IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Farm Specific Production Function Model For the Study of Technical Efficiency in Rice Production: Thoubal and Bishnupur Districts of Manipur

Narumbam Achouba,
Department of Economics,
N.G.College, Imphal

Abstract

A farm level study of rice production in Thoubal and Bishnupur districts of Manipur was carried on with the field survey data on the input uses in these districts. Six farm specific production function models were employed for selecting the best model by using the data from the field survey and applied the model for further study. Translog Production Function model was found to be the best model from among the models so studied. This production function model is applied for the stochastic frontier production and technical efficiency measure of rice production these districts. The study found that there is a large gap between actual production per hectare and potential production per hectare. Most of the farmers were found inefficient in input used and there is sufficient room for increasing yield of rice with the same amount of inputs used.

Keywords: Stochastic Frontier Production Function, Technical Efficiency, Yield Gap

Introduction:

The present study is an attempt to investigate how the farmers in Thoubal and Bishnupur districts of Manipur are using their inputs efficiently in rice cultivation. A field survey was conducted during 2015-16 to collect data relating to the inputs used by the farmers in these districts. Rice productivity would depend on various factors, viz. fertility of the land, rice variety, methods of cultivation, applications of chemicals and fertilizers, level of farm mechanization, irrigation facilities, rainfall, etc. This is a crucial area for study since majority of the people in the state are employed in this sector. To derive technical efficiency measures, various production function models at the farm level are studied and from these, the best model is selected by using the Field Survey data. The best model thus selected is used for further study of Stochastic Frontier Production Function and Technical Efficiency measure.

Objectives:

- To select the best model for analysis of Stochastic Frontier Production Function and Technical Efficiency measure of rice production in Thoubal and Bishnupur Districts of Manipur,
- To examine input use efficiency among the rice farmers with the help of technical efficiency analysis.

Methodology:

The present investigation is based mainly on primary sources of data collected from the farmers in the study area by *multi-stage stratified random sampling method.*

Primary sources of data on related aspects of cultivation method and various inputs used in rice cultivation by the farmers are collected with the help of survey method in a specially designed questionnaire. In the first stage, four villages from each of Thoubal and Bishnupur districts were selected *purposively*. By using Electoral Roll of the respective villages, 50 rice farmers from each village were *randomly* selected. There are, altogether 400 (50 x 8) farmers, 200 each from the two districts in the randomized selection. In the second stage, 20 respondents out of 50 farmers from each village were picked up *randomly*. Altogether, 160 respondent farmers, 80 from each district were selected for the study.

Yield rate and production of paddy is in the form of 'clean rice'. Weight of green paddy is converted into clean rice by using the standard conversion factor (i.e. 1kg of green paddy=0.667kg of clean rice) as given by the Driage Experiment for all the sample villages.

Criteria for Model Selection:

With an increase in the numbers of variables in a model, the residual sum of squares $\sum \bar{\upsilon}_t^{\,2}$ will decrease and R^2 will increase, but at the cost of a loss in degrees of freedom. R bar Square and the standard error of residuals, $[ESS/(n-k)]^{1/2}$ (ESS is residual sum of squares, n is number of observations and k is number of parameters) takes account of the trade-off between the reduction in ESS and the loss of degrees of freedom. These are the most commonly used criteria for model selection.

Simpler models are generally recommended for two technical reasons: firstly, the inclusion of too many variables makes the relative precision of individual coefficients worse, and secondly, the resulting loss of degrees of freedom would reduce the power of tests performed on the coefficients. Thus, the probabilities of not rejecting a false hypothesis (type II error) increase as the degrees of freedom decrease. Simpler models are also easier to comprehend than complex models. It is therefore, desirable to develop criteria that penalize larger models but do not go to the extreme of always choosing.

Several criteria for choosing among models have been proposed and all of these take the form of the residual sum of squares (ESS) multiplied by a penalty factor that depends on the complexity of the model. A more complex model will reduce ESS but raise the penalty. The criteria thus provide other types of trade-off between goodness of fit and model complexity. A model with a lower value of a criterion statistic is judged to be preferable.

Akaike (1970, 1974) developed two procedures, one known as the finite prediction error (FPE) and the other known as Akaike information criterion (AIC). Hannan and Quinn (1979) suggested another procedure known as HQ criterion. Other criteria include those suggested by Schwarz (1978), Shibata (1981) and Rice (1986) and a generalized cross validation (GcV) method developed by Craven and Wahba (1979) and used by Engle, Granger, Rice and Weiss (1986). Each of these statistics is based on some optimality property.

An ideal model has lower values for all these statistics, as compared to an alternative model. Although it is possible to rank some of these criteria for a given ESS, n, and k, this ordering is meaningless because models differ in both ESS and k. Ramanathan (1992) examined certain special cases more closely and in these special cases, some of the criteria might become redundant - i.e., a model found to be superior under one criterion will also be superior under a different criterion. In general, it is possible to find a model superior under one criterion and inferior under another. For example, the Schwarz criterion penalizes model complexity more heavily than do other measures and hence might give a different conclusion. A model that outperforms another in several of these criteria might be preferred. The AIC criterion, however, is a commonly used in time series analysis.[1]

Analysis of Farm Specific Production Functions:

By considering the above criteria for selecting the best model for further analysis in determining Frontier Production Function and Technical Efficiency measure, the Field Survey data is fitted to the models and tested for Akaike Information Criterion (AIC), Schwarz Criterion and R-squared estimate. Those models are:

(i) Cobb-Douglas Type Production Function,
(ii) Transcendental logarithmic or Translogarithmic or Translog Production Function,
(iii) Transcendental Production Function,
(iv) Log-Linear Functional model,
(v) Linear-Log Functional model, and
(vi) Simple Linear Model

The above production function models were estimated and the estimates in which explanatory variables having statistically insignificant parameters were excluded from the model and the refined model was again estimated for further analysis.

(1) The specified Cobb-Douglas Type Production Function in the fitted model is as follows:

$$YD = \beta_o\, AA^{\beta 1} MD^{\beta 2} FM^{\beta 3}\, e^u \qquad (1)$$

Where, YD = production of rice in kg.
AA = area in hectares,
MD = Human labour in mandays, and
FM = cost of fertilizers and hiring farm machineries
The linearized version, used for estimation is as follows:

$$\log (YD) = \log \beta_o + \beta_1 \log (AA) + \beta_2 \log (MD) + B_2 \log(FM) + u$$

Or in the form

$$\log (YD) = \alpha + \beta_1 \log(AA) + \beta_2 \log (MD) + B_2 \log (FM) + u \qquad (2)$$

Where $\alpha = \log \beta_o$

This model is linear in parameters $\alpha + \beta_{1,}$ linear in the logarithms of the variables included in the model and can be estimated by the method of OLS. Since both sides of the equation are in logarithm of variables, such models are also known as double-log models.

The estimated equation is given below

log (YD)=7.6558+0.8287log(AA)+0.0349log(MD)+0.0456log(FM)
(33.096)*** (14.190)*** (0.790) (0.968)

[1] (i) Ramanathan, R. (2002), 'Introductory Econometries with Applications', Thomson Asia Pte Ltd., Singapore, Fifth Edition, pp. 151-152.
(ii) Damodar, N. Gujarati (2004) : 'Basic Econometrics'. Fourth edition, McGraw Hill, New Delhi, pp-536-38

N.B. figures within brackets indicates t-values, ***is significant at 1% level of significance.
Adjusted R-squared = 0.971308
Akaike info criterion = -1.864465
Schwarz criterion = -1.787585

(2) The general form of the Translog Production Function is given as:

$$\log Y = \beta_o + \sum_{i=1}^{n} \beta_i \log X_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{k=1}^{n} \beta_{ik} \log X_i \log X_k + \varepsilon_i \qquad (3)$$

The three explanatory variables are fitted in the above Translog Production Function (3) and the fitted model is specified as follow:

$$\log(YD)=\alpha_o + \beta_1\log(AA)+ \beta_2\log(MD)+ (\beta_3\log(FM) + \beta_4\log(AA^2)/2 + (\beta_5\log(MD)^2)/2+(\beta_6\log(FM)^2)/2 + \beta_7\log(AA)\log(MD)+ \beta_8\log(AA)\log(FM)+ \beta_9\log(MD)\log(FM)+ \epsilon_i \qquad (4)$$

Where α_o is the intercept and β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 and β_9 are the parameters to be estimated, and
YD = production of rice in kg,
AA = area under rice in hectares,
MD = human labour in mandays, and
FM = cost of fertilizers and hiring farm machineries.
After substituting the values of the coefficients

$$Log(YD)=-10.2- 7.5 \log(AA)+4.3 \log(MD)+4.9 \log(FM)+(-2.0 \log(AA)^2)/2+(-0.2 \log(MD)^2)/2+$$
(-1.59) (-2.6)** (2.03)** (3.36)*** (-2.82)** (-0.57)

$$(-0.1 \log(FM)^2)/2+1.1 \log(AA)\log(MD)+0.9 \log(AA)\log(FM)-0.9 \log(MD)\log(FM)$$
(-0.72) (2.26)** (3.07)*** (-2.81)**

N.B. figures within brackets indicate t-values, *** and ** are significant at 1% and 5% respectively.
Adjusted R-squared = 0.974872
Akaike info criterion = -1.980370
Schwarz criterion = -1.788172

(3) The explanatory variables from the Field Survey data were also fitted to the Transcendental Production Function and the fitted model is as follow:

$$YD= \beta_o AA^{\beta 1} MD^{\beta 2} FM^{\beta 3} e^{\beta_4 \log(AA)+\log \beta_5 (MD)+ \beta_6 \log(FM)} \qquad (5)$$

After taking logarithms and adding the stochastic disturbance term, the stochastic Transcendental Production Function can be stated as:

$$\log(YD) = \log \beta_0 + \beta_1\log (AA) + \beta_2\log (MD) + \beta_3\log (FM) + \beta_4 (AA) + \beta_5 (MD) + \beta_6 (FM)+ u$$

Or, in the form, in which $\alpha=\log \beta_0$ is the intercept and β_1 , β_2 , β_3 , β_4 , β_5 and β_6 are the parameters to be estimated.

$$\log(YD) = \alpha + \beta_1\log (AA) + \beta_2\log (MD) + \beta_3\log (FM) + \beta_4 (AA) + \beta_5 (MD) + \beta_6 (FM)+ u \qquad (6)$$

By substituting the parameter values in (5.4.6), estimated Transcendental Production Function becomes

$$\log(YD)=7.12 +0.77 \log(AA) +0.09 \log(MD) +0.19 \log(FM) +0.09 \log(AA) - 0.001 (MD) - 0.008 (FM)$$
(13.77)*** (5.64)*** (1.16) (1.53) (0.55) (-0.85) (-1.27)

N.B. figures within brackets indicate t-values, *** is significant at 1%
Adjusted R-squared = 0.9729
Akaike infor criterion = -1.9248
Schwarz criterion = -1.7902

Over and above the commonly used production function specifications presented in (1), (3) and (5), other types of functional relationships between production and explanatory variables, viz. Log-Linear model, Linear-Log model, and Linear model are also examined.

(4) The Field Survey data fitted to the Log-Linear Production Function may be stated as follows:

$$\log(YD) =\alpha + \beta_1 (AA) + \beta_2 (MD) + \beta_3 (FM) + u \qquad (7)$$

The model estimated using OLS

$$\log(YD)=6.597+0.691 (AA)+0.004 (MD)+0.005 FM)$$
(210.16)*** (4.27)*** (3.028)** (0.901)

N.B. figures within brackets indicate t-values, *** and ** are significant at 1% and 5% respectively.
Adjusted R-squared = 0.850
Akaike info criterion = -0.231
Schwarz criterion = -0.1538

(5) Linear – Log Model fitted with the above explanatory variables is presented below:

$YD = \alpha + \beta_1 \log(AA) + \beta_2 \log(MD) + \beta_3 \log(MD) + \beta_4 (FM) + u$ (8)

$YD = 3403.682 + 1815.101 \log(AA) - 89.546 \log(MD) - 1.496 \log(FM)$

(4.31)*** (9.11)*** (-0.59) (-0.01)

N.B. figures within brackets indicate t-values; *** is significant at 1%.

Adjusted R-squared = 0.911
Akaike info criterion = 14.405
Schwarz criterion = 14.482

(6) The explanatory variables from the Field Survey data was also fitted in the simple Linear Model which takes the form:

$YD = \alpha + \beta_1(AA) + \beta_2(MD) + \beta_3(FM) + u$ (9)

The estimated linear production function is given as under:

$YD = 258.56 + 2173.93(AA) + 2.18(MD) + 5.69(FM)$

(7.779)*** (12.681)*** (1.518) (1.017)

N.B. figures within brackets indicate t-values, *** is significant at 1%.

Adjusted R – squared = 0.956
Akaike info criterion = 13.699
Schwarz Criterion = 13.776

TABLE:1

Estimated Values of Adjusted R-squared, Akaike info criterion and Schwarz criterion

Production Function models	Adjusted R-squared	Akaike info criterion	Schwarz criterion	Remarks
Extended Cobb-Douglas Type Production	0.971	-1.864	-1.787	All the variables are not statistically significant
Translog Production Function	**0.975**	**-1.980**	**-1.788**	**All the variables are statistically significant**
Transcendental Production Function	0.973	-1.925	-1.790	All the variables are not statistically significant
Linear-Log Function	0.911	14.405	14.482	All the variables are not statistically significant
Log-Linear Function	0.850	-0.231	-0.154	All the variables are not statistically significant
Linear Production Function	0.956	13.699	13.776	All the variables are not statistically significant

The study of six alternative production function models which could be applied to the Field Survey data on rice farmers in Thoubal and Bishnupur districts are given in the above Table 1. All the estimated parameters in the cases of production function models, viz. Extended Cobb Douglas model, Log-Linear model, Linear-Log model, Linear model and Transcendental model are found statistically insignificant. But, in the case of Translog Production Function model, the estimated parameters are found statistically significant. Therefore, statistically insignificant production function models are discarded for further study.

In the case of Translog Production model, adjusted R-squared is estimated at 0.974872, which is sufficiently high, all the parameters are statistically significant and values of Akaike Information Criterion and Schwarz Criterion are found comparatively lower than other models. Therefore, Translog Production Function model is considered to be the best model among the models studied and so, this model is used for study of stochastic frontier production function and technical efficiency.

Technical Efficiency Measure

The empirical model of Translog production Function model considered for the present study consists of two stages. In the First stage, the Stochastic Frontier Function is estimated and in the second stage, Technical Efficiency indices for each farmer are estimated.

The general form of the Translog Production Function considered for the present study is given as:

$$\log Y = \beta_o + \sum_{i=1}^{n} \beta_i \log X_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{k=1}^{n} \beta_{ik} \log X_i \log X_k + \varepsilon_i \quad (10)$$

The three explanatory variables are fitted in the above Translog Production Function (1) and the fitted model is specified as follow:

$$\log(YD)=\alpha_o+\beta_1\log(AA)+\beta_2\log(MD)+\beta_3\log(FM)+(\beta_4\log(AA)^2)/2+(\beta_5\log(MD)^2)/2+(\beta_6\log(FM)^2)/2+\beta_7\log(AA)\log(MD)+\beta_8\log(AA)\log(FM)+\beta_9\log(MD)\log(FM)+\epsilon_i \quad (11)$$

Where α_o is the intercept and β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 and β_9 are the parameters to be estimated, and
YD = production of rice in kg,
AA = area under rice in hectares,
MD = human labour in mandays, and
FM = cost of fertilizers, chemicals and hiring farm machineries.

The estimated equation is given as:

$$\text{Log}(YD)=-10.2-7.5\log(AA)+4.3\log(MD)+4.9\log(FM)+(-2.0\log(AA)^2)/2+(-0.2\log(MD)^2)/2+(-0.1\log(FM)^2)/2+1.1\log(AA)\log(MD)+0.9\log(AA)\log(FM)-0.9\log(MD)\log(FM) \quad (12)$$

The Stochastic Frontier Production Function is given by:

$$\log(YD_F)=\beta_o+\beta_1\log(AA)+\beta_2\log(MD)+(\beta_3\log(FM)+(\beta_4\log(AA)^2)/2+(\beta_5\log(MD)^2)/2+(\beta_6\log(FM)^2)/2+\beta_7\log(AA)\log(MD)+\beta_8\log(AA)\log(FM)+\beta_9\log(MD)\log(FM)+\epsilon_i \quad (13)$$

Where YD_F is the potential rice production at the farm level and β_o is the adjusted intercept term. The estimated equation is given as:

$$\log(YD_F)=-9.89-7.53\log(AA)+4.30\log(MD)+4.95\log(FM)+(-2.02\log(AA)^2)/2+(-0.23\log(MD)^2)/2+(-0.11\log(FM)^2)/2+1.13\log(AA)\log(MD)+0.94\log(AA)\log(FM)-0.98\log(MD)\log(FM)$$

The estimated Frontier Production Function indicates that the elasticity of rice production with respect to area is highest among the other inputs used in production. It means that area under rice has the highest influence on production, and at the same time, human labour has the least impact on production.

Technical Efficiency indices for each farmer can be found out by using either the relations
TE = Actual Production/potential production or
TE = exp (residuals)/Max (exp (residuals).

The estimated technical efficiencies are tabulated into efficiency class indices as presented in Table 2. For comparative purpose, frequency distribution for each efficiency classes is sorted out.

Table 2:
Distribution of Technical Efficiency Indices among the 160 Farmers

Tabulation of TE Included observations: 160 Number of categories: 8

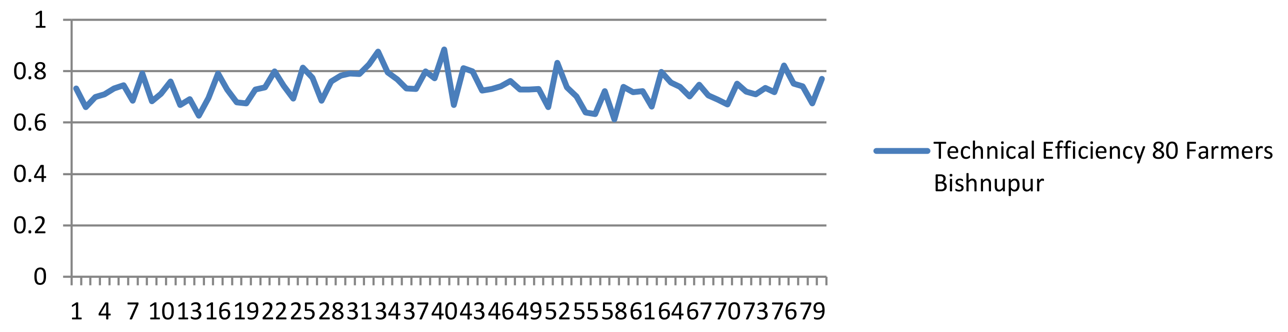
Efficiency Class	Count	Percent	Cumulative Count	Cumulative Percent
[0.6, 0.65)	8	5	8	5
[0.65, 0.7)	28	17.5	36	22.5
[0.7, 0.75)	53	33.12	89	55.62
[0.75, 0.8)	43	26.88	132	82.5
[0.8, 0.85)	21	13.12	153	95.62
[0.85, 0.9)	4	2.5	157	98.12
[0.9, 0.95)	2	1.25	159	99.38
[0.95, 1)	1	0.62	160	100
Total	160	100	160	100

Source: Estimated from the Field Survey Data

As revealed in the Table 2, efficiency levels of the farmers in this study are concentrated to 0.7-0.8., i.e. 60 percent of the farmers are operating within this efficiency level. Yield of rice in this efficiency level is around 3000 kg/ha to 3400 kg/ha. Farmers operating within the lowest efficiency level of 0.6-0.7 comprised of 22.5 percent of the 160 farmers investigated. These farmers are getting a yield of around 2300kg/ha to 2800kg/ha with the available inputs they employed. 13.12 percent of the farmers are operating at the efficiency level of 0.8-0.85, i.e. with a yield rate of around 3300kg/ha to 3400kg/ha. Farmers operating the efficiency level of 0.85-0.95 is 3.75 percent with a yield rate of around 3400kg/ha to 3600kg/ha. (ANNEXURE-1)

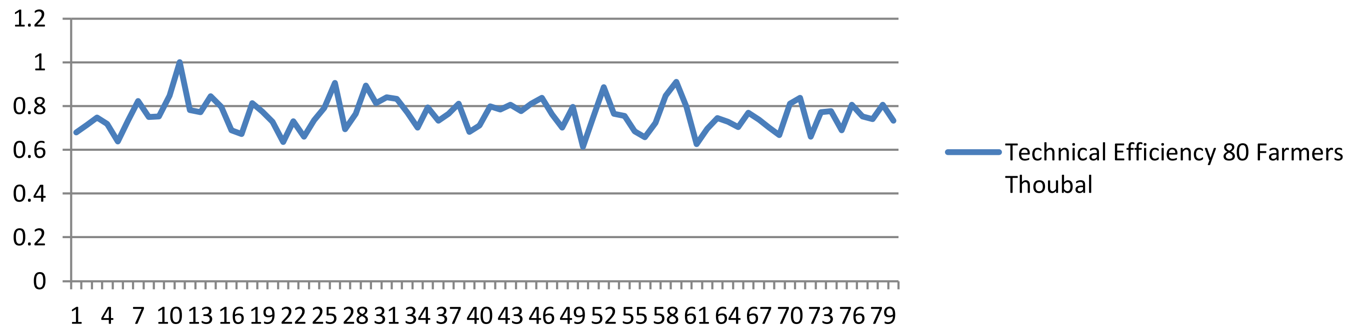
Technical efficiency graph of the farmers in Thoubal and Bishnupur districts is shown in figures 1A & 1B. Ups and downs in the graph may be the result of differences in input use, differences in soil characteristics, availability of irrigation facilities, etc. both in Thoubal and Bishnupur districts. Seed variety is an important determinant of yield. It was found in the survey that all the farmers in both the districts were using HYV seeds. There are also differences in productivity of YHV seeds depending on the seed variants. The graph also shows that the farmer in Bishnupur districts has a more uniform distribution of technical efficiency, i.e. the uses of inputs by the farmers are more or less the same. But in the case of Thoubal district, some farmers used the inputs more efficiently while some farmers could not utilise the inputs efficiently.

Figure 1A: Technical Efficiency Graph of 80 Farmers Bishnupur



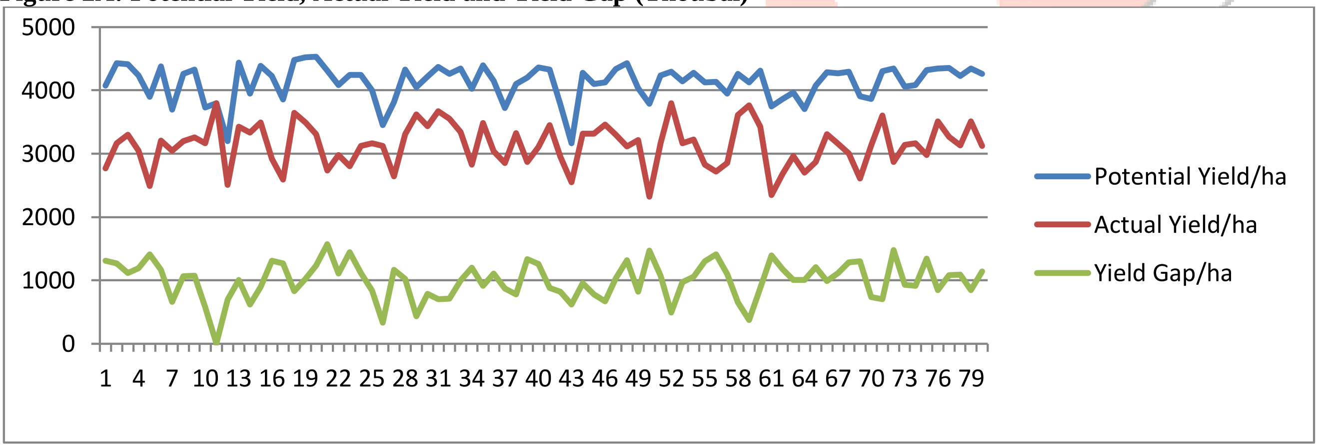
Source: Field Survey Data

Figure 1B: Technical Efficiency Graph of 80 Farmers Thoubal



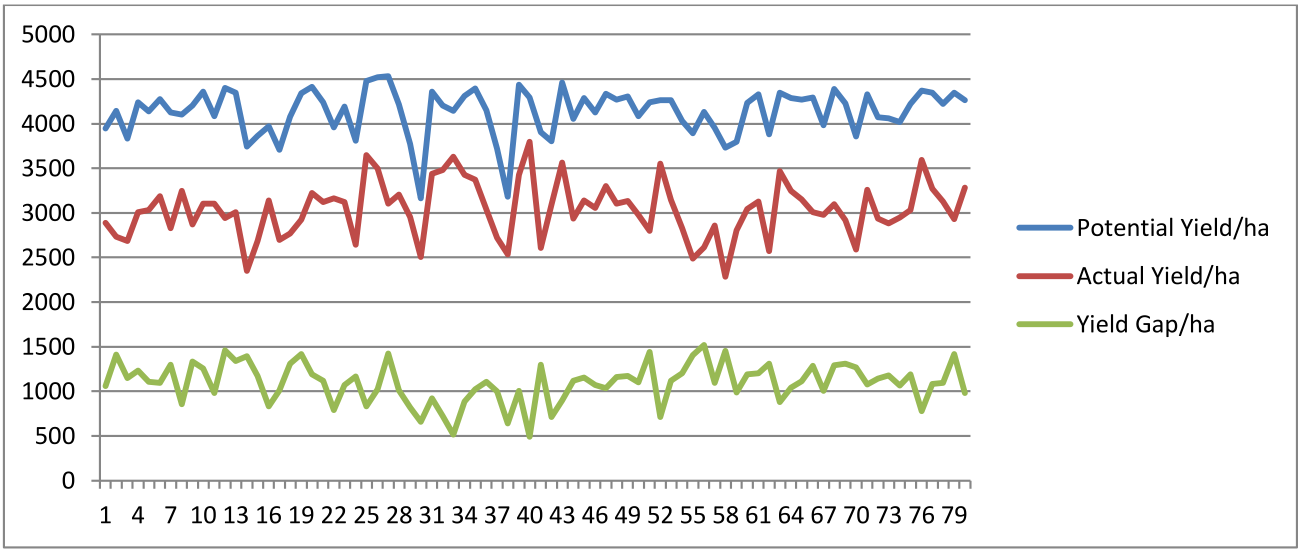
Source: Field Survey Data

Figure 2A: Potential Yield, Actual Yield and Yield Gap (Thoubal)



Source: Field Survey Data

Figure 2B: Potential Yield, Actual Yield and Yield Gap (Bishnupur)



Source: Field Survey Data

Graph of actual yield, potential yield and yield gap of rice per hectare for both the districts are shown in figures 2A & 2B. Actual yield per hectare is sorted out in ascending order with the corresponding potential yield per hectare so as to examine the yield gap and extent of improvement that can be given to input use. The potential yield per hectare only shows the maximum yield attainable by farmers with the present set of inputs they employed. Potential yield will change with the change in the combinations of inputs and therefore, farmers required to see both the potential attainable with the present set of inputs and potential attainable with a change in combination of inputs.

Conclusion

The present study found that most of the farmers were employing their inputs inefficiently in rice production; there is sufficient room for increasing yield of rice with the same amount of inputs used. There is a large gap between actual production per hectare and potential production per hectare. It means that there is sufficient room to increase efficiency of the currently employed inputs so as to narrow down the yield gap. Majority of the farmers in the sample survey were operating at a moderately high level of Technical Efficiency, i.e. 53(33.12%) and 43 (26.88%) out of the 160 farmers are operating at an efficiency class of (0.7, 0.75) and (0.75, 0.8) respectively. Whereas, 36(22.5%) farmers use the inputs at a very low efficiency level, and only 7(4.37%) farmers can employed the inputs at a high efficiency level. It was found that yield gap was highest in the case of villages in Bishnupur district at an average of 1096 kg per hectare. The average yield gap for the villages in Thoubal district was found at 995 kg per hectare. The maximum yield gap in the survey of 160 farmers was found at 1572 kg per hectare. The overall yield gap stood at around 1045 kg per hectare.

Reference:

1. Amaza, P. S., Maurice, D. C. (2005), 'Identification of Factors that Influence Technical Efficiency in Rice-Based Production Systems in Nigeria'. In the paper presented at Workshop on Policies and Strategies for Promoting Rice Production and Food Security in Sub-Saharan Africa, November 2005, Cotonou (Benin), pp.6-8
2. Anuradha, N., Zala Y.C. (2010), 'Technical Efficiency of Rice Farms under Irrigated Conditions in Central Gujarat'. In *Agricultural Economics Research Review*, Vol. 23, pp 379-380
3. Aigner, D.J., Lovell, C.A.K., Schmidt, P., (1977). 'Formulation and Estimation of Stochastic Frontier Production Function Models'. In Journal of Econometrics (vol. 6).
4. Christopher, M, Cornwell, Jens-Uwe Wachter.(1999). In 'Productivity Convergence and Economic Growth: A Frontier Production Function Approach', Working Paper, Center for European Integration Studies, Germany, (http://www.zei.de, accessed on 22-12-07)
5. Battese, G. E.(1991). 'Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics'. In the 35th Annual Conference of the Australian Agricultural Economics Society, University of New England, Armidale, 11-14 February, 1991, pp-13-28
6. Basnayake, B.M.J.K. et al (2002). 'Estimation of Technical Efficiency and its Determinants in the Tea Small Holding Sector in the Mid Country Wet Zone of Sri Lanka'. In Sri Lankan Journal of Agricultural Economics, Volume 4, Part-1, p-137
7. Battese, G.E., and Coelli, T.J. (1995), 'A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data'. In Empirical Economics, 20(2), (as referred by Jaume Puig-Junoy andJosep M. Argiles (2000): 'Measuring and Explaining Farm Inefficiency in a Panel Data Set of Mixed Farms'Pompeu Fabra Univ., Barcelona, Spain, P. 5
8. Dina, P., Fernandez, M., and Peter L. N. (2009). 'Technical Efficiency in the Production of Sugar Cane in Central Negros Area, Philippines: An Application of Data Envelopment Analysis'. In *J. ISSAAS Vol. 15 No. 1: 77-88*
9. Damodar, N. Gujarati (2004), 'Basic Econometrics'. Fourth Edision, Tata McGraw-Hill Publishing Company Limited, New Delhi, pp. 536-38
10. David, L. Debertin (1986), 'Agricultural Production Economics', Macmillan Publishing Company, New York, p. 190
11. Farrel, M. J. (1957), 'The Measurement of Production Efficiency'. In Journal of the Royal Statistical Society, Vol. 120 series A, Part 3. p. 253 (As referred by K.R. Shanmugam in Indian Journal of Agricultural Economics, Vol. 58 No. 1. Jan. – March 2003
12. GoM, Directorate of Economics & Statistics, (2012), 'Report on Crop Estimation Survey, Manipur 2011-12', pp-25-26
13. Huynh, V.K., Misuyasu, Y, (2011). 'Technical Efficiency Analysis of Rice Production in Vietnam'. In J.ISSAAS, Vol. 17, No. 1, pp.135-146
14. Idiong, I.C. (2007). 'Estimation of Farm Level Technical Efficiency in Small scale Swamp Rice Production in Cross River State of Nigeria: A Stochastic Frontier Approach'. In World Journal of Agricultural Sciences 3 (5), pp. 653-657, ISSN 1817-3047,© IDOSI Publications.
15. Jayaram. H. Et al (1992), 'An Economic Analysis of Technical Efficiency in Rice Cultivation in Mandya-Some Issues in Resource Pricing'. In Indian Journal of Agricultural Economics, Vol. 47 No. 4 Oct. – Dec. 1992, p. 671
16. Jaume, P. J. et al (2000), 'Measuring and Explaining and Farm Inefficiency in a Panel Data Set of Mixed Farms'. Pompeu Fabra University, C/Ramon Trias Fargas pp. 25-27,Barcelona
17. Krishna, R. (1964), 'Some Production Functions for the Punjab'. In Indian Journal of Agricultural Economics, Vol. 19, pp. 87-97
18. Klacek J. (2007), 'KLE Translog Production Function and Total Factor Productivity'. In Statistika 4/2007, p. 2

ANNEXURE-1

Estimates of Technical Efficiency (TE), Actual Yield of Rice in kg (YD) and Potential Yield of Rice in kg (YDF)

	Bishnupur						Thoubal					
Sl.No.	AA	FM	MD	TE	YD	YDF	AA	FM	MD	TE	YD	YDF
1	0.35	8	30	0.73231	1012	1381.929	0.758	24	90	0.679312	2100	3091.362
2	0.26	5.5	30	0.659278	710	1076.935	0.253	9	28	0.713743	800	1120.851
3	1.102	36	120	0.700394	2960	4226.192	0.38	13	42	0.747697	1254	1677.151
4	0.25	7	25	0.70983	752	1059.409	0.506	18	62	0.718568	1540	2143.151
5	0.75	21	75	0.732994	2276	3105.073	1.012	30	120	0.639152	2520	3942.724
6	0.506	14	50	0.7447	1612	2164.63	0.253	9	30	0.733201	812	1107.472
7	0.379	10	30	0.685159	1071	1563.14	1.265	37.6	150	0.822602	3850	4680.272
8	0.9	28	80	0.791414	2922	3692.128	0.225	8	30	0.750819	720	958.9531
9	0.506	14	40	0.682326	1452	2128.014	0.35	11	45	0.751926	1140	1516.106
10	0.255	8	20	0.712221	792	1112.014	1.153	37.5	140	0.846436	3960	4678.441
11	0.75	27	85	0.759403	2326	3062.934	1.012	36	120	0.999995	3840	3840.018
12	0.27	9	30	0.668281	794	1188.124	2.265	63	225	0.782304	5670	7247.818
13	0.26	8	28	0.691533	782	1130.821	0.35	11	30	0.772994	1200	1552.405
14	1.265	35	150	0.627049	2970	4736.474	0.95	27	120	0.844685	3168	3750.508
15	1.012	32	120	0.696062	2720	3907.699	0.25	8	24	0.796295	874	1097.584
16	0.758	24	105	0.790661	2380	3010.14	0.74	25	72	0.690162	2160	3129.701
17	1.26	40	140	0.727885	3400	4671.065	1.112	30	96	0.670973	2880	4292.272
18	0.758	24	90	0.679312	2100	3091.362	0.5	18	48	0.814396	1824	2239.696
19	0.253	6.5	35	0.673985	740	1097.947	0.375	13	36	0.773726	1311	1694.398
20	0.38	13	42	0.729809	1224	1677.151	0.253	9	24	0.728938	836	1146.874
21	0.365	10	32	0.736434	1140	1548	0.25	7.5	24	0.635011	684	1077.146
22	0.955	28	110	0.799979	3024	3780.099	0.255	7	20	0.729968	760	1041.142
23	0.74	22	60	0.744312	2310	3103.538	0.5	13	50	0.660151	1400	2120.727
24	1.112	27	100	0.693948	2940	4236.627	0.365	10	32	0.736434	1140	1548
25	0.5	18	48	0.814396	1824	2239.696	0.955	28	96	0.791753	3024	3819.372
26	0.375	13	36	0.773726	1311	1694.398	0.64	12	60	0.905146	2310	2552.074
27	0.253	9	24	0.685341	786	1146.874	1.112	27	100	0.693948	2940	4236.627
28	0.38	9	40	0.759736	1218	1603.188	0.506	15	48	0.763608	1672	2189.606
29	1.265	35	120	0.782935	3740	4776.897	0.9	27	90	0.893877	3256	3642.557
30	2.24	56	160	0.791425	5612	7091.007	0.25	7	24	0.81313	858	1055.181
31	0.506	12	65	0.788626	1740	2206.37	0.255	8	24	0.839575	936	1114.85
32	0.758	16	90	0.827217	2636	3186.587	0.355	10	30	0.832591	1260	1513.349
33	0.758	18	85	0.875708	2750	3140.315	0.5	15	44	0.769888	1672	2171.745
34	0.28	8	30	0.795282	960	1207.119	0.56	14	44	0.70214	1584	2255.961
35	0.36	11	34	0.767326	1214	1582.118	0.36	11	34	0.792608	1254	1582.118
36	0.76	22	62	0.732543	2310	3153.397	0.76	22	62	0.732543	2310	3153.397
37	1.112	28	80	0.731528	3028	4139.278	1.112	28	80	0.765351	3168	4139.278
38	2.265	68	225	0.798561	5750	7200.448	0.9	28	80	0.810373	2992	3692.128
39	0.35	11	30	0.772994	1200	1552.405	0.506	14	40	0.682326	1452	2128.014
40	0.5	14	50	0.885629	1900	2145.367	0.255	8	20	0.712221	792	1112.014
41	1.012	32	112	0.667753	2640	3953.56	0.38	11	35	0.797569	1313	1646.252
42	1.012	32	130	0.812473	3128	3849.975	1.265	35	120	0.782935	3740	4776.897
43	0.506	11	70	0.799196	1804	2257.269	2.24	56	160	0.805527	5712	7091.007
44	0.758	22	105	0.7246	2228	3074.8	0.506	14	50	0.776114	1680	2164.63
45	0.253	7	30	0.731493	794	1085.451	0.253	7	20	0.809639	840	1037.5

46	0.25	7	20	0.740482	764	1031.76	0.25	7	20	0.837404	864	1031.76
47	0.3	9	25	0.761501	990	1300.064	0.3	9	25	0.761501	990	1300.064
48	0.506	14	48	0.72788	1572	2159.697	0.35	11	25	0.702508	1089	1550.16
49	0.25	7.5	24	0.727849	784	1077.146	0.26	7	20	0.796482	836	1049.616
50	0.255	7	20	0.729968	760	1041.142	1.102	29	80	0.61277	2560	4177.753
51	0.5	13	50	0.660151	1400	2120.727	0.25	7	25	0.747587	792	1059.409
52	0.355	10	30	0.832591	1260	1513.349	0.5	14	50	0.885629	1900	2145.367
53	0.5	14	44	0.73765	1572	2131.093	0.75	21	75	0.765199	2376	3105.073
54	0.56	14	44	0.70214	1584	2255.961	0.506	14	50	0.753939	1632	2164.63
55	1.012	30	120	0.639152	2520	3942.724	0.379	10	30	0.685159	1071	1563.14
56	0.55	14	48	0.632095	1436	2271.81	0.55	14	48	0.658506	1496	2271.81
57	1	28	80	0.722511	2856	3952.881	1	28	80	0.722511	2856	3952.881
58	1.253	37.5	140	0.611315	2860	4678.441	0.758	24	60	0.846574	2736	3231.851
59	1.012	36	120	0.73958	2840	3840.018	0.758	21	75	0.91039	2850	3130.528
60	0.506	18	62	0.718568	1540	2143.151	0.28	8	30	0.795282	960	1207.119
61	0.253	7	40	0.722701	792	1095.888	1.265	35	150	0.627049	2970	4736.474
62	1.265	27.5	150	0.661898	3250	4910.122	1.012	32	120	0.696062	2720	3907.699
63	0.225	6	40	0.797773	780	977.7219	0.758	27	95	0.745923	2244	3008.352
64	0.506	16	60	0.756744	1642	2169.823	1.26	40	140	0.727885	3400	4671.065
65	0.253	7	28	0.738915	798	1079.962	0.758	24	90	0.704544	2178	3091.362
66	0.379	10	40	0.700755	1140	1626.818	0.506	16	60	0.77057	1672	2169.823
67	0.95	27	105	0.747419	2828	3783.686	0.253	7	28	0.738915	798	1079.962
68	0.25	8	24	0.705185	774	1097.584	0.379	10	40	0.700755	1140	1626.818
69	0.74	25	72	0.690162	2160	3129.701	1.012	32	112	0.667753	2640	3953.56
70	1.112	30	96	0.670973	2880	4292.272	1.012	32	120	0.810707	3168	3907.699
71	0.35	11	45	0.751926	1140	1516.106	0.506	14	65	0.837854	1824	2176.991
72	0.379	41	45	0.720009	1112	1544.426	0.379	11	38	0.660892	1089	1647.772
73	0.8	27	90	0.710494	2308	3248.446	0.8	27	90	0.772061	2508	3248.446
74	0.9	25	105	0.734365	2656	3616.728	0.75	27	85	0.775727	2376	3062.934
75	0.25	7	24	0.71836	758	1055.181	0.27	6	35	0.69009	805	1166.515
76	0.255	8	24	0.821635	916	1114.85	0.26	8	28	0.806494	912	1130.821
77	0.38	11	40	0.751374	1242	1652.973	0.38	11	40	0.751374	1242	1652.973
78	0.253	7	25	0.741217	792	1068.512	0.253	7	25	0.741217	792	1068.512
79	0.26	8	28	0.673847	762	1130.821	0.26	8	28	0.806494	912	1130.821
80	0.38	10	38	0.770159	1248	1620.445	0.38	10	38	0.733132	1188	1620.445

YD = production of rice in kg, AA = area under rice in hectares, MD = human labour in mandays, and FM = cost of fertilizers and hiring farm machineries.