale efficiency in vegetable farms

The efficiency scores distribution in vegetable farms assuming CRS and VRS approach using the DEAP 2.1 program (Coelli, 1996) is presented in Table 3. Efficiency scores showed that there was higher extent of inefficiency in vegetable farms that can be recovered using existing technology operating the vegetable farms at the optimum level. Inefficient farmers could substantial increase their vegetable output by adopting improved technologies.

The technical efficiency score was higher under VRS as compared to CRS assumption, and consistent with the previous findings of Dhungana et al. (2004), and Murthy et al. (2009). The mean of the technical efficiency was found to be 0.65 under CRS DEA assumption, which is far below the frontier efficiency level, indicates that there is a higher levels of inefficiencies in vegetable farms, implied that vegetable farms could increase 35% of outputs using the same cost levels. Twenty one % of the

farms exhibited the technical efficiency scores more than 0.81; few farms (15 %) showed efficiency score between 0.51 to 0.80, and 25 % farms had efficiency scores less than 0.50. The average technical efficiency score under VRS assumption was found to be 0.77; more than 50% farms exhibited efficiency score more than 0.81, about 30 % farm showed efficiency score between 0.51 to 0.80, and less number of farms (18 %) performed efficiency score less than 0.50.

The mean of scale efficiency was found to be 0.86; majority of the farms (71%) exhibited efficiency scores more than 0.81, about 26% farms showed efficiency scores between 0.51 to 0.80, and very less farms (2 %) had efficiency scores less than 0.50. The efficiency indexes indicated that there is wider scope of increasing efficiency in vegetable production by improving the technical efficiency, while very limited scope by changing the scale of operation of the farms.

Table 3. Technical and scale efficiency in vegetable farms

Efficiency score	Technical efficiency (CRS)		Technical efficiency (VRS)		Scale efficiency	
	No. of farms	%	No. of farms	%	No. of farms	%
≤ 0.40	14	16	8	9	0	0
0.41-0.50	11	12	8	9	2	2
0.51-0.60	12	13	13	14	3	3
0.61-0.70	17	19	9	10	9	10
0.71-0.80	16	18	5	6	12	13
0.81-0.90	6	7	3	3	20	22
> 0.91	14	16	44	49	44	49
Mean efficiency	0.65	-	0.77	-	0.86	-
Standard error	0.207	-	0.24	-	0.136	-

Women and socio-economic factors affecting the efficiency in vegetable production

The explanatory variables were regressed on the technical efficiency scores of each DMUs under VRS approach to determine if there is underlying effects of factors related on women labor and socio-economic variables on vegetable production efficiency (Table 4). The null hypothesis of technically efficient in vegetable farms was strongly rejected with the LR statistics ($102.48_{(0.99,9)} > 18.548$), confirmed that there was inefficiency existed in vegetable farming.

All the variables, except for women labor in land preparation and vegetable plantation were found to be significantly determining the levels of efficiencies in vegetable production. The gender of household head was statistically significant negative effect on the efficiency, implied that women farmers were more efficient and productive than that of male counterpart, and was consistent result of Udry et al. (1995), and Shrestha et al. (2014b). The wealthier households headed by women and those with a larger share of assets appeared to be positive significant effect on efficiency

(Fletschner, 2008). FAO (2009) reported that investment in empowering rural women is not only for moral imperative but also to be a promising strategy in fighting against poverty and hunger. Thus, encouraging and empowering women farmers in vegetable farming would improve overall socio-economic condition in the rural community.

The coefficient of women participation in crop management was significant positive effect on the efficiency, implied that women involvement in crop management activities in vegetable farming, particularly on irrigation system management, insect-pest management, fertilizer application, and weed control management was more efficient and productive than that of male farmers. Crop management is a huge component in whole vegetable farming that required broader knowledge and skills. The capacity building of women farmers by providing trainings programs on irrigation management, integrated pest management (IPM), composting, fertilizer application methods, weed management, and effects of chemical used on human health would help to improve the efficiency levels in vegetable farming, and eventually contribute to safe health of

producers and consumers. Recently, farmers' field school programs on integrated pest management (IPM) have been instrumental to build farmers' competencies in crop management practices (Joshi & Karki, 2010).

The coefficient of women participation in harvesting and marketing was statistically significant positive, implied that the contribution of women labor on harvesting and marketing activities would enhance the efficiency in vegetable production. FFTC (2015) reported that the largest portion of vegetable losses during post-harvest and marketing stages estimated at 20-50% of the total outputs in developing countries. The main causes could be poor infrastructure, lack of marketing facilities, poor handling and transportation, and loading

and unloading. Shrestha et al. (2014a) argued that vegetable farmers are greatly affected to be hurt and discouraged because of negative price shock at the market hubs. The policies on empowering women farmers through training programs in harvesting and marketing activities would reduce marketing losses and increase farmers' income.

The positive coefficient of women participation in decision-making indicates that the involvement of women in decision-making process significantly contribute in increasing vegetable production efficiency. Therefore, empowerment of women to reach them up to decision-making position is crucial not only to increase vegetable production but also to improve socio-economic condition of rural communities.

Table 4. Women and socio-economic factors affecting the technical efficiency (VCR) in vegetable farms

Variables	Coefficient	Std. error	Standardized coefficient	Rank
Constant	.467 ***	.126	-	-
Gender of household head	-.107 ***	.045	-.217	2
Women labor in land preparation	-.008	.018	-.033	9
Women labor in vegetable plantation	-.021	.024	-.065	8
Women labor in crop management	.029**	.017	.121	5
Women labor in harvesting- marketing	.042***	.016	.193	4
Women labor in decision-making	.045***	.015	.245	1
Education level of farm manager	.008**	.005	.105	7
Training received by farm manager	.018***	.006	.204	3
Distance of farm to market	-.003*	.002	-.115	6
Sigma	.136	.010	-	-
Log likelihood	49.714	-	-	-
LR statistics	102.48	-	-	-

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

The coefficient of education of farm manager was estimated to be significantly position effects on the technical efficiency, implied that higher levels of education facilities

improve the efficiency in vegetable production. Wu (1977) reported that medium levels of education (six years of schooling) significantly contributed in agriculture production where



production is typically carried out by small family farms in Taiwan. The author found that there was strong effect of education of worker on allocative and scale efficiency. The women's education has strong contribution in agriculture production, while women are discriminated to access education and technical supports (Trauger et al., 2008). Further, education and experience are substitutes and play a significant role in the level of efficiency (Stefanou and Saxena, 1988). Education is found to have higher payoff to productivity in a modernizing environment than in traditional agriculture (Pudasaini, 1983).

The number of trainings received by farm manager had positive significant effects on the efficiency of vegetable production. The previous results of some studies (for example, Bhatta et al., 2008; Enwerem and Ohajianya, 2013) also got similar results. Farmers' training and extension programmes help to disseminate technologies on improved crop management practices that increase the productivity and efficiency of vegetable farms. Such training programs should include farmer's field school on integrated pest management, cultivation and management practices, cost-benefit analysis, harvesting and marketing, and cross-cutting issues of vegetable productions with health hazard, income and nutrition security.

The small scale vegetable farmers are handicapped by market access because of unavailability of markets nearby the production areas. The distance of farm to markets was statistically significant and negative effects on the technical efficiency, implied that longer the distance lower the efficiency levels in vegetable production. The vegetable farms, closer to the markets would have greater opportunities to sell their products in the markets in competitive price. The market infrastructures consist of vegetable collection centers, cooperative markets, wholesale or retail markets need to be established nearby vegetable production areas. In addition, the construction of rural road networks links the production areas to the markets. But such infrastructures developments are more costly and require more resources. Thus, strong government support is crucial to allocate resources with strategic cooperation among possible donors and cooperatives.

The standardized coefficients of explanatory variables (Table 4) showed that the elasticities in decreasing order were higher in women participation in decision-making, followed by gender of farm manager, training received by farm manager, women participation in harvesting and marketing, women participation in crop management, distance of farm to markets, and education levels of farm manager. These are the most effective components in decreasing order to increase vegetable outputs and enhance the efficiency in vegetable production.

Conclusions and policy implications

This study estimated the efficiencies (technical and scale) for vegetable farms and assessed the contribution of women related socio-economic factors on the efficiency of vegetable production. We adopted output oriented DEA model using survey data collected from vegetable farmers during July-August 2013 in mountain region of Nepal. Considering seven input variables in the DEA model, the mean of the technical efficiency was found to be 0.65, indicates that large extents of inefficiencies exist in smallholders vegetable farms that can be improved by operating the vegetable farms at the frontier levels. The scale efficiency was 0.86, indicates that there was limited opportunities to increase additional vegetable outputs by rescaling the size of farms.

Based on the results of Tobit model, some important policy suggestions can be derived to improve the efficiency in vegetable production. Being a women as a household head play an paramount role in vegetable farming, and thus the policies should be derived to promote women empowerment by providing training, strengthening women farmer's groups, targeted programs to women, and different women focused programs. The education and training programs and market access to the vegetable farmers are the major components to enhance vegetable production efficiency. The training programs to the women farmers should include improved technologies on plantation techniques, IPM and farmer's field schools, crop management practices, harvesting and marketing practices, and cross-cutting issues of gender and



development. Women can be empowered by the synergetic efforts of education, gender-sensitive planning and development programs, and encourage women to be involved in vegetable farming.

Finally, we recommend policies on empowering women farmers with adequate incentive packages in vegetable farming that would certainly increase household income, reduce poverty, and eventually improve rural livelihoods. Future research need to be focused in the areas that represent hills and terai to analyze the effects of women labor and related socio-economic factors on the efficiency in vegetable production.

References

- [1.] Ali, A. I., and Seiford, L. M. (1993). *The Mathematical Programming Approach to Efficiency*. Oxford University Press.
- [2.] Alkire, S., Peterman, A., Quisumbing, A., and Seymour, G. (2013). The women's empowerment in agriculture index. *World Development*, 52, 71–91.
- [3.] AVRDC. (2010). *Prosperity for the poor and health for all: Strategic plan 2011-2025*. AVRDC-The World Vegetable Center, Taiwan.
- [4.] Banker, R. D., Charnes, A., and Cooper, W. W. (1984). Models for the estimation of technical and scale inefficiencies in DEA. *Management Science*, 30, 1078–1092.
- [5.] Bhatta, K. P., Ishida, A., Taniguchi, K., and Sharma, R. (2008). Whose Extension Matters? Role of Governmental and Non-Governmental Agricultural Extension on the Technical Efficiency of Rural Nepalese Farms. *Journal of South Asian Development*, 3(2), 269-295.
- [6.] Bjurek, H., Hjalmarsson, L., and Førsund, F.R. (1990). Deterministic parametric and nonparametric estimation in service production. *Journal of Econometrics*, 46, 213–227.
- [7.] Bozoğlu, M., and Ceyhan, V. (2007). Measuring the technical efficiency and exploring the inefficiency determinants of vegetable farms in Samsun province, Turkey. *Agricultural Systems*, 94(3), 649-656.
- [8.] Coelli, T. (1996). *A guide to DEAP version 2.1: A Data Envelopment Analysis (Computer Program)*. Department of Econometrics, University of New England, Armidale, Australia.
- [9.] Cooper, W. W., Seiford, L. M., and Editors, J. Z. (2011). *Handbook on Data Envelopment Analysis: Second edition*. Springer. New York, Dordrecht Heidelberg London.
- [10.] Dhungana, B. R., Nuthal, P. L. I., and Nartea, G. V. (2004). Measuring the economic inefficiency of Nepalese rice farms using data envelopment analysis. *Australian Journal of Agricultural Resource Economic*, 48(2), 347-369.
- [11.] Enwerem, V.A., and Ohajianya, D. O. (2013). Farm size and technical efficiency of rice farmers in Imo state, Nigeria. *Greener Journal of Agricultural Sciences*, 3:128-136.
- [12.] FAO. (2000). *Gender and Integrated Pest Management (IPM) in Nepal*. The FAO Program for Community IPM in Asia, Food and Agriculture Organization.
- [13.] FAO. (2009). *Women and Rural Employment: A Policy Brief*. Food and Agriculture Organization of the United Nations.
- [14.] FAO. (2011). *The Role of Women in Agriculture. ESA working paper No. 11-02*. Food and Agriculture Organization, Rome, Itali.



- [15.] FAO. (2013). *FAO Statistical Year Book*. Food and Agriculture Organization of the United Nations, Rome.
- [16.] Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, 120(3), 253-290.
- [17.] Favero, C. A., and Papi, L. (1995). Technical efficiency and scale efficacy in the Italian banking sector: A non-parametric approach. *Applied Economics*, 27, 385–395.
- [18.] FFTC. (2015). *Postharvest Losses of Fruit and Vegetables in Asia*. Food and Fertilizer Technology Center, Asia and Pacific Region.
- [19.] Fletschner, D. (2008). Women's access to credit: Does it matter for household efficiency? *American Journal of Agricultural Economics*, 90(3), 669-683.
- [20.] Førsund, F. R., and Hernaes, E. (1994). *A Comparative Analysis of Ferry Transport in Norway*. In A. Charnes, applications. Kluwer Academic Publishers.
- [21.] Joshi, N. N., and Karki, R. (2010). *Small-Scale Commercial Vegetable Production to Promote Livelihood and Food Security in the Rural Hills of Nepal*. Rural Reconstruction Nepal.
- [22.] Heath, R. (2014). Women's access to labor market opportunities, control of household resources, and domestic violence: evidence from Bangladesh. *World Development*, 57, 32-46.
- [23.] Hill, R. C., Griffiths, W. E., and Lim, G. C. (2011). *Principle of Econometrics (6th Eds)*. John Wiley and Son, United States of America.
- [24.] ILO. (2008). *Promotion of Rural Employment for Poverty Reduction*. International Labor Organization, International Labour Office, Geneva.
- [25.] Maddala, G. S. (1985). *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, United Kingdom.
- [26.] MOAD. (2004). *National Agriculture Policy*. Ministry of Agricultural Development, Government of Nepal.
- [27.] MOAD. (2013). *Statistical Information on Nepalese Agriculture*. Ministry of Agricultural Development, Government of Nepal.
- [28.] MOAD. (2014). *Agriculture Development Strategy*. Ministry of Agricultural Development, Government of Nepal.
- [29.] Murthy, D. S., Sudha, M., Hegde, M. R., and Dakshinamoorthy, V. (2009). Technical efficiency and its determinants in tomato production in Karnataka, India: Data envelopment analysis (DEA) approach. *Agricultural Economics Research Review*, 22, 215-224.
- [30.] NPC. (2014). *Thirteenth Interim Development Plan 2014-2016*. National Planning Commission, Government of Nepal.
- [31.] Pudasaini, S. P. (1983). The effects of education in agriculture: evidence from Nepal. *American Journal of Agricultural Economics*, 65(3): 509-515.
- [32.] Rahman, S. (2010). Women's labour contribution to productivity and efficiency in agriculture: Empirical evidence from



- Bangladesh. *Journal of Agricultural Economics*, 61(2), 318–342.
- [33.] SAARC. (2014). *Best Practices in Poverty Alleviation and SDGs in South Asia: A Compendium SAARC*. SAARC Secretariat, Kathmandu, Nepal.
- [34.] Shrestha, R. B., Huang, Wen-Chi, and Ghimire, R. (2014a). Market price cointegration of tomato: effects to Nepalese farmers. *International Journal of Food and Agricultural Economics*, 2(2), 87-96.
- [35.] Shrestha, R. B., Huang, Wen-Chi, and Ghimire, R. (2014b). Production efficiency of smallholder vegetable farms in Ilam district, eastern Hill, Nepal. *American-Eurasian Journal of Agriculture and Environmental Science*, 14 (2), 150-154.
- [36.] Shrestha, R. B., Huang, Wen-Chi, and Pradhan, U. (2014). Resource use efficiency in vegetable production in the high hills of eastern Nepal. *Nepalese Journal of Agricultural Economics*, 2(1), 65-72.
- [37.] Spieldoch, A. (2011). *Key Role of Rural Women in Achieving Food Security*. Paper presented at the European Forum on Rural Development, Palencia, Spain.
- [38.] Tiwari, K. R., Nyborg, I. L. P., Sitaula, B. K., and Paudel, G. S. (2008). Analysis of the sustainability of upland farming systems in the middle mountains region of Nepal. *International Journal of Agricultural Sustainability*, 6(4), 289-306.
- [39.] Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica*, 26(1), 24-36.
- [40.] Trauger, A., Sachs, C., Barbercheck, M., Kiernan, N. E., Brasier, K., and Findeis, J. (2008). Agricultural education: gender identity and knowledge exchange. *Journal of Rural Studies*, 24:432–439.
- [41.] Stefanou, S. E., and Saxena, S. (1988). Education, experience, and allocative efficiency: a dual approach. *American Journal of Agricultural Economics*.
- [42.] Warth, L., and Koparanova, M. (2012). *Empowering Women for Sustainable Development, Discussion Paper Series*. United Nations Economic Commission For Europe Geneva, Switzerland.
- [43.] Weinberger, K., and Lumpkin, T. (2007). Diversification into horticulture and poverty reduction: a research agenda. *World Development*, 35(8), 1464–1480.
- [44.] Wu, C. C. (1977). Education in farm production: the case of Taiwan. *American Journal of Agricultural Economics*.
- [45.] Udry, C., Hoddinott, J., and Alderman, H. (1995). Gender differentials in farm productivity: implications for household efficiency and agricultural policy. *Food Policy*, 20(5), 407-423.
- [46.] UN, ITC and IFAD (2012). *Rural Women and the Millennium Development Goals*. United Nations, International Training Center, International Fund for Agricultural Development.