ISSN 2187-946X

The Japanese Journal of Rural Economics

Volume 16, 2014

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The Agricultural Economics Society of Japan

vaccines used by the farms studied are made by Guangdong Dahuanong Animal Health Product Co., Ltd. in China. This is the only government permitted HP-PRRS vaccine available in Vietnam. Although the vaccine efficacy is reported to be 95% (Zhuyiwang [16]), in consideration of the differences in pig farming between China and Vietnam, we conservatively postulated the vaccine efficacy h as 90%.

9) From the field survey, 2,441 pigs were culled; on the other hand, in the modeled SO strategy, the total number of culled pigs was estimated at 2,882. The simulated culled number is very close to the actual number; therefore, we consider this epidemiological model to be appropriate. As indicated in Figure 1, our SIR model considered that time is required to administer the vaccination, in line with the actual situation in developing countries, and it also considered the time required for spread of the virus (Zhang *et al.* [15]). However, this model still differs from the real situation, in which there is a time lag between vaccine administration and acquirement of immunity. This time lag varies according to pig breed, age, and HP-PRRS pathogen strain. Further research is required to evaluate this time lag in the SIR model.

10) The infectious period is the time period between the pig being infected and culled. We assumed the surveillance was adequately functional and the infectious period was 1 week (parameter ν = 0.143) in the epidemiological simulation. However, if the surveillance system is not functionally efficient, and the infectious period increases to more than 2 weeks (parameter ν = 0.071), the outbreak will continue for more than 1 year, which is outside our period of analysis.

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Technical Inefficiency Effects among National Cereal Grain Balance Producers and Need for Implementation of Land Reform in Nepal

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1. Introduction

Nepalese economy is predominantly an agricultural economy. Thirty-seven percent share of gross domestic product (GDP) comes from agriculture (GON [8]). Based on food and non-food poverty line, 25.16 percent of population is still below poverty (CBS [4]) and food security is an issue of national concern. Since; cereal crop production is an important contributor to national food security, National Cereal Grain Balance (NCGB) is a crucial component of agricultural output constituting more than 60 percent share in total agricultural production. NCGB is calculated by the Ministry of Agricultural Development of Nepal and includes: paddy, maize, wheat, millet, barley and buckwheat. Table 1 shows the latest situation of NCGB in Nepal for the crop year 2010/11 and further illustrates broadly by cereal crop type, acreage, output and productivity. Paddy is the most important cereal crop contributing about 52 percent in the production of NCGB, and it is cultivated in about 43 percent of acreage. Moreover, its productivity is the highest of 2.98 metric tons per hectares (mt/ha) among other cereals. We see that buckwheat has the lowest productivity of 0.87 mt/ha. Average productivity of NCGB is 2.48 mt/ha in Nepal. Data show that productivity of cereals in neighboring countries is higher than in Nepal. India has cereal productivity of 2.54 mt/ha, Pakistan 2.59 mt/ha, Srilanka 3.97 mt/ha, Bangladesh 4.14 mt/ha and China 5.52 mt/ha (The World Bank [17]).

Since; more than seventy percent of population is dependent on agricultural sector for livelihood (GON [8]), without improving the productivity of this sector, it is almost impossible to lift the living standard of people and reduce the absolute poverty level. Investment in new technology, availability of extension services, market accessibility and farmers' knowledge of proper farming technique are very important for commercialization of agriculture, which can raise the productivity of this sector. We neither can create nor destroy the physical land, because it is the natural gift with limited supply. Therefore, the only alternative measure we have is the use of land in most productive way by trained farmers. Finding the sources of technical inefficiencies if any and reducing those barriers to enhance efficiency is very crucial during production process in utilizing land resource. Proper size of agricultural land and management of it by maximum possible efficient way is an important issue for Nepalese agriculture. This paper, thus studies about land size, technical efficiency and inefficiency effects of NCGB producers in Nepal.

Table 1: Area and Production of Cereal Crop in 2010/11

	Acreage		Production		Productivity
Cereal type	'000 ha*	Percent	'000 mt**	Percent	(mt/ha)
Paddy	1496	43.02	4460	51.77	2.98
Maize	906	26.05	2067	23.99	2.28
Wheat	767	22.05	1746	20.27	2.28
Millet	270	7.76	303	3.52	1.12
Barley	29	0.82	30	0.35	1.05
Buckwheat	10	0.30	9	0.10	0.87
Total	3478	100.00	8615	100.00	2.48

Source: Authors' calculation based on CBS[5]

Note: * in thousand hectares, ** in thousand metric tons

Nepal is a land scarce country. Since, the Northern part (Mountains) is covered by snow with high range mountains, middle part (Hills) is affluent with steep slopes and in comparison only the Southern part (Terai) has much productive land. To meet the need of growing population, the agricultural land needs to be managed in productive way. For this, the Government makes land reform laws and implements them time to time. In case of Nepal, The comprehensive land legislation of 1964 (GON [9]) is the milestone law for land reform. The Fifth Amendment to the 1964 Land

Related Act in 2002 (FALRA 2002) drastically reduced land ceiling aiming to use land in most productive way. Table 2 shows land ceiling policy before and after FALRA 2002. According to this, each household could hold 7.45 hectares (ha) of land in Terai, 1.52 ha of land in Kathmandu Valley and 3.81 ha of land in other regions (Hills and Mountains). There are about 3 percent of households, which have large sized lands beyond legal ceiling with more than 15 percent share in total acreage of households land and 25 percent of landless/marginal households have less than 4 percent share in total acreage of household land (GON[10]). This shows that there is huge inequality of land distribution, hence immediate needful implementation of land reform in Nepal. Land reform in Nepal has always been criticized for lack of will power to implement it. Even FALRA 2002 was not properly implemented, which indicates a failed reform on land. The scenario of land distribution would be different if the land ceilings of FALRA 2002 were properly implemented (Paudel & Saito [14]).

Table 2: Per Household Land Ceiling Policy of Government (in ha)

Region	Before Fifth Amendment			After Fifth Amendment		
	Agricultural	Homestead	Total	Agricultural	Homestead	Total
Terai	16.40	2.00	18.40	6.77	0.68	7.45
Kathmandu Valley	2.70	0.40	3.10	1.27	0.25	1.52
All other regions	4.10	0.80	4.90	3.56	0.25	3.81

Source: Authors' calculation based on(GON[9])

In the above-mentioned context, we in this paper, study the relationship between household land size (marginal/landless, medium-within limit and large-beyond limit) and technical efficiency of NCGB producers. Household land size category used in this paper is based on the land ceiling provisions of land reform law. The farmers who have less than 0.15 hectares of land in Terai, less than 0.04 hectares of land in Kathmandu valley and less than 0.08 hectares of land in other regions (Hills and Mountains) are identified as marginal/landless farmers. This criteria for the land less and marginal farmers who are eligible to get land is based on the proportion of land ceiling defined by FALRA 2002. Large farmers are those who have land beyond ceiling but medium farmers are in between marginal/landless and large farmers. Moreover, medium farmers are not affected by implementation of FALRA 2002.

The main objective of this study is to identify the efficiency gap and analyze the sources of technical inefficiencies for NCGB production in Nepal. Is there any inefficiency in NCGB production? If any what are the sources of inefficiencies? How land reform implementation can reduce inefficiencies? These are the main research questions, we plan to answer in this paper. To search for answers, our null hypotheses are: NCGB producers exhibit constant return to scale production technology; they produce on frontier; they do not have any technical inefficiency; farmers in all regions are equally efficient and there is no difference in efficiencies based on household land size. To check the validity (acceptance or rejection) of these null hypotheses, we estimate NCGB production behavior by using stochastic production frontier (SPF) methods and find mean efficiencies based on regions and size of lands.

The findings of this paper suggest that NCGB producers are operating less than their frontier and the gap is 28 percent. Moreover, there are many sources of inefficiencies such as less irrigation facilities, lack of extension services, lack of farmers' education and lack of use of modern equipments. Land is found to be the most important input for NCGB production and proper land size matters for raising efficiency of farmers. More importantly, there are still some households that have land holding beyond legal ceiling proposed by FALRA 2002, and they are technically less efficient, land reform implementation can enhance technical efficiency of NCGB producers in Nepal.

2. Literatures

Going through relevant literatures, we found many studies estimating efficiency or inefficiency effects of different grain producers based on different countries, regions, farms, crops etc. using cross section, time series or panel data. For example, using cross-section data and frontier function, Taylor and Shonkwiler [16]; Squires and Tabor [15] estimated

technical efficiency of about 70 percent in average. More importantly, Bravo-Ureta et al [2] used a meta-regression analysis including 167 farm level technical efficiency studies of developing and developed countries and found the overall efficiency of 76.6 percent. The study of Tian and Wan [18], Kaur et al [12], Hasan and Islam [11], Dağistan [7], Kurkalova and Jenson [13] etc. studied technical efficiency of cereal grain (rice, wheat or corn) farmers and they found mean efficiency between 70 to 80 percent. All the studies mentioned here noticed that there are different factors that have some level of impact on technical efficiency of agricultural production. Their finding suggests the inefficiency effects such as lower level of farmers' education and experience, lack of market access, lack of irrigation etc. which are almost common in most of the existing literatures.

In Nepalese context, Adhikari and Bjorndal [1] studied the technical efficiencies of Nepalese agriculture using household survey data of 2003/04 and using stochastic distance function and data envelopment analysis methods. They could measure technical efficiency effects of 73 percent in Nepalese agriculture but their study did not mention about the existing land reform provisions and they also lack identifying the large household lands in their sample that are beyond legal ceiling in size and less efficient in production.

To the best of our knowledge, there are many papers which measure technical efficiency and estimate inefficiency effects, but there is no any paper that has linked technical inefficiency effects of NCGB producers to household land size category and identified the beyond legal ceiling lands which are subject to entail land reform implementation immediately. This study using latest household survey data, i.e., Nepal Living Standard Survey 2010/11 dataset, estimates technical efficiencies based on regional categories of land proposed by FALRA 2002, and clearly identifies the need of land reform implementation in Nepal. In this context, this study may draw some attention of researchers and policy makers, hence the relevance of this study.

3. Research Methods

3.1 Data

The data source used in this paper is Nepal Living Standard Survey III dataset (CBS [3]). This is a household survey conducted by the Government of Nepal in 2010/2011. This survey follows Living Standard Measurement Survey (LSMS) methodology developed and promoted by the World Bank and covers the whole country, five-development regions-eastern, central, western, mid-western and far western region and 75 administrative districts. The survey enumerated 5,988 sample households from 499 primary sampling units (PSUs) such as wards or sub-wards over 3 ecological zones, 5 development regions, 75 districts, 58 municipalities and 3,914 Village Development Committees. This cross section sample covers information from 34,344 individuals living in 5,988 households of the country. This was done in two stages using probability proportional to size (PPS) sampling method.

In this study, the households, which produce cereal crops, are taken for analysis. Among 5,988 households, the households whose share of cereal production in total agricultural production is more than 80 percent are taken as NCGB producers, which give adjusted sample of 1,133 as total observations. Those who produce less than 80 percent are excluded because the input used in production are same for a household and only households with at least 80 percent share in total household agricultural production could represent the NCGB producers in Nepal and this would rather give more realistic estimations. The data set has information of total harvested output of each crop in different ten units such as gram, kilogram, ton, muri, pathi, mounds etc. and their price according to respective units. Multiplying total harvested quantity by its price, we calculated the output of cereal grains. There is information in the data set about the inputs used- land, labor, capital, seed, fertilizer and other inputs in a household level but no information for inputs used in each crops. Therefore, calculation of elasticities for each crop is not possible. Moreover, other inputs include expenditure on irrigation, storage, transportation etc.

Table 3 shows the production composition of types of cereal crop according to our sample data. Out of total cereal crop production, early paddy constitutes 2.04 percent. Early paddy is cultivated in April-July. Main paddy is the main crop of NCGB in Nepal. The share of it is 57.57 percent. The cultivation time is July-December. Main paddy needs intensive water supply. Similarly, share of upland paddy is 1.23 percent. The cultivation time is June-November. Similarly, share of wheat is 16.76 percent, share of spring/winter maize is 2.68 percent, share of summer maize is 14.95 percent, share of millet is 4.13 percent, share of barley is 0.47 percent, share of buckwheat is 0.12 percent and share of other cereals such as oats, rye etc. is 0.06 percent respectively. Wheat needs a little water supply but for maize, millet, barley and buckwheat rain water supply is enough.

Table 3: Share of Cereal Crops

Cereal Crop Type	Share (%)
Early Paddy	2.04
Main Paddy	57.57
Upland Paddy	1.23
Wheat	16.76
Spring/ Winter Maize	2.68
Summer Maize	14.95
Millet	4.13
Barley	0.47
Buckwheat	0.12
Other Cereals	0.06
Total	100.00

Source: Authors' calculation

3.2 Stochastic Production Frontier (SPF) Model

In this paper, SPF method is applied to measure technical efficiency of NCGB producers in Nepalese agriculture. As given in Coelli et al. [6], a Cobb-Douglas stochastic frontier model for cross section data takes the form:

$$\ln(y_i) = \beta_0 + \beta_1 \ln x_i + v_i - u_i \quad (1)$$

$$y_i = \exp\ (\beta_0 + \beta_1 \ln x_i + v_i - u_i) \quad (2)$$

$$y_i = \exp\ (\beta_0 + \beta_1 \ln x_i) \times \exp(v_i) \times \exp(-u_i) \quad (3)$$

where,

$\exp\ (\beta_0 + \beta_1 \ln x_i)$: deterministic term

$\exp(v_i)$: disturbance term

$\exp(-u_i)$: inefficiency term

The observed output can be written as:

$$y_i = f(x_i \beta) \times \exp(v_i - u_i),\ \ u_i \geq 0 \quad (4)$$

Assuming that observed output lies below the stochastic frontier,

$$y_i \leq f(x_i \beta) \times \exp(v_i) \quad (5)$$

Consequently, we have:

$$\mathrm{TE}_i = \frac{\text{observed output}}{\text{potential maximum output}} = \frac{f(x_i \beta) \times \exp(v_i) \times \exp(-u_i)}{f(x_i \beta) \times \exp(v_i)} = \exp(-u_i), 0 \leq TE_i \leq 1 \quad (6)$$

3.3 Inefficiency Effects Model

The inefficiency effects model is used to estimate inefficiency of NCGB producers in Nepalese agriculture. The empirical model is as follows:

$$\eta_i = \delta + \xi z_i + e_i \quad (7)$$

Where η_i a technical inefficiency score (1-TE_i) used as a dependent variable, z_i is a vector of independent variables related to farm household specific characteristics, δ is constant and ξ is the unknown parameter and e_i an error term.

4. Estimation Results

4.1 Descriptive statistics

Table 4 shows the summary statistics. Mean output of NCGB is 55,220.65 Nepalese Rupees (NPR). Average labor used is 1,559.52 hours with average household operated land input of 0.74 hectares (ha). The minimum value of land is 0.002 ha and maximum is 32.77 ha. This shows that household cultivated land varies between almost landless to large landlords. The maximum land limit permitted by land act is 7.45 ha in Terai regions but sample data set shows there are still large size of household land beyond limit. The size of land dummy shows that there are 10 percent households with marginal land, which are almost landless being eligible to acquire land if land reform laws were implemented properly. Majority (89 percent) households have medium land (up to legally permitted limit) and 1 percent household have large land (beyond the limit). In the land reform implementation process, large landowners lose their land beyond limit and landless and marginal farmers are eligible to acquire those lands.

Table 4: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Dependent Variable				
(y) Output (NPR)	55,220.65	96,648.36	586.00	1,707,191.00
In dependent Variables				
(x1) Labor (hours)	1,559.52	2,079.16	12.23	43,404.25
(x2) Land (hectares)	0.74	1.48	0.00	32.77
(x3) Capital (NPR)	3,491.35	8,001.29	45.00	178,800.00
(x4) Seed (NPR)	1,070.15	6,677.54	15.00	208,000.00
(x5) Fertilizer (NPR)	1,768.12	11,101.22	15.00	348,825.00
(x6) Other inputs (NPR)	228.87	265.79	10.00	2,500.00
Inefficiency effects				
(z1) Unused land dummy	0.12	0.33	0.00	1.00
(z2) Age of head (years)	31.62	18.42	16.00	85.00
(z3) Schooling of head (years)	3.69	2.07	3.00	17.00
(z4) Extension service dummy	0.26	0.44	0.00	1.00
(z5) Year round irrigation dummy	0.12	0.33	0.00	1.00
(z6) Use of modern equipment dummy	0.22	0.41	0.00	1.00
Regions (dummy)				
(z7) Kathmandu Valley (reference)	0.05	0.22	0.00	1.00
(z8) Terai	0.50	0.50	0.00	1.00
(z9) All other regions	0.45	0.50	0.00	1.00
(z9-1) Hills	0.39	0.49	0.00	1.00
(z9-2) Mountains	0.06	0.23	0.00	1.00
Size of land (dummy)				
(z10) Marginal (reference)	0.10	0.30	0.00	1.00
(z11) Median	0.89	0.31	0.00	1.00
(z12) Large	0.01	0.07	0.00	1.00
Number of observations	1,133			

Source: Authors' calculation

Average values of inputs such as capital, seed, fertilizer and other inputs are 3,491.35 NPR, 1,070.15 NPR, 1,768.12 NPR and 228.87 NPR respectively. About 12 percent households have at least some unused or fallow land. This unused land is the land left unproductive. Average age and schooling of household head farmers are 31.62 and 3.69 years respectively. Additionally, only 26 percent household have access to extension services, 12 percent have year round irrigation system, 22 percent are using modern equipment for farming such as tractor, thresher etc.

While looking to the regional distribution of sample households, we see that 5 percent households are from Kathmandu valley. Kathmandu valley is the region where the capital of Nepal Kathmandu is situated. 50 percent households are from Terai region. This region lies in the Southern part of the country bordering with India and have very productive land for cereal crops. Rest 45 percent households are from all other regions, which further divided as 39 percent households from Hills, the middle hilly part of the country followed by 6 percent households from Northern Mountainous region boarding to China.

4.2 SPF Estimation Results

Table 5 shows the estimation results of SPF model. Here, we estimated the Cobb-Douglas Production Frontier with one output and six inputs. All of the coefficients of inputs are significant. Land has the highest coefficient of 0.32 followed by other inputs (expenditures on irrigation, transportation, draft animals, storage, management etc.). Labor, capital and fertilizer have same coefficient of 0.07 and seed has 0.06 coefficients. Since, production of NCGB is highly labor-intensive task; the coefficient of labor is low. The sum of all the coefficients of inputs is 0.87 (0.07+0.32+0.07+0.06+0.07+0.26)<1.00 and statistically significant. This shows that there is decreasing returns to scale production technology, rejecting our null hypothesis of constant return to scale.

Since the coefficient of sigma squared u is statistically significant, this shows that the model shows there are some technical inefficiencies present in the model. This also reveals that due to inefficiencies present in the production process, the observed output is less than the maximum possible output, which rejects our null hypotheses of farmers produce on frontier and there are no technical inefficiencies.

Table 5: Estimation of SPF Model

Variables	Coefficient	z-value
Dependent variable: ln(Output)		
ln(Labor)	0.07 ***	3.71
ln(Land)	0.32 ***	13.63
ln(Capital)	0.07 ***	5.04
ln(Seed)	0.06 ***	3.66
ln(Fertilizer)	0.07 ***	4.47
ln(Other inputs)	0.26 ***	11.33
Constant	8.18 ***	42.59
ln (sigma squared v)	-0.88 ***	-14.42
ln (sigma squared u)	-1.81 ***	-11.08
lambda	0.63 ***	
Wald chi squared (6)	956.17***	
Log likelihood value	-1,295.74	
No. of observations	1,133	

*** Significant at 1 %, ** at 5% and * at 10%

Source: Authors' estimation

4.3 Efficiency Scores

Table 6 shows the mean efficiency scores in NCGB production. Scores are presented by household land size across regions. In overall, the mean technical efficiency of NCGB producers is found to be 0.72, which is consistent with the findings of Adhikari and Bjorndal [1] as they found mean technical efficiency of 0.73 in Nepalese agriculture. Technical inefficiency in average is 0.28 (1-technical efficiency). This shows that there is possibility of increasing NCGB production by 28 percent if the farmers could achieve the maximum efficiency using the same resources they have.

Medium sized households lands are the most efficient among three sizes of lands. The average efficiency score of medium lands is 0.72. Marginal lands (efficiency score 0.67) are less efficient than medium and statistically significant in mean difference test and large lands have slightly smaller efficiency scores (0.70) than medium but they are not stastically significant. While going through regions, Terai exhibits highest efficiency with score 0.74 followed by all other regions with efficiency score 0.70 (Hills-0.69 and Mountains 0.71). Kathmandu valley has the lowest efficiency score (0.69) among the regions. Comparing land sizes among three regions, results show that medium household farms in Terai region are the most efficient among all (efficiency score 0.74). In contrary, marginal household farms in Hills are the most inefficient (efficiency score 0.59). The sample shows that among large sized household farms which are subject to imply land reform, four are in Terai and two are in Hills region. The results presented above reject our null hypotheses - farmers in all regions are equally efficient and there is no difference in efficiencies based on household land size.

Table 6: Technical Efficiency Scores by Holding Size and Regions

Region	Marginal		Medium		Large		Total	
	obs.	score	obs.	score	obs.	score	obs.	score
Kathmandu Valley	11	0.66	45	0.70	-	-	56	0.69
Terai	70	0.71	497	0.74	4	0.73	571	0.74
All other regions	33	0.60	471	0.70	2	0.63	506	0.70
Hills	25	0.59	418	0.70	2	0.63	445	0.69
Mountains	8	0.63	53	0.72	-	-	61	0.71
Total	114	0.67	1,013	0.72	6	0.70	1,133	0.72

Source: Authors' calculation

Terai is the plain area with productive quality of land. Compared to other areas, NCGB producing farmers in Terai have more access to irrigation, transportation, seeds, fertilizer, storage etc. They produce more paddy than other cereals, which is water intensive crop with more value in market. Therefore, they are more efficient. On the contrary, in Mountains, most of the cereal farming consists of maize, millet, barley and buckwheat and almost no paddy and wheat. So, the cereal crops produced in Mountains region are less intensive to water. In Hills, farmers produce all types of cereal crops but due to lack of irrigation system, productivity of paddy is less than in Terai. Hills have the least efficiency because they have

both water intensive and non-intensive cereal farming. For water non-intensive cereals such as maize and barley, Mountains is better than Hills and for water intensive cereals such as paddy, Terai is better than Hills. This gets expressed by the efficiency results in table 6.

4.4 Inefficiency Effects

Table 7 shows the sources of inefficiencies among NCGB producers. The significant positive source of inefficiency is found to be unused land but significant negative sources are schooling of head, extension service, year round irrigation, use of modern equipment etc. The NCGB producers from Terai have less inefficiency effects than those from Kathmandu valley. In the same way, producers with medium sized household land have less inefficiency effects than marginal. Large lands have positive effects of inefficiency but they are not significant.

The households which left some of their land as fallow, and do not cultivate it or do not use it in production is unused land, and if the households have unused land, they have higher technical inefficiency by 2 percent than those who use all of their land in cultivation. Regarding the size of household land, results suggest that medium sized lands have less inefficiency effects by 4 percent than marginal lands. Though; results are insignificant because the size of sample is very small (only 6 households with large sized lands in sample data set), the relationship with inefficiency effects is positive. Among the farmers, which are liable to land reform by implementing FALRA 2002 (marginal-receiving and large-losing), marginal are technically less efficient than medium sized farmers.

Table 7: Estimation of Inefficiency Effects Model

Variable	Coefficient	t-value
Dependent variable: Technical inefficiency score		
Unused land dummy	0.02 *	1.80
Age of head	0.01	0.98
Schooling of head	-0.01 **	-2.36
Extension service dummy	-0.03 ***	-4.09
Year round irrigation dummy	-0.04 ***	-3.84
Use of modern equipment dummy	-0.03 ***	-3.32
Regions (dummy)		
Kathmandu Valley (reference)	–	–
Terai	-0.03 **	-2.09
All other regions	0.01	0.32
Size of land (dummy)		
Marginal (reference)	–	–
Median	-0.04 ***	-4.32
Large	0.01	0.31
Constant	0.35 ***	20.64
F (11,1121)	11.93 ***	
R-squared	0.09	
No. of observations	1,133	

*** Significant at 1 %, ** at 5% and * at 10% level

Source: Authors' estimation

Schooling of head has negative correlation on inefficiency effects suggesting that knowledge of farmer is very important to increase their efficiency. Similarly, availability of extension service reduces inefficiency effects. Availability of year round irrigation and use of modern equipments also reduce inefficiency of NCGB producers. Moreover, the producers from Terai region have less inefficiency effects than those of Kathmandu valley. This is because Terai is a region with more productive land than Kathmandu valley. Moreover, the major crop cultivated in Terai region is paddy, its productivity is higher than other crops in Nepal (see table 1) and market value of paddy is also higher than other crops.

5. Concluding Remarks

This study estimates technical efficiencies of national cereal grain balance producers in Nepal using stochastic production frontier (SPF) methods. The empirical application uses household level Nepal Living Standard Survey III, 2010/2011 data.

The average technical efficiency scores vary widely between household land sizes and regions. Efficiency scores range between 0.59 and 0.74 showing an overall mean technical efficiency of 0.72. Based on these results, sample NCGB producers could increase about 28 percent of their output through better use of available resources. Additionally, estimated results reveal that improper size of household land (marginal and large) is an important source of technical inefficiency. Other sources of inefficiencies are found to be lower level schooling of head, lack of extension services, lack of irrigation facilities, lacking use of modern equipments etc. Producers from Terai region are more efficient than those of other regions.

If the government enforces redistribution of land from large to marginal, the size of both marginal and large farm will be driven to be medium farm whose efficiency is significantly higher than marginal, though the mean efficiency between medium and large is not stastistically significant. This means that, in the process of land redistribution, size of large land will decrease and size of marginal land will increase while size of medium farms remains unaffected. Moreover, the unused land converted to cultivation by means of land reform will also raise the total efficiency and productivity of farmers. Therefore, we insist on that land reform laws need to be implemented urgently for increasing technical efficiency of NCGB producers in Nepal.

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Characteristics and Significance of the Indigenous Rice Farming Technology in Sri Lanka

A Case Study of Indigenous and Modern Rice Farmers in the Padaviya Irrigation System

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1. Introduction

In Sri Lanka, rice is a historically and culturally important crop grown in all regions of the country.[1)] Rice production in the country began in the dry zone area in 900 B.C. (Deraniyagala [3]) and has developed in an organized way since 300 B.C. (Mahawansa, Trans. by Geiger [9]). Until the early 1960s, this major crop was grown entirely based on the indigenous rice farming technology (IRFT). The IRFT is a set of time-tested agricultural and natural resource management practices, which were developed solely based on the extensive experience and knowledge of the local people (Venkatratnam [11]). This technology makes use of traditional rice varieties, which were developed and cultivated by the local people over centuries, in association with a set of practices, including the application of organic fertilizers, the management of weeds through pre-planting techniques, water management and hand weeding, and the management of pests and diseases by maintaining biodiversity using homemade biopesticides and by practicing agricultural rituals (Dharmasena [4]). The IRFT also takes into consideration the lunar cycle and is based on the natural conditions of the region, including field conditions, recycling of organic materials, and biological control mechanisms that correspond to the natural features of the region, including rainfall patterns, soil conditions, temperature, and humidity.[2)]

As emphasized in agricultural history, the IRFT was replaced by the modern rice farming technology (MRFT) during the Green Revolution (Farmer [5]; Wilson [12]). The MRFT used modern varieties (high yielding varieties (HYVs), in association with imported inorganic fertilizers and other agro-chemicals and with pre-scheduled irrigation and new methods of farming (Andersen and Hazell [1]; Farmer [5]; Kikuchi et al. [7]). Sri Lanka first attempted to improve seeds by selecting traditional varieties that had been used since the 1940s (Jayathilaka [6]). Those improved varieties were referred to as "old improved varieties—H series" (see Figure 2) (Kikuchi et al. [7]). Similar to other countries in Asia, the key elements of the Green Revolution were first introduced to Sri Lanka in the mid-1960s, with the release of IR8 from the International Rice Research Institute (IRRI), following establishment of the IRRI in the Philippines in 1962 (Farmer [5]; Jayathilaka [6]; Kikuchi et al. [7]). Specifically, the major initiative of the technology package of the Green Revolution was addressed by the "Food Drive" program of 1967 (Jayathilaka [6]). As stated in agricultural history in the 20^{th} century, the main reasons for this technological transformation were the future challenges predicted to be associated with our food supply due to the rapidly increasing population.

Forty years after the Green Revolution, there was a contentious discussion in the academic literature about the adverse effects of abandoning the IRFT in the technological transformation. First, according to the World Health Organization (WHO), the chronic kidney, cancer, and diabetes issues in the main rice-growing areas of Sri Lanka are likely due to the long-term use of agrochemicals by the farmers (WHO [13]). Second, the MRFT has resulted in significant environmental problems, including the pollution of ground water, the decline in natural soil fertility, the imbalance of biodiversity, and the disappearance of essential flora and fauna. These issues endanger the lives of all people in the country, in terms of food safety and health. The relationship of the MRFT to these problems is demonstrated by the drastic increase in chemical fertilizer application per hectare (ha), by 190%, from 76.5 kg in 1967 to 222 kg in 2004 (DCS [2]) and 2006; pesticide application per ha also increased by 1,350%, from 0.2 liters in 1968 to 2.9 liters in 1995 (Kikuchi et al. [7]). Third, the MRFT has resulted in a severe farm management problem. Although the MRFT led to a doubling in rice production, from 2,127 kg to 4,337 kg per ha during the last 40 years (see Figure 1), the actual income for farmers has declined by 16% (DCS [2]). This decline has resulted in persistent poverty among the rice farmers in the country. Therefore, the government has to provide a significant amount of fertilizer subsidies to modern farmers. In 2009, the cost of fertilizer subsidies was Rupee (Rs.) 24,705 million, which represented 3% and 0.6% of government expenditures and gross domestic product (GDP), respectively (DCS [2]). In addition, health problems related to the use of agrochemicals have also added to the unaccounted costs of the rice farmers. Fourth, the indigenous rice varieties (heterogeneous varieties), which