Comparing technical efficiency of organic and conventional coffee farms in Nepal using data envelopment analysis (DEA) approach.

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Abstract

Data Envelopment Analysis (DEA) approach was used to estimate technical efficiency and followed by regressing the technical efficiency scores to farm specific characters under tobit regression model. Primary data was collected from random samples of 240 (120 from each) coffee famers. Mean technical efficiency score was 0.89 and 0.83 in organic and conventional coffee farming respectively. Farms operating under constant return to scale (CRS), decreasing return to scale (DRS) and increasing return to scale (IRS) were 31.67, 3.83 and 37.5% respectively in organic coffee and 29.17, 25 and 45.83% respectively in conventional farming areas. These scale technology defines a production set that is closed and convex with property of strong disposability. Tobit regression showed the variation in technical efficiency was related education, farm experience and training/extension services and access to credit. Farmers would reconsider the rationing of input and learn from technically efficient farms practices. Policy implication will rest on production planning strategy.

Key words: Production frontier; Resource use; Technical efficiency; Organic; Altitude

Introduction

Growing awareness of health and environmental issue in agriculture has demanded production of organic food which is emerging as an attractive source of rural income generation (Bhattacharya and Chakraworty, 2005). The organic movement began in the 1930s and 1940s as a campaign to minimize the overwhelmingly growing reliance on synthetic fertilizers. Organic farming is a form of agriculture that relies on sustainable production system maintaining feasible crop rotation, green manure and farm-yard manure with paying greater attention towards biological pest control so that soil properties keep improving. Increased interest in environmental issues has sparked a significant movement in favor of organic or ecological farming. This is

because organic farming involves several environmentally friendly growing methods and also responds more effectively to consumers' growing interest in food safety. Despite the uncertainty of financial viability, there has been expanding organic enterprises worldwide. Lotter (2003) estimated that USA and European Union has annual growth rate of 20% and 25% respectively. This market expansion makes it possible for farmers to reap the benefits of a trade with relatively high price premium (Yussefi and Willer, 2002). In term of output, leaving some exceptions, organic crops have lower than conventional (Morris et al. 2001). However it is contradicts with the finding in Indian experiments (Bhattacharya and Chakraworty, 2005) that the productivity of organic farming may be less in initial years, but the yield increases progressively under organic farming equating the yield under inorganic farming by sixth years. As with any other agricultural products, development of organic system requires considerations of its economic viability. It mainly depends on products price. Adoption of organic farming methods often depends on favorable market price (price expectation) for products (Pacini et al. 2002; Morris et al. 2001).

More than 65 % of the populace are engaged in agriculture in Nepal (MOAC, 2010). Peasants have average land holding of less than 1.0 ha. (CBS, 2007). Nepal has a great potential to produce organic coffee as it has been producing organic by default. Both types of coffee are grown with shade crops of multipurpose tree species. In terms of area and production, coffee has tiny presence in the world coffee arena. However, organic coffee has been getting niche markets since decade. This gradually accelerated the extension of farming in the rural areas of Nepal. Small fraction of production zone is certified as organic. Farmers are affiliated either to small groups or cooperatives and have vertical linkage to district level cooperative. This is the fundamental success in producing coffee. It could be an important means for the soil

conservation; bio-diversity maintenance and watershed balance in the mid-hills of Nepal (Nepal, 2006). Farmers have been producing coffee without external inputs even in nonorganic belts. Organic coffee has been exporting overseas market niches such as Japan and South Korea; 30 mt. each year since 2005 and other coffee in USA, Germany and other EU member countries (TEPC, 2009). Coffee industry is in rudimentary stage and still unable to yield extra economic leverage and excess production. However, it has been a livelihood support for many rural and marginal people in mid-hill region. NTCDB (2009) estimated that coffee production engages around 15,000 farm families. The productivity of coffee is very low and farmers are unable to identify the causes and its resolution measures. Because of poor investment capacity, they are not involved in complete value addition which could provide additional farm income. Despite these hurdles, the expansion of total coffee cultivation area, production and productivity has been increased by 17, 24.36 and 6.5% respectively. The growth rate of area, production and productivity of organic coffee were 15.75, 16.48 and 0.62% respectively (MOAC, 2009). The slow growth rate of productivity of organic coffee in the backdrop of higher demand in the international markets was appealing for analyzing the production management from farm to fork in complete package. This research was designed accordingly and this part explains about production aspects only.

Technical Efficiency and Input Optimization

In the past, the role of agriculture in economic development has been recognized by many authors (Johnston and Mellor, 1961; Hayami and Ruttan, 1985). In this regard, the adoption of new technology has received more attention in developing countries. However, agricultural growth is not only determined by the level of technology but also by the level of efficiency that is associated with the utilization of given technology. The potential contribution of efficiency to

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the overall output growth has yielded a number of past studies on production efficiency (Bravo-Ureta and Pinheiro, 1993). Several hypotheses were tested to analyze the low production efficiency in developing countries. One of the celebrated hypotheses proposed by Schultz (1964) says that the poor farmers in developing countries are efficient under the given socio-economic circumstances. This hypothesis had a strong influence in shaping the agricultural development policy in developing countries. Policy makers overlooked the inexpensive way of increasing agricultural production through increasing efficiency and focused only on the expensive option such as investment on new technology. The poor but efficient hypothesis assumes that the external conditions are steady and farmers are in a continuous equilibrium. In reality, farmers find themselves in disequilibrium because of continuously generated new technology and variation in input and output prices (Ali and Chaudhari, 1990). Thus, against Schultz's hypothesis, many past studies proposed that farmers in developing countries failed to exploit the existing technology no matter whether it's traditional or modern. For example, the study by Ali and Flinn (1989) concluded that the profit of rice farmers in Pakistan's Punjab could be increased by 28% through enhancing efficiency in the existing state of technology. Similarly, many other studies carried out in developing countries found similar results (Jamison and Moock, 1984; Squires and Tabor, 1991; Tadessea and Krishnamurthy, 1997; Dhungana et al, 2004; Idiong, 2007; Rahman, 2010). Thus, the technological advancement may not bring the expected impact if inefficiency is pervasive in farming business.
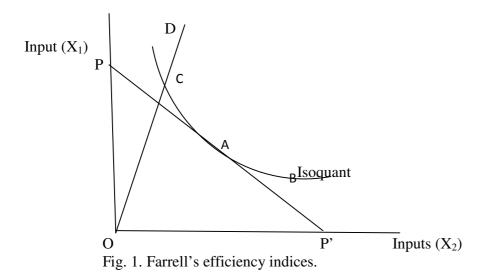
Past studies have explained the difference in technical efficiency mainly by socio-economic characteristics of farm households. Infrastructure, soil fertility, experience, extension service, tenancy and share of non-agricultural income were the main factors to affect the efficiency of rice farms in Bangladesh, (Rahman, 2010). Similarly, Brazdik (2006) found a rapid land

fragmentation as the important factor affecting the technical efficiency of rice farms in West Java, Indonesia during the Green Revolution. The behavior of production entity can be described either by production function, cost function, profit function, or demand and supply functions. A producer always tries to either maximize profit or minimize cost. There are different alternative economic theories of peasant household behavior, which assume that peasant households maximize one or more household objectives (Mendola, 2007). In this study, we analyze the behavior of producer in terms of production function.

Technical efficiency have positive role in enhancing economies of scale. Agricultural farms are very heterogeneous in developing countries. Very few are commercialized but many are still subsistence. Due to imperfect information in the subsistence farming, the informal institutional arrangements have high efficiency costs (De Janvry et al, 1991). In commercial farming, due to competition in the market, farmers' decisions tend to be more effective to utilize the given technology to its maximum extent. Thus, production decisions tend to be based on the local informal institutions. Such a system lacks competitive environment and increases inefficiency in production.

The concept of a production frontier is consistent with the "standard" representation of technology; specifically, a production function. Deviations from a production frontier can be interpreted as a measure of inefficiency from a technical perspective. If the output of the firm lies below the frontier, it is regarded as inefficient. The degree to which a firm is "off" the production frontier is an indication of technical efficiency. According to Färe et al. (1985: pp. 3-4) a producer is said to be technically efficient if production occurs on the boundary of the producer's production possibilities set, and technically inefficient if production occurs on the interior of the production possibilities set. Alternatively, a firm is technically efficient if an increase in any

output requires a reduction in at least one other output or an increase in at least one input (Koopmans, 1951). The concept of economic efficiency provides a theoretical foundation for the measurement of producer's performance (Colman and Young, 19950). The concept basically starts from the seminal work of Farrell (1957), who argued that the efficiency could only be meaningfully be gauged in a relative sense, as a deviation from the best practice of a representative peer group of producers. Farrell distinguishes between technical and allocative efficiency. In technical efficiency maximum output is obtained from the given set of inputs whereas in allocative efficiency, for the given input prices, factors are used in proportions to maximize profit. Figure 1 explains about the efficiency concept.

Fig. 1. Farrell's efficiency indices.

The diagram shows the efficient unit isoquant for four farms (A, B, C and D). Farms located on this isoquant use the least amount of these inputs to produce a unit of output. Here A, B and C could be termed as efficient and D does not. Measure of technical efficiency for farm D is given by OC/OD that is farm D could reduce both inputs by a proportion OC/OD and still produce the same level of output. Given isocost line PP', the farm A deserves greatest economic efficiency as

it lies on the tangential point between isocost line and isoquant. Farrell (1957) proposes that overall economic efficiency measure can be decomposed as follows.

Economic Efficiency = Technical Efficiency x Allocative efficiency

From the definition above, farm A would be economically efficient, farms B and C would be technically efficient but not allocative efficient, and farm would be neither technically nor allocative efficient. It should be clear from above that TE does consider for maximum output that is physical attributes of production process. It can be universal goal. However, in practical farm management, the profit maximization is utmost. The economic efficiency is expected. The profit maximizing level of farm is derived as follows.

The farm wishes to maximize profit (π), given the production function (Y= f(X), price of the input (Px), price of output (Py) and fixed cost (FC), the problem becomes,

Maximize π = Py.Y- Px X-FC

Subject to Y = f(X).

The optimal solution can be derived by applying first order derivative,

$$\frac{\partial \pi}{\partial X} = P \frac{\partial Y}{\partial X} - Px = 0$$

$$P \frac{\partial Y}{\partial X} = Px$$

Which is equivalent with Value Marginal Product (VMP) should equal with Marginal Input Cost (MIC) approach in maximizing input demand.

Government of Nepal envisages accelerated agricultural growth through cash crops such as coffee (APP, 1995). Cultivation of shade coffee, Arabica variety with marketable intercrops is way of farming in the region. Shade crops are multipurpose tree species ensuring additional farm

income. Intercropping is the growing of two or more crops simultaneously on the same parcel of land with distinct row arrangement (Ruthenberg, 1980). It has been associated with advantage such as better utilization of environmental factors, greater yield, soil protection and socio-economic betterment (Beets, 1982). The way to increase productivity in small scale farming system is to use available set of resources efficiently. The production process has momentous impact from variable inputs like seeds, fertilizers, capitals, labor employed and other managerial skills. Production economics is related to optimization and optimization implies efficiency. Bravo-Ureta and Rieger (1991) explained that efficiency measurement is important because it leads to a substantial resource savings. Efficiency measures can be estimated using nonparametric and parametric approaches (Varian, 1984). Data envelopment analysis (DEA) is a nonparametric method. The nonparametric approach does not impose any parametric restrictions on technology and there is no need of a functional form for production relationships which is thus considered more flexible to calculate efficiencies (Fare et al., 1985; Chavas and Aliber, 1993; Featherstone et al., 1997 and Ray, 2004). But is enriched with two disadvantage: it does not allow direct hypothesis testing (Ray, 2004) and derived measures of inefficiency are confounded with the effects of noise, measurement errors, and exogenous shocks beyond the control of production entity ((Färe et al., and Ray, 2004).

Study area, sampling and data collection

Gulmi and Palpa districts were chosen purposively in the western mid-hill region of Nepal. Gulmi is the only group certified organic Arabica coffee producing location which maintains its production above 800 meter from sea level. Since 1998, NASAA accredited certification in group approach is following the strict measures for organic farming with articulate internal control system. Palpa is adjoining district producing same variety of coffee with more or less

equal farm altitude without organic certification. Both types of coffee production are shade coffee. The basic difference is holding organic certificate and farm management practices. In Gulmi, completely organic in input supply. Framers in Palpa use both organic and inorganic sources of inputs such fertilizer and plant protection measures. Albeit, the chemical fertilizers and other external inputs usage is gradually reduced. Most of the elite farmers called it as conversion period. The data was collected in 2011 from interviews with 120 randomly selected coffee farming households selected from 454 households in five Village Development Committee (VDC) of Palpa district. The selected VDCs were Barangdi, Satyawati, Madanpokhara, Jamire and Bhairabsthan. An equal sample of 24 from each VDC was chosen randomly after complete enumeration of coffee growers in Palpa. VDCs selection was purposive in Gulmi because to ensure the vicinity to Palpa and matching social and ecological resemblances. Five VDCs were covered in generating primary data from sample of 120. Sample sizes were 34, 18, 18, 28 and 22 in Apchaur, Arkhale, Balithum, Deegam and Huga VDCs of Gulmi district.

Primary data were obtained through face-face interview with administering the pre-tested semi-structured questionnaires. Besides, Participatory Rural Appraisal (PRA) tools such as Focus Group Discussion (FGD), Key Informant Survey (KIS) and ranking were deployed for assessing information and observing general understanding. These selected VDCs are pre-dominantly coffee producing and have a similar topography, soil type and irrigation environment. The data was for the 2009 normal coffee growing year. The surveyed areas ranged between 800 to 1410 m above sea level in Gulmi and 800 to 1050 m in Palpa district. Sampling elements were owner operated, has similar livelihood objectives and face a similar socio-economic and marketing environment for factors and products. Both types of coffee production in the area ascribes to cash

generating and environmental conservation means in gentle to moderate slope and mostly north-facing landscape adjoining to natural forest owned as community forestry program. Farmers are abided to either of the farmers group or local cooperatives and district coffee producers' association (DCPA) in Gulmi and Palpa districts respectively.

Analytical Framework

This study used two step methodologies, first, data envelopment analysis (DEA) to model technical efficiency in variable inputs management and second, the farm specific variables such as age, family size, education, training and gender for assessing variation in farm inefficiency under tobit regression frame work. To our knowledge there are no studies that have estimated technical efficiency comparison between organic and non-organic coffee production in Nepal. The objective of this study was to estimate the technical efficiency of both types of farming and evaluating the factors affecting farm inefficiency of each farming category of coffee in rural region of Nepal.

An absolute efficiency position of farms is seldom known. This is why we have to measure the efficiency of farm on peers. There are two main competing methods available for estimating the relative efficiency of farms: parametric and non-parametric. Well defined functional relationship between inputs and outputs, large sample size and sophisticated statistical tools are assumed under parametric approach. In contrast, non-parametric approach builds a linear piecewise function from empirical observation on inputs and outputs without assuming nay priori functional relationship. The DEA efficiency index (value ranges from 0 to 100) are grouped in inefficient (other than index value 100) and efficient as binary censored to apply tobit regression which yields relationship to produce effects on farm level efficiency.

Data Envelopment Analysis (DEA)

The general agreement towards sustainable economic development is promoting productivity and output growth in the agricultural sector, particularly among small-scale producers. To achieve productivity growth, either technological innovation or the better efficient use of available technologies or combination both is inevitable. Empirical evidence suggests that small farms are desirable not only because they reduce unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Pinheiro, 1993, 1997). During the last few decades, major technological gains stemming from the green revolution have been effective across the developing world. This suggests that attention to productivity gains arising from a more efficient use of existing technology is justified (Bravo-Ureta and Pinheiro, 1993, 1997; Squires and Tabor, 1991). In developing countries, most new agricultural technologies have only been partially successful (Xu and Jeffrey, 1998). It will be more cost effective to motivate farmers in improving efficiency rather than grafting new technology if farmers are not efficiently using existing technology (Shapiro 1983, Belbase and Grabowski, 1985). It would work well in case of Nepalese resource poor and marginalized farm characteristics. Because, Government of Nepal has been incapable in improving productivity growth despite her long implementing periodic plan and program. This sort of study will carry pertinent messages to moderate and rethink towards formulating long term production planning of high value cash crop.

The evaluation of farm performance is usually based on economic efficiency. The primary understanding is technical efficiency which allows understanding for efficient allocation of available scarce resources which has been procured within the defined farm budget ceiling. TE defined as the ability of a farm to either produce the maximum possible output from a given set

of inputs and a given technology, or to yield the given level of output from the possible minimum quantum of inputs. Fare and Lovell (1978) defined technical efficiency as the "degree to which the actual output of production unit approaches its maximum". Seminal paper of Farrell (1957) has been a growing interest in methodologies and applications to efficiency measurement. Banker et al (1984) and Fare et al. (1985, 1994) have proposed the input oriented DEA approach to illustrate TE via linear programming (LP) method. LP used in Data Envelopment Analysis (DEA) constructs a non-parametric piece-wise frontier over the data (Coelli et al. 2005). Technical Efficiency (TE) measures are then calculated relative to this surface. Farrell (1957) proposed this piece-wise-linear convex hull approach to frontier estimation. This paper used DEA in constant return to scale (CRS) model. Assuming that, the farm is entitled with N inputs and M outputs. Inputs and output vectors of i^{-th} firm then becomes N*I input matrix of X and M*I output matrix of Q. Ratio of all output to overall inputs is expected under DEA approach via assigning optimal weights by solving mathematical programming problem. We followed Coelli et al. (2005) in formulating solving equation.

Max u,v{$u'q_i/v'x_i$}, u= M*I vectors of output weights and v= N*I vectors of inputs weights.

Subject to u'$q_j/v'x_j \leq 1$, j= 1, 2, 3…I

$$u,v \geq 0. \hspace{4cm} (1)$$

Equation developed in 1 involves solving for u and v, such that the efficiency measures for the i-th firm is maximized subject to the constraints that efficiency value be less than or equal to 1. To overcome the problem of infinite number of solution from this specific ratio formulation, impose the constraints, $v'x_i$=1, then

Max μ,v{ $\mu'q_i$}

Subject to v' x_i = 1

$$\mu'q_j - v'x_j \leq 0, \quad j = 1, 2, 3 \tag{2}$$

$$\mu, v \geq 0 \tag{3}$$

The problem formulated in (3) is known as the multiplier form. Finally the derivation of an equivalent envelopment by introducing the duality in linear programming is:

$$Min_{\theta\lambda} \ \theta$$

Subject to $-q_i + Q\lambda \geq 0,$

$$\theta X_i - X \geq 0,$$

$$Q\lambda \geq 0 \tag{4}$$

Where λ is a I*1 vector of constant, θ is a scalar and efficiency scores for the i-th firm which satisfies: $\theta \leq 1$. Here θ is independent of input prices.

Charnes et al. (1984) and Fare et al. (1994) used this input oriented DEA model under CRS assumption to solve the overall technical efficiency.

$$\begin{matrix} min\theta \\ \theta\lambda \end{matrix} \ s.t \ xj \ \theta - \sum_{j=1}^{M} xj \ \lambda j \geq 0; \ \sum_{j=1}^{N} qj - qj \geq 0; \lambda j \geq 0 \tag{5}$$

$$for \ \forall j \ (denotes \ all \ j), \theta \ unconstrained$$

If $\theta = 1$, the farm in on the frontier and technically efficient

If $\theta < 1$, the farm lies below the frontier and technically inefficient.

Farm specific factors responsible for technical inefficiency were measured through the second stage regression model. This sort of analysis was found in Dhungana (2010), Dhungana (2004), Wadud and White (200), Sharma et al. (1999), Hallam and Machado (1996), Parikh and Shah (1995) and Kalirajan (1991). Early methodologies were based on deterministic models that attribute all deviations from the maximum production to efficiency; recent advances have made it possible to separately account for factors beyond and within the control of firms such that only

the latter will cause inefficiency. The popular approach to measure the technical efficiency component is the use of frontier production function (Tzouvelekas et al., 2001, Wadud and White, 2000, Sharma et al., 1999, Battese and Coelli (1995), Aigner et al. (1977). The present study employs the empirical model,

$$\boldsymbol{TE} = \beta_0 + \sum_{n=1}^{N} \beta_n Z_n$$

$$TE^* = \beta_0 + \beta_1 Z_{1j} + \beta_2 Z_{2j} + \beta_3 Z_{3j} + \beta_4 Z_{4j} + \beta_5 Z_{5j} + \beta_6 Z_{6j} + ui \tag{6}$$

$$TE = \begin{cases} TE^* & if\ TE^* < 100 \\ 100 & otherwise \end{cases}$$

Where TE is efficiency index (between 0 and 100) from DEA were used as binary dependent variable, Z1= household size, Z2= education, Z3= sex, Z4= training/extension, Z5= age, and Z6 = farm experience, β is a vector of unknown parameter associated with the farm specific covariates, and u_i is an independently and identically distributed normal random variables with zero means and common variances, σ^2 as;

$$u_i \sim \text{iidN}(0, \sigma^2).$$

To the immediate moving, it is noted that the dependent variable in the regression equation (6) cannot have normal distribution. It has a censored distribution (as TE lies between 0 and 100). Because OLS yields inconsistence estimates, we follow maximum likelihood approach to estimate the parameters of tobit regression model (6).

Results and discussions

Notations and definitions of variables incorporated to research study are illustrated in table 1. Inputs and outputs, and socio-demographic parameters were considered for empirical analysis. A summary descriptive statistics of agro-economic characteristics of the organic coffee

production and conventional farms/farmers are depicted in table 2. The first section of table describes about farm economic characteristics and lower section about socio-demographic information. Plant density and coffee output was recorded higher in conventional along with higher labor consumption. The fertilizer cost is about three times higher in organic coffee farm. This eventually led the higher TVC to organic than conventional and thereby lower GM and non-discounted benefit ratio (Table 2). It is found difficult to calculate the organic farm gate price within country. We generally understand that there is low cost for organic production compare to conventional one. The restriction on the use of chemical fertilizers, pesticides and feed concentrates on organic farm results on reduction of cost of production (Morris et al. 2001). In 21 European countries, Madder et al. (2002) found that fertilizer and energy were 34 to 53 % lower and pesticide 97% lower on organic than conventional farm. This seems comparatively cheaper production of organic products. However, Morris et al. (2001) opined that reduction in machinery depreciation with reduced fertilizers and spray application on organic farms may be offset by additional use of mechanical weed control and tillage operation. Farmers are avoiding chemical inputs but taking organic equivalents would ultimately yield more or less same cost for production. A recent study by Greer et al. (2008) on comparing the financial performance of organic and conventional farms in New Zealand also concluded that there are no significant differences in the economic outcomes of the management system.

Table 1. Variable definition and measurement.

Variables	Unit	Definitions
Farm size (X_{1j})	Ropani*/farm	Area of the organic coffee plot wherein input-output data was collected for farm j
Labor(X_{2j})	Mandays/farm	Total labor employed for coffee production for farm j
Fertilizer(X_{3j})**	Rs/farm†	Cost incurred for organic fertilizer in coffee production for farm j
Capital(X_{4j})	Rs/farm	Farm operating small equipment and irrigation devices etc used during coffee production for farm j
Output(Y_{1j})	Kg/farm	Quantity of green bean produced for farm j
Inter/shade crops(Y_{2j})#	Rs/farm	Market value of intercrops and shade crops' in coffee farm for farm j
Coffee tree(X_{7j})	Number/farm	Total number of healthy coffee tree for farm j
Household size(Z_{1j})	No. of person	Number of individual in a family for farm j
Education(Z_{2j})	1,0	1 if farm manger is educated, 0 otherwise for farm j
Sex(Z_{3j})	1,0	1 if the coffee farm manager is male, 0 otherwise for farm j
Training/Extension(Z_{4j})	1,0	1 if the coffee farm manager received training/extension services, 0 otherwise for farm j
Age(Z_{5j})	Year	Age of farm manager♣ for farm j
Farm experience (Z_{6j})	Year	Years of coffee cultivating experiences for farm j
Access to farm credit(Z_{7j})	1,0	1 if farmer access to farm loan, 0 otherwise for farm j
Group/Coop. member(Z_{8j})	1,0	1 if farmer is participated in group or producers cooperative, 0 otherwise for farm j
Labor cost (X_{5j})	Rs/person-day	Cost incurred for using labor in production management for farm j
Plant protection(X_{6j})	Rs/farm	Cost incurred for using botanical and some other low hazardous pesticides for farm j

*One Ropani= 511.14291 m^2 and is a local unit for measuring area. **Farm Yard Manure (FYM), Green manure and Compost. #Production of annual short cycled vegetable crops/permanent perennial multipurpose tree species with relatively wider canopy. ♣Age of person who is responsible for managing the household/coffee business is called the farm manager. †As variables X3, X4, X5 and Y2 are expressed in value terms and measured in local currency unit. Rs, Rupees, a Nepalese currency and Rs1 = $US (1/74) in May 2011.

Table 2. Farm characteristics of organic and conventional coffee farms in Nepal.

Factors	Organic (n=120)		Conventional (n=120)	
	Mean	SD	Mean	SD
Coffee planted area (Rop.)	3.15[**]	5.01	3.76[**]	2.12
Coffee tree (No/Farm)	141.17	205	159.03	91.20
Coffee output (Kg/Farm)	54.22[*]	83.21	88.70[*]	43.36
Labor Cost (Rs/Farm)	2444.17	2189.27	2580.00	1471.50
Fertilizer (Rs/Farm)	4738.42[*]	8264.72	1605.79[*]	741.69
Crop Protection(Rs/Farm)	287.85[*]	492.26	1229.35[*]	627.92
Marketing(Rs/Farm)	327.96[*]	487.25	2039.57[*]	1001.74
Total variable cost(Rs/Farm)[++]	8086.25	11147.66	7973.65	3156.46
Gross revenue(Rs/Farm)[♣]	12205.38[*]	16843.41	17498.96[*]	8918.29
Gross margin (Rs/Farm)[†]	4119.13[*]	10912.45	9525.31[*]	7171.77
Benefit-cost (Rs/Farm)[††]	1.71[*]	0.80	2.25[*]	0.69
Farm Manager's Age (Rs/Farm)	44.32	8.94	45.70	10.07
Farm experience (Years)	11.92	3.24	11.74	2.60
Family size (Number)	4.70	1.35	4.53	1.32
Education of farm manager (Literate. %)	92.50		88.33	
Training/extension service (Receiver %)	79.16		55.00	
Access to agri. credit	83.33		45	
Group/Coop. member (Member %)	100		60.83	

*and ** indicates means are significantly different in paired t-test at 5% and 10% test level respectively. [++]Total outlays of fund for all productive variable factors of production ($TVC = \sum_{i=1}^{N} P_{xi}X_i$). [♣]Aggregation of income from the sales of farm outputs ($GR = \sum_{i=1}^{N} R_{xi}Y_i$). [†]Difference of GR and TVC excluding fixed cost ($GM = GR - GM$). [††]Non-discounted ratio of GR to TVC ($B/C\ ratio = GR/TVC$

Source: Field survey 2011.

Table 3 shows the descriptive statistics for estimated TE obtained from DEA Excel Solver 2.0 computer program developed by Jhu (2002). Technical efficiency ranged from 0.62 to 1.00.When TE gets closer to one, the farm is considered more technically efficient. Mean technical efficiency score was 0.89 in organic coffee farms. This means, in principle, that sample farms can potentially reduce their inputs of coffee production on average by 11% and still achieve the same level of output from the existing technology. Coffee farms operating with more than 80% technical efficiency were 75% of the sampled farms. Approximately 53% of the farmers achieved more than the average technical efficiency. Farms operating under CRS, DRS

and IRS were 31.67, 3.83 and 37.5% respectively (Table 4). The average coffee output in the

farms operating under CRS was higher than DRS and IRS.

Table 3. Distribution of Technical Efficiency of organic coffee in deciles range.

Efficiency level	Frequency	Percentage
< 50	0	0
0.50-0.59	0	0
0.60-0.69	9	7.50
0.70-0.79	21	17.50
0.80-0.89	27	22.50
0.90-0.99	25	20.83
1	38	31.67
Mean TE	0.89	
Standard deviation (sd)	0.11	
Coefficient of variation (cv)	12.35	
Minimum	0.62	

Source: Field survey 2011.

Table 4. Summary of returns to scale results (n=120) in organic cultivation of coffee.

Characteristics	No. farms	Coffee output(kg/farm)		
		Mean	Min	Max
CRS	38(31.67)*	69.86(122.16)**	1	600
DRS	37(30.83)	62.91(74.27)	5	305
IRS	45(37.5)	33.84(31.02)	5	160

*value in the parenthesis indicates percentage and ** value in the parenthesis indicates sd
Source: Field survey 2011.

Similarly, table 5 shows the descriptive statistics for estimated TE obtained in conventional

coffee farms. Technical efficiency ranged from 0.36 to 1.00 and mean technical efficiency score

0.83. This means, in principle, that sample farms can potentially reduce their inputs of coffee

production on average by 17% and still achieve the same level of output from the existing

technology. In this category, farms operating less than 50% technical efficiency were 5%. Coffee

farms operating with more than 80% technical efficiency were 63.33% of the sampled farms.

Farms achieved more than the average technical efficiency in conventional system is 60%. Farms

operating under CRS, DRS and IRS were 29.17, 25 and 45.83% respectively (Table 6). The

average coffee output in the farms operating under DRS was higher in conventional coffee farming. The coefficient of variation explains the consistency of TE in two different farming system revealed that farms in organic system were more consistence and relatively efficient in input management than conventional one.

Table 5. Distribution of Technical Efficiency of conventional coffee in deciles range.

Efficiency level	Frequency	Percentage
< 50	6	5
0.50-0.59	8	6.67
0.60-0.69	15	12.50
0.70-0.79	15	12.50
0.80-0.89	22	18.33
0.90-0.99	19	15.83
1	35	29.17
Mean TE	0.83	
Standard deviation(sd)	0.17	
Coefficient of variation(cv)	20.48	
Minimum	0.34	

Source: Field survey 2011.

Table 6. Summary of returns to scale results (n=120) in conventional cultivation of coffee.

Characteristics	No. farms	Coffee output(kg/farm)		
		Mean	Min	Max
CRS	35(29.17)*	101.91(42.22)**	48	230
DRS	30 (25)	119.43(44.56)	66	235
IRS	55(45.83)	63.52(25.88)	22	140

*indicates percentage and ** indicates standard deviation.
Source: Field survey 2011.

An application of tobit command for regression with limited dependent variables was used to estimate factors associated to technical efficiency as illustrated in equation (6). The sources of inefficiency were examined by using the estimated β-coefficient (as regression coefficient in SHAZAM version 10.0 output). The inefficiency effects were specified as those relating to family size, education, gender, training, age and farming experience. The maximum likelihood estimation of determinants of technical efficiency was calculated differently to organic and conventional farms. The results are presented in table 7 and 8 for organic and conventional

farming respectively. None of the factors were found statistically significant in organic coffee farming (Table 7). The coefficient of household size, farming experience and access to credit were positive. The importance of farming experiences in agricultural enterprises were presumed and followed the findings of Dhungana (2010), Inoni (2006), Dhungana (2004), Kebede (2001) and Coelli and Battese (1996). This indicates that farmers with more years of experiences may be contributing towards better doing in coffee farming. House hold size is the industry to supply farm labors in Nepalese farming context. It will have setback in Nepalese coffee industry in the near future because of rapid migration from hill region to either city areas of Nepal or to overseas searching lubricant jobs. The coefficient of education was negative and this suggested that organic coffee production is not related with educational background. This was in line with Umoh (2006), reported that education does not contribute to farm efficiency in studying urban farming in Nigeria.

Table 7. Tobit regression analysis of organic coffee farms in Gulmi district

Independent variables	Regression coefficient	Asymptotic Std. error	T-ratio
Household size (Z_1)	0.002	0.013	0.149
Education(Z_2)	-0.009	0.033	-0.229
Sex (Z_3)	-0.096	0.083	-0.951
Training/extension (Z_4)	-0.038	0.426	-0.074
Age (Z_5)	-0.212	0.274	-0.638
Farm experience (Z_6)	0.193	0.357	0.446
Access to farm credit (Z_7)	1.161	3.173	0.301
Constant	-1.171	3.192	-1.171
Variance of the estimate ($\widehat{\sigma^2}$)	1.4766		
Standard error of the estimate ($\hat{\sigma}$)	1.2152		
Log likelihood function	-102.688		
Square correlation between observed and expected values	0.15548		

***- Significant at 0.01, **- Significant at 0.05 and *- Significant at 0.1
Source: Field survey 2011.

Similarly, the estimated coefficients of most of the factors were not significant except for age of the farm manager in conventional coffee farming (Table 8). However, most of the factors had positive coefficient implying for positive relationship with conventional coffee farming. Our general understanding for farm manager's experience could foster productivity was not statistically significant in both types of farming. Experienced farmer is not enough to reach a farm to attain higher level of efficiency unless farm managers rearrange the basket of inputs with a given technology.

Table 8. Tobit regression analysis conventional coffee farms in Palpa district.

Independent variables	Regression coefficient	Asymptotic Std. error	T-ratio
Household size (Z_1)	0.013	0.011	0.958
Education(Z_2)	0.049	0.047	0.874
Sex (Z_3)	-0.112	0.086	-1.099
Training/extension (Z_4)	0.111	0.278	0.334
Age (Z_5)	0.675	0.215	2.633***
Farm experience (Z_6)	0.260	0.365	0.598
Access to farm credit (Z_7)	0.002	0.347	0.006
Constant	-1.864	0.811	-1.928*
Variance of the estimate ($\widehat{\sigma^2}$)	1.4204		
Standard error of the estimate ($\hat{\sigma}$)	1.1918		
Log likelihood function	-95.986		
Square correlation between observed and expected values	0.0303		

***- Significant at 0.01, **- Significant at 0.05 and *- Significant at 0.1
Source: Field survey 2011.

In analyzing efficiency affecting factors in organic coffee cultivation, it was observed that the total variance of output (expressed as variance of estimate) was higher in organic farming (1.476) than conventional farming (1.420).We did public auditing of factors responsible for organic coffee output in the study areas through alternative to face to face questionnaire survey. The participatory appraisal tool, focus group discussion was used to executive members of the farmers' cooperatives/groups. The result obtained from massive interaction is depicted in table 9.

Table 9. Frequency distribution of field level problems of organic and conventional coffee farming.

Field level problem	Organic coffee farms		Conventional coffee farms	
	Frequency	Rank	Frequency	Rank
Skill labor	102(85)	I	82(68.33)	III
Farm yard manure	86(71.67)	II	62(51.67)	VI
Insect/pests	82(68.33)	III	108(90)	I
Operating utensils	69(57.50)	IV	66(55)	IV
Irrigation	29(24.17)	VI	64(53.33)	V
Training/Extension	51(42.50)	V	92(76.67)	II
Wild animals	0		24(20)	VIII
Water for processing	23(19.16)	VII	32(26.66)	VII

Value in the parenthesis indicates percentage.
Source: Field survey 2011.

Shortage of skill labor in organic and plant protection from insect/pest in conventional farming was the top most problem in the study areas. Availability of farm yard manure and insect/pest were second and third ranked problems in organic farming. But deficit of training and extension program stood for second ranked followed by skill labor problem in conventional coffee farming. However, location specific problems ranking could be different. The overall assessment smoothly supported for our whole quantitative analysis. The facts of skill manpower development and management in emerging market oriented coffee production with wider program to expanding livestock population to produce enough farm yard manure (FYM) is urgent issue to be addressed. The mitigation measures for insect pest prevailing are highly demanded in conventional farming.

Conclusions

The article summarizes the technical efficiency of organic and conventional coffee farming in hill region of Nepal. The study was conducted in Gulmi and Papla districts of Nepal representing organic and conventional area respectively. Both GM and non-discounted b/c ration was higher in conventional coffee farming system. Mean technical efficiency score was 0.89 and 0.83 in

organic and conventional coffee farming respectively. Farms operating under CRS, DRS and IRS were 31.67, 3.83 and 37.5% respectively in organic coffee while farms operating under CRS, DRS and IRS were 29.17, 25 and 45.83% respectively in conventional coffee farming areas. Efficiency index were regressed to farm specific characteristics in tobit regression model produced all most non-significant results in both types of farming except the variable age of farm manager in conventional coffee farming. The coefficient of household size, farming experience and access to credit were positive in organic coffee but most of the factors have positive coefficient in conventional farming except for the factor sex. This concluded the research that in the sampled areas the technical efficiency were explained positively by household size to provide farm labor, farm experiences in input/output rationalization, credit for investment in both types farming. The positive coefficient for factors education and training could be implied that educated people are more likely to adopt technical knowhow on farming system management. The steady outflow of male people has been a threat in supplying skill labor and limited quantity of farm yard manure were the major problems to organic coffee farming. Protecting coffee from insects/pest and availability of technical know- how is utmost in conventional farming.

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