Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 498-502
Received: 03-05-2018
Accepted: 07-06-2018

K Thomas Felix
Research Scholar, Department of Agricultural Economics, TNAU, Coimbatore, Tamil Nadu, India

Dr. S Murali Gopal
Professor, Department of Agricultural Economics, TNAU, Coimbatore, Tamil Nadu, India

Dr. KR Ashok
Professor and Head, Department of Agricultural and Rural Management, TNAU, Coimbatore, Tamil Nadu, India

Dr. S Panneerselvam
Professor and Head, Agro Climate Research Centre, TNAU, Coimbatore, Tamil Nadu, India

Dr. MR Duraisamy
Professor and Head, Department of Physical Science and Information Technology, TNAU, Coimbatore, Tamil Nadu, India

Correspondence
K Thomas Felix
Research Scholar, Department of Agricultural Economics, TNAU, Coimbatore, Tamil Nadu, India

Technical efficiency of maize production in different vulnerable agro climatic zones of Tamil Nadu

K Thomas Felix, Dr. S Murali Gopal, Dr. KR Ashok, Dr. S Panneerselvam and Dr. MR Duraisamy

Abstract
The main objective of this study is to estimate the level of technical efficiency in maize production in North Western and Southern zone of Tamil Nadu using the Stochastic Frontier Approach. The study will also attempt to determine factors which influence technical efficiency of maize production in two different vulnerable agroclimatic zones of Tamil Nadu. This study utilizes the most recent development in the stochastic frontier modeling by using a one-step process in Rstudio and primary cross-sectional data (2016-2017) for the agricultural year. The results indicated that, in the case of adopters, nitrogen fertilizer usage had positive significant impact on output at one percent level in both zones, phosphorous fertilizer usage in southern zone, seed rate and human labour in north western zone showed a positive impact on yield but machine hours in southern zone, farm yard manure in north western zone were found to be negative impact on yield at one percent level. In the case of adopters, phosphorous fertilizer usage had positive significant impact on output at one percent level in both zones, nitrogen fertilizer usage in southern zone, potash fertilizer usage and rupees spend on plant protection chemicals in north western zone showed a positive impact on yield but potash fertilizer usage and machine hours in southern zone, seed rate and human labour in north western zone were found to be negative impact on yield at one percent level. The results evident that the mean technical efficiency of adopter category in less vulnerable (southern zone) had the highest value with 93.96 percent followed by adopter category in high vulnerable zone with 89.52 percent followed by non adopter category in less vulnerable zone with 77.51 percent and finally non adopter category in high vulnerable zone with 77.11 percent. Based on the results appropriate policy were suggested to the present study.

Keywords: technical efficiency, frontier, maize, agro climatic zone, Tamil Nadu

1. Introduction

Maize (*Zea mays*) is one of the most important cereals of the world that provides more human food than any other cereal. Maize is an origin of America and domesticated about 7000 years ago. Globally, maize is known as "*Queen of cereals*" because it has the highest genetic yield potential among the cereals. It is cultivated in about 160 countries and having wider diversity of soil, water, climatic condition and adapted to varied management practices that contributes 36 per cent (782 million tonnes) of the global grain production. Global production of maize has grown at a CAGR (Compound Annual Growth Rate) of 3.4 per cent over the last ten years, from 717 million tonnes in 2004-05 to 967 million tonnes in 2013-14 (USDA report). The crop has tremendous genetic variability, which enables it to thrive in tropical, subtropical, and temperate climates. The world maize production was around 991.92 million tonnes in 2014-2015 covering an area of 177.77 million hectares with an average yield of 6.5 to 7.0 tonnes per hectare. Maize is the third most important cereal crop in India after rice and wheat. It accounts for 9 per cent of total food grain production of the country. Maize production in India has grown at a CAGR of 5.5 per cent over the last ten years from 14 million tonnes in 2004-05 to 23 million tonnes in 2013-14. During 2009-10 there was a decline in production primarily due to drought that affected production of *kharif* crops in the country. The area under maize cultivation in the period has increased at a CAGR of 2.5 per cent from 7.5 million hectare in 2004-05 to 9.4 million hectare in 2013-14, the remaining increase in production is due to increase in yield. Factors such as adaptability to varied agro-climatic conditions, less labour intensive and low water consuming crop and many areas, Maize become alternate cop to rice and cotton, which resulted in increase in area under Maize. At present in Tamil Nadu, the area under maize has exceeded 2.91 lakh ha with the production of 9.46 lakh tonnes and productivity of 4389 kg per hectare. Maize demand in India continues to increase with the rate of 5.41 percent each year compared to 3.21 percent production increase rate.

Due to forementioned issue, the government endeavor to apply maize self-sufficiency policy. The policy is made by the government in line with the increasing maize consumption. In order to achieve maize self-sufficiency, efforts could be directed in increasing production, either through increased productivity and expansion. Increased production should also be followed by competitiveness improvement, ensuring that the products are capable to compete in domestic and international markets. Mentioned objectives could be achieved by increasing farming efficiency. One method to improve farming efficiency is by utilizing farm inputs optimally. This study aims to estimate the technical efficiency of a wide range of farmers in North Western and Southern zone of Tamil Nadu, in order to formulate policies for enhancing maize productivity.

2. Methodology

Tamil Nadu state is classified into seven distinct agro-climatic zones namely North Eastern zone, North Western zone, Western zone, Cauvery Delta zone, Southern zone, High Rainfall zone andHilly zonebased on rainfall distribution, irrigation pattern, soil characteristics, cropping pattern and other ecological, social and physical status. Of the five zones, the North East zone and Southern zone occupies the first two places with 24 per cent and 20 per cent of the total area followed by Cauvery delta (15 per cent), North West (14 per cent), Western zone (12 per cent) and hilly zones which occupy less than four per cent of the geographic area. Based on the vulnerability index, the present study focuses on the North western (most vulnerable) and Southern zone (less vulnerable) of Tamil Nadu.

Based on the Adoption Index, The respondents were classified as adopters if the adoption index was 50 or above. The recommended practices for crop production are given in the 'Package of Practices' approved by the State Department of Agriculture in consultation with the Tamil Nadu Agricultural University. From this package of practices technologies recommended for rainfall variability/water stress were identified to quantify adoption. The recommended technologies considered in the present study were change in cropping pattern, change in variety, change in irrigation method, drought tolerant varieties, mulching, summer ploughing and agricultural allied activities like animal husbandry.

Data were collected through a well structured and pre tested interview schedule from randomly selected maize farmers in more vulnerable zone (North Western zone) also in less vulnerable zone (Southern zone)

2.1 Technical Efficiency analysis

It is hypothesized that technology adoption increases technical efficiency and thus leads to higher yield (due to direct and indirect effects), higher productivity, and ultimately higher income. The level and determinants of technical efficiency (TE) were estimated to identify the causes of efficiency (or inefficiency) and to analyze whether technology adaptation leads to higher efficiency. A stochastic function approach proposed by Battese and Coelli (1995) [2] was used in the study in which the technical inefficiency effects in a stochastic frontier are an explicit function of other farm-specific explanatory variables, and all parameters are estimated in a single-stage maximum likelihood (ML) procedure. The stochastic production frontier is defined as

$$LnY_i = \beta_0 + \sum_{j=1}^{n} \beta_j Ln(X_{ij}) + (v_i - u_i)$$

where subscript i refers to the i^{th} farmer; Ln represents the natural logarithm; Y is that the ascertained farm yield (Kg/ha); X_1 is that the total farm yard manure (t/ha); X_2 is that the total seed rate (Kg/ha); X_3 is that the quantity of nitrogen applied (kg/ha); X_4 is that the quantity of phosphorous applied (kg/ha); X_5 is that the quantity of potash applied (kg/ha); X_6 is that the amount spent on plant protection chemicals (Rs/ha); X_7 is that the total machine hours used (hrs/ha); X_8 is that the total irrigation water applied (mm/ha); and X_9 is that the pre harvest labor use of family and employed labor (person days/ha).

The above equation has two error terms: one (v_i) to account for random shocks (weather conditions, disease, measurement errors in the output variable, etc. and the combined effects of unobserved/uncontrollable inputs on production) and the other (u_i) to account for technical inefficiency in production. The v_i is a random error that is assumed to be independently and identically distributed N (0, σ_v^2) and independent of the u_i;u_i is a nonnegative random variable. The model, defined by in the above equation, is a stochastic frontier function because the random error (v_i) can be positive or negative and the output values are bounded above by the stochastic (random) variable, exp($X_i\,\beta$+v_i).

The farm-specific technical efficiencies (TE_i) are computed by taking the exponentiation of the negative of u_i, that is

$$TE_i = \exp(-u_i)$$

The estimation of technical efficiencies is based on the conditional expectation of exp (-u), given the model specification ((Coelli, 1996) [3]; (George E Battese & Broca, 1997)) [1].

3. Results and Discussion

3.1 Technical Efficiency in Maize Production

3.1.1 Technical efficiency in maize production of southern agro climatic zone of Tamil Nadu

The frequency distributions of technical efficiency of maize farmers are presented in Table 3.1.

The results indicated that, in the case of adopters, nitrogen fertilizer and phosphorous fertilizer usage had positive significant impact on output at one percent level, but potash fertilizer usage and machine hours were found to be negative impact on yield at one percent level. In the case of non adopters, the use of farm yard manure and phosphorous fertilizer usage had positive and significant impact on output but the variable human labour in man days had significant negative impact on output.

In the case of Adopters, the estimated lamda (λ) parameter is 89.042, which means that the total error variance is mainly due to inefficiency, whereas random errors are less important. The percentage of total variation due to variation in efficiency is 99.987 per cent. The estimated variance for the variation in efficiency is sigma^{2}u value is equal to 0.008664102 is considerably larger than variation due to random errors sigma^{2}v value is equal to1.09E-06.

Similarly for non adopters, the estimated lamda (λ) parameter is 2.444, which means that the total error variance is mainly due to inefficiency, whereas random errors are less important. The percentage of total variation due to variation in efficiency is 85.663 per cent. The estimated variance for the variation in efficiency is sigma^{2}u value is equal to 0.435629868 is considerably larger than variation due to random errors sigma^{2}v value is equal to 0.072907.

Table 3.1: Maximum Likelihood Estimates for maize production in Southern Agro climatic zone of Tamil Nadu

	Adopters				Non Adopters			
	Parameters	**Std.err**	**t-value**	**Pr(>|t|)**	**Parameters**	**Std.err**	**t-value**	**Pr(>|t|)**
Intercept	3.298***	1.058	3.119	0.005	4.730 NS	3.324	1.423	0.165
Farmyard Manure	-0.042NS	0.044	-0.941	0.358	0.189***	0.069	2.725	0.010
Seed rate	-0.233 NS	0.096	-2.426	0.025	0.249 NS	0.180	1.381	0.177
Nitrogen (Kg/ha)	0.482***	0.029	16.537	0.000	0.153 NS	0.412	0.372	0.712
Phosphorous (Kg/ha)	0.160***	0.025	6.509	0.000	0.332***	0.145	2.282	0.029
Potash (Kg/ha)	-0.373***	0.027	-14.031	0.000	-0.453***	0.167	-2.720	0.010
Human Labour (Mandays)	-0.076 NS	0.040	-1.869	0.077	-0.283 NS	0.212	-1.336	0.191
Plant Protection Chemicals (Rs)	-0.010 NS	0.061	-0.160	0.874	-0.072 NS	0.314	-0.229	0.820
Machine hours	-0.387***	0.048	-8.144	0.000	-0.244 NS	0.128	-1.901	0.066
Irrigation (mm/ha)	0.115 NS	0.105	1.095	0.287	-0.056 NS	0.329	-0.170	0.866
Lambda	89.042**	35.699	2.494	0.012	2.444***	0.524	2.756	0.009
$Sigma^2$	0.009				0.509			
$Sigma^2v$	0.000				0.073			
$Sigma^2u$	0.009				0.436			
Log likelihood	50.940				1.264			
Variation in efficiency	99.987				85.66337			

Note: ***- Significant at 1 per cent level, **-Significant at 5 per cent level,NS- Non Significant

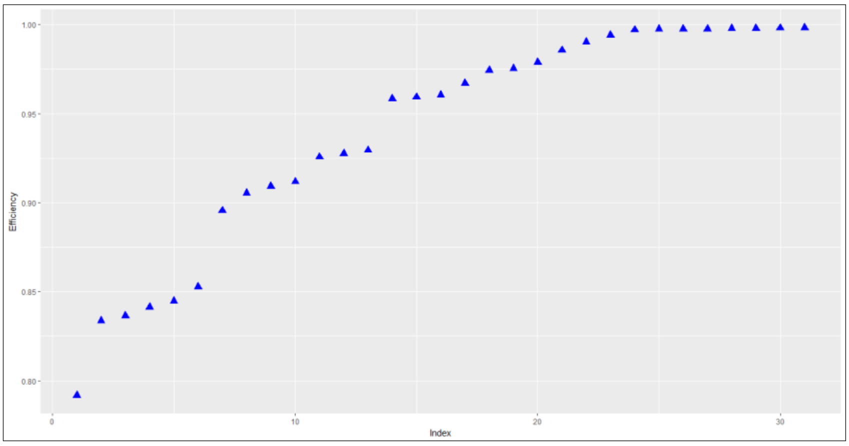

Fig 3.1: Technical efficiency distribution of maize farmers in southern agro climatic zone of Tamil Nadu (Non adopter)

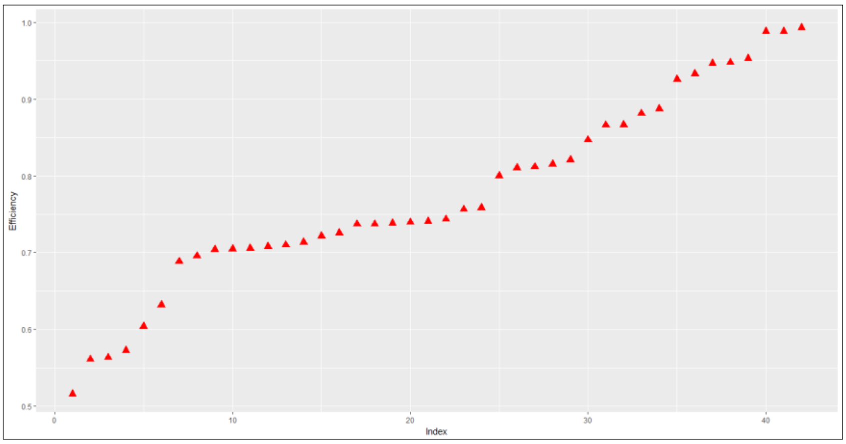

Fig 3.2: Technical Efficiency Distribution of Maize farmers in southern agro climatic zone of Tamil Nadu (Non Adopter)

Table 3.2: Maximum Likelihood Estimates for maize production in North Western Agro climatic zone of Tamil Nadu

	Adopters				*Non Adopters*			
	Parameters	*Std.err*	*t-value*	*Pr(>|t|)*	*Parameters*	*Std.err*	*t-value*	*Pr(>|t|)*
Intercept	-14.260***	3.527	-4.043	0.000	2.042***	0.350	5.829	0.000
Farmyard Manure	-0.467***	0.111	-4.219	0.000	-0.022 NS	0.073	-0.304	0.763
Seed rate	1.179***	0.147	7.999	0.000	-0.168***	0.007	-25.014	0.000
Nitrogen (Kg/ha)	2.884***	0.560	5.153	0.000	-0.014 NS	0.021	-0.678	0.503
Phosphorous (Kg/ha)	0.241 NS	0.272	0.887	0.384	0.265***	0.020	13.171	0.000
Potash (Kg/ha)	-0.039 NS	0.169	-0.233	0.817	0.098***	0.013	7.583	0.000
Human Labour (Mandays)	2.004***	0.221	9.059	0.000	-0.075***	0.010	-7.650	0.000
Plant Protection Chemicals (Rs)	0.007 NS	0.105	0.066	0.948	0.158***	0.051	3.100	0.004

Machine hours	-0.038 NS	0.049	-0.783	0.441	-0.045 NS	0.045	-0.985	0.332
Irrigation (mm/ha)	-1.372***	0.147	-9.348	0.000	0.068**	0.025	2.687	0.011
Lambda	78.383**	37.019	2.117	0.045	662.128***	227.700	2.908	0.001
$Sigma^2$	0.036				0.036			
$Sigma^2v$	0.000				0.000			
$Sigma^2u$	0.036				37.214			
Log likelihood	32.492				0.036			
Variation in efficiency	99.984				99.99977			

Note: ***- Significant at 1 per cent level, **-Significant at 5 per cent level,NS- Non Significant

3.1.2 Technical efficiency in maize production of north western zone of Tamil Nadu

The results of the Table 3.2 indicated that, in the case of adopters, seed rate, nitrogen fertilizer and human labour in mandays had positive significant impact on output at one percent level, but farm yard manure and irrigation were found to be negative impact on yield at one percent level. In the case of non-adopters, the use of farm yard manure and phosphorous fertilizer usage had positive and significant impact on output but the variable human labour in man days had significant negative impact on output.

In the case of Adopters, the estimated lamda (λ) parameter is 78.383, which means that the total error variance is mainly due to inefficiency, whereas random errors are less important. The percentage of total variation due to variation in efficiency is 99.984 per cent. The estimated variance for the variation in efficiency is $sigma^2u$ value is equal to 0.03616771 is considerably larger than variation due to random errors $sigma^2v$ value is equal to 5.89E-06.

3.1.3 Technical efficiency distribution

The technical efficiency distribution of maize farmers is presented in Table 3.3. In the southern zone (less vulnerable zone), in the adopter category, majority of the farmers (77.42 per cent) achieved a technical efficiency above 90 per cent followed by 19.35 per cent of farmers falling in the technical efficiency range in 81-90 per cent and 3.23 per cent of the farmers having efficiency in the range of 71-80 per cent. In the non adopter category, 38.10 per cent of the farmers having efficiency in the range of 71-80 per cent followed by 23.81 per cent of farmers were having technical efficiency in the range of 81-90 per cent followed by19.05 per cent of the farmers having efficiency in the range of more than 90 percent and 9.52 per cent of the farmers having efficiency in the range of both 51-60 per cent and 61-70 per cent. It is noteworthy, that mean technical efficiency of maize farmers was 93.96 per cent for adopter and 77.51per cent for non adopters. In the North western zone (high vulnerable zone), in the adopter category, majority of the farmers (65.71 per cent) achieved a technical efficiency above 90 per cent,

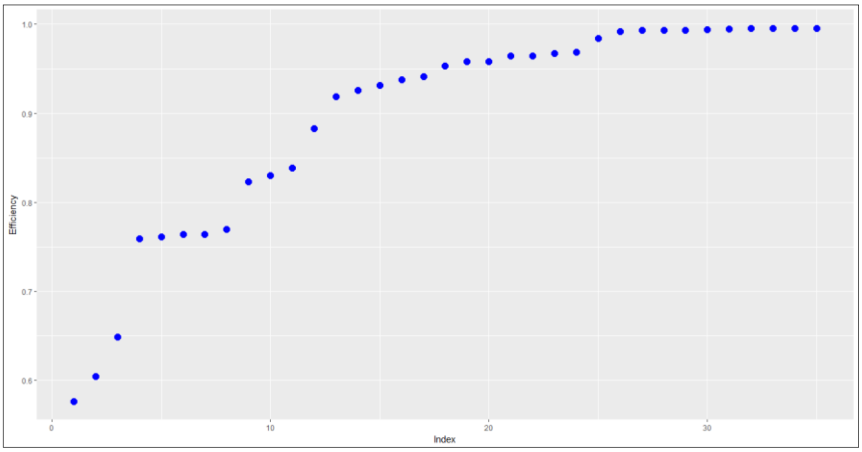

Fig 3.3: Technical efficiency distribution of maize farmers in north western agro climatic zone of Tamil Nadu (Adopter)

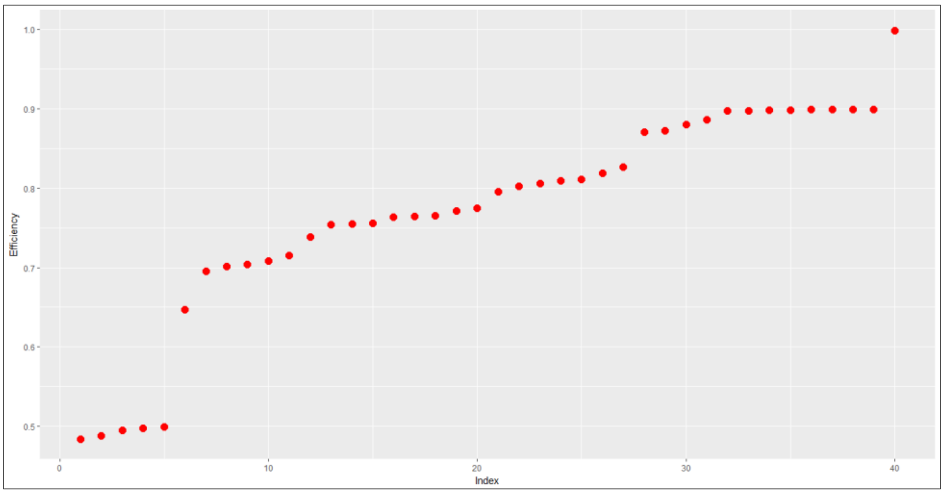

Fig 3.4: Technical efficiency distribution of maize farmers in north western agro climatic zone of Tamil Nadu (Non Adopter)

Table 3.3: Technical Efficiency Distribution of Maize Farmers in Southern and North Western Agro climatic zones of Tamil Nadu

	Southern agro-climatic zone				North western agro-climatic zone			
	Frequency		Percentage of Frequency		Frequency		Percentage of Frequency	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
<50			0	0		3.00	0.00	7.50
51-60		4.00	0.00	9.52	1.00		2.86	0.00
61-70		4.00	0.00	9.52	2.00	2.00	5.71	5.00
71-80	1.00	16.00	3.23	38.10	5.00	16.00	14.29	40.00
81-90	6.00	10.00	19.35	23.81	4.00	18.00	11.43	45.00
>90	24.00	8.00	77.42	19.05	23.00	1.00	65.71	2.50
	31.00	42.00	100.00	100.00	35.00	40.00	100.00	100.00
MTE	0.939636	0.775103			0.895296	0.771138		

Note: MTE – Mean Technical Efficiency

followed by 14.29 per cent of farmers falling in the technical efficiency range in 71-80 per cent followed by 11.43 per cent of the farmers having efficiency in the range of 81-90 per cent followed by 5.71 per cent of the farmers having efficiency in the range of 61-70 per cent and 2.86 per cent of farmers falling in the technical efficiency range in 51-60 per cent.In the non adopter category, 45 per cent of farmers were had having technical efficiency in the range of 81-90 per cent followed by 7.50 per cent of the farmers having efficiency in the range of less than 50 per cent followed by five per cent of farmers falling in the technical efficiency range of 61-70 per cent and 2.50 per cent of farmers falling in the technical efficiency range of above 90 per cent. It is noteworthy, that mean technical efficiency of maize farmers was 89.52 per cent for adopter and 77.11per cent for non adopters.

4. Conclusion and policy implication

The results indicated that, in the case of adopters, nitrogen fertilizer usage had positive significant impact on output at one percent level in both zones, phosphorous fertilizer usage in southern zone, seed rate and human labour in north western zone showed a positive impact on yield but machine hours in southern zone, farm yard manure in north western zone were found to be negative impact on yield at one percent level. In the case of adopters, phosphorous fertilizer usage had positive significant impact on output at one percent level in both zones, nitrogen fertilizer usage in southern zone, potash fertilizer usage and rupees spend on plant protection chemicals in north western zone showed a positive impact on yield but potash fertilizer usage and machine hours in southern zone, seed rate and human labour in north western zone were found to be negative impact on yield at one percent level. In the case of adopter category in both zones, more than 65 percent of the maize farmers had more than 90 percent technical efficiency but in non-adopter category of high vulnerable zone, only 2.50 percent of the farmers are having more than 90 percent technical efficiency. The results evident that the mean technical efficiency of adopter category in less vulnerable (southern zone) had the highest value with 93.96 percent followed by adopter category in high vulnerable zone with 89.52 percent followed by non-adopter category in less vulnerable zone with 77.51 percent and finally non adopter category in high vulnerable zone with 77.11 percent. Government have to strengthen the extension activities especially optimal use of inputs like nitrogen, phosphorous, potash and seed rate to increase the technical efficiency of maize.

5. References

1. Battese GE, Broca SS. Functional forms of stochastic frontier production functions and models for technical inefficiency effects: A comparative study for wheat farmers in Pakistan. Journal of Productivity Analysis. 1997; 8:395-414.
2. Battese GE, Coelli TJ. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empirical Economics. 1995; 20:325-332.
3. Coelli TJ. A guide to Frontier Version 4.1: A computer program for stochastic frontier production and cost function estimation, mimeo, Department of Econometrics, University of New England, Armidale, 1996.
4. USDA Reports. World Agriculture supply and demand estimated, 2013, 538-542.