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**Research Paper**

# Resource Use and Technical Efficiency of Sri in Madurai District of Tamilnadu

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*The conventional paddy growing tracts are in worst crisis due to social, biological and technical setbacks. In order to maintain the present level of self-sufficiency, India needs to enhance rice production. In line with this SRI was introduced in India and it gains momentum among farmers. In this context the present study makes an attempt to examine the input use and technical efficiency of SRI based on primary data collected from 120 sample farmers selected randomly in Vadipatti Taluk of Madurai District, Tamil Nadu. Decomposition model and Stochastic Frontier Production Function were made use of in the study. The study reveals that the inputs such as human labour, seed, fertilizer, PPC and machine labour influence SRI rice yield. The study also reveals that SRI cultivation has recorded technical efficiency in relation to non-SRI cultivation in the study area. As such it indicates the possibility of increasing rice yield through adopting SRI method.*

***Key Words:*** *System of Rice Intensification (SRI), Decomposition analysis, Resource use and technical efficiency.*
***JEL Classification:*** *Q16, Q18, Q24.*

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## I. INTRODUCTION

In India rice is cultivated in 534 districts spread across 30 states and Union Territories of the country. Further intensification of irrigated rice farms is necessary to feed the growing population and to maintain food security in the near future. Rice farmers, however face several problems besides water scarcity, stagnating yield, declining profit (due to rising input costs and the low rice price), less land, and labour for rice cultivation, crop failures due to adverse weather, and growing environmental concerns. In an agrarian country like India, intensified efforts to improve both crop and water productivity and the farmers' income is a vital need of the hour. Besides inefficiency in resource use, the yield also stagnated in many parts of rice growing regions in India. There is little scope to increase in the area. Hence increase in production and productivity with an improvement in efficiency of production through farm technology is necessary to meet the growing demand (Haldar, Honnaiah and Govindaraj, 2012). In this context, extensive efforts to relieve off from threats of water scarcity and enhance productivity have resulted in a farm technology consisting of a set of practices in wetland rice through System of Rice Intensification (SRI) (Shanmugasundaram and Helen, 2015). The novelties of SRI include conservation of land, water and bio-diversity. SRI is gaining momentum among farmers (Barah 2009). There are only less number of studies with fairly large sample in respect of resource use and technical efficiency of SRI in recent times that to after withdrawal of the promoting agencies.

## II. REVIEW OF LITERATURE

The earlier works on input use and technical efficiency of SRI method of paddy cultivation are reviewed here. Barah (2009) who conducted a study among SRI and non-SRI farmers in four districts of Tamil Nadu found that SRI farmers have demonstrated higher efficiency (technical as well as economic) as compared to their counterparts under conventional methods. Jhana Pathak (2010) in his study conducted among 119

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farmers in thirteen villages of Gujarat experimenting SRI by allocating small patch of land (the rest on traditional method) found that the average yield oriented efficiency score for farmers cultivating paddy using SRI method is more than the farmers that follow traditional techniques. A socio-economic evaluation of boro rice cultivation under SRI method in a village in Satkhira district of Bangladesh showed that SRI boro rice recorded 38 percent higher yield as compared to conventional method (Islam, 2010). Halder, Honnaiah and Govindaraj (2012) from their study conducted among 120 farmers under SRI and Conventional method of rice in Barchaman district of West Bengal state reported that the efficiency level (both technical and allocative efficiency in SRI is higher compared to Conventional method. Durga and Kumar (2013) conducted a study among 84 SRI and traditional farmers in the three major rice growing blocks in Kerala. Based on the technological efficiency analysis, they found that relatively more percentage of non-SRI farmers are falling in the maximum possible frontier level of technology and they pointed out that it was possible to increase the rice yield by adopting the SRI technology. Max Xlur Alam (2015) conducted a study among 104 household-heads with 47 SRI farmers and 57 non-SRI farmers in Wita Ponda Sub-Regency of Morowali Regency, Indonesia to analyze technical efficiency in SRI farming and the factors affecting the efficiency. The study revealed that SRI rice farming had a higher technical efficiency level when compared with non-SRI rice farming. Farmers could increase rice production with organic SRI. A study conducted by Mwatete et al. (2015) at West Kano rice scheme in Western Kenya with a sample of 123 households compared conventional method of rice production with SRI method of production. It revealed that SRI farmers relatively more technically efficient than farmers using conventional rice production method. The study also revealed that adoption of SRI was critical to the achievement of efficiency in rice production in West Kano. Maridjo et al. (2016) conducted a study among 90 rice farmers in Ringgit village in Purworejo district. The study revealed that the technical efficiency of organic rice farming is higher which began using SRI method. The length of the use of the SRI method has a significant effect on the organic rice production. Mwalupaso et al. (2019), with the collected from 208 farmers (104 adopters and 104 non-adopters) in Mali of Western Africa using stochastic production frontier revealed that SRI adopters are more technically efficient than non-adopters. Thayaparan and Jayathilaka (2020) have used the translog frontier analysis to measure the determinants of technical efficiency of farmers in Kurunegala district of SriLanka.

Similar analysis was carried out for Sri Lanka by Suresh et al. (2021). A meta analysis of technical efficiency was carried out for Sri Lanka by Senevirathne et al. (2021) in selected agricultural sub-sectors in Sri Lanka. They point out to the need for meta analysis research of technical efficiency in future. Arsil et al. (2022) in their study have identified the compatibility, complexity and relative advantages of SRI attributes among Indonesian rice farmers from the point of diffusion innovation. Meesala and Rasala (2022) in their study on a programme effort for SRI impact assessment in 20 project village of Narayanpet block of Telengana have presented relative benefits of SRI in quantitative and qualitative terms. The studies reviewed here all, national and international invariably show that relative benefits and technical efficiency are more under SRI method of paddy cultivation. With this background the present study formulates the following hypothesis.

- $H_1$: Technical efficiency is higher under SRI cultivation than non-SRI cultivation

## III. OBJECTIVES OF THE STUDY

- To identify the factors that influence the productivity as also resource use efficiency of SRI vis-a-vis., non-SRI, cultivation.
- To estimate technical efficiency of SRI and non-SRI cultivation.

## IV. METHODOLOGY

The present study seeks to examine the resources use and technical efficiency of SRI cultivation vis-a-vis. non-SRI cultivation. The study is based on primary data. The data were collected from 120 farmers across four villages in Vadipatti Taluk of Madurai district, Tamil Nadu state of India. The SRI cultivation was introduced in Madurai district during 2005-06 by the department of agriculture. Although the programme was introduced in all the seven taluks, Vadipatti taluk was given priority and so the SRI was intensively propagated. The main reason is that this taluk gets irrigation for two crops and assured irrigation for at least one crop as Vaigai River and Anaipatty canal are flowing across the taluk taking water from Vaigai dam, just away. The taluk's location is advantageous in terms of availing water from Vaigai dam and Peranai first as compared to other taluks on the river basin. As SRI has been relatively intensively propagated and followed, Vadipatti taluk of Madurai district was purposively chosen for the study. Villages were selected from the Vadipatti taluk, based on the criterion that the adoption of SRI method is more in terms of number of farmers who adopted. The list of farmers adopting SRI across the villages in Vadipatti taluk was obtained from the Department of Agriculture, Madurai. As such the top four villages that have relatively more SRI farmers were selected from village wise details of SRI farmers. viz. Irumbadi, Neerathan, Sholavandan and Nachikulam. The farmers adopting SRI were selected randomly from the lists of SRI farmers in four villages. In order to compare SRI cultivation, a matching sample of non-SRI paddy cultivating farmers from the same villages was also randomly selected from the list of non-SRI farmers in the four villages. From each village 15 SRI farmers and 15 non-SRI farmers were chosen for the study. The total sample for the study was 120 farmers out of which 60 were SRI cultivators and 60 farmers were non-SRI paddy cultivators from four villages. A detailed set of data on economics of SRI and non-SRI cultivation were collected for a comprehensive analysis. These data include various quantities of inputs, yields, by-produce yields and key socio economic variables. The data pertain to one crop, Kharif crop cultivated during July to October 2017. The study has employed decompositions model to identify factors of productivity and Stochastic Frontier Production Function for estimating technical efficiency which are described in the respective sections.

## V. RESULTS AND DISCUSSION

### 5.1. Decomposition of Factors Contributing to Productivity Difference between SRI and Non-SRI Methods

Decomposition analysis is used to measure the contributions of technology and resource use differentials to the total productivity differences between non-SRI and SRI methods of paddy cultivation. Before presenting the results the process of adopting decomposition analysis is described.

Earlier studies have used such an analysis for analysing technological change and output. Solow (1957) introduced decomposition analysis to evaluate the effects of technological change on output growth in US agriculture. In order to examine technological changes in Indian agriculture, Bisalaih (1977) extended the framework of decomposition analysis to examine technological change in Indian agriculture. Palanisami et al. (2002) used this analysis specific to measuring the contribution of technology and resource use differentials to the total productivity difference between non-SRI and SRI methods. Basavaraja, Mahajanashetti and Sivanagaraju (2008) also used such decomposition analysis in their study. These studies have used decomposition analysis with the help of Cobb-Douglas production function.

Following the earlier works the Cobb-Douglas production function is employed here. However, two more variables, machine labour and bullock labour used are incorporated in the model. These two variables were kept included in plant protection chemicals (PPC) and miscellaneous expenditure in studies specific to SRI cultivation. The model of present study is specified as follows.

$Y=AX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}\,X_6^{b6}\,X_7^{b7}e^u$

Where,

$Y$ = Output in kgs/acre,

$X_1$ = Seeds in kgs/ acre,

$X_2$ = Human labour in man-days/acre,

$X_3$ = Fertilizer in kgs/acre,

$X_4$ = Farm yard manure in tonnes/acre,

$X_5$ = Plant protection chemicals and miscellaneous expenditure in Rs/acre,

$X_6$ = Machine Labour in days/acre

$X_7$ = Bullock Labour in man-days/acre

$u$ = Error term.

The miscellaneous expenditure in the model included the expenditure on irrigation charges, land revenue and rent, interest on working and fixed capital and depreciation.

Using the subscripts 's' and 't' respectively to represent production functions of SRI and Non-SRI methods, the difference in the natural logarithms of paddy output between the SRI and Non-SRI methods may be written as follows.

$$[\ln Y_s - \ln Y_t] = [\ln A_s - \ln A_t] + \sum_{i=1}^{7} [b_{si}\ln_{si} - b_{ti}\ln X_{ti}]$$

Adding and subtracting

$$\sum_{i=1}^{7} [b_{si}\ln X_{ti}]$$

in the above equation and rearranging the terms provides the following decomposition model.

$$[\ln Y_s - \ln Y_t] = [\ln A_s - \ln A_t] + \sum_{i=1}^{7} [b_{si}\ln X_{si} - b_{ti}\ln X_{ti}] + \sum_{i=1}^{7} [b_{si}\ln X_{ti}]$$

The model given above involves decomposing the logarithm of ratio of per acre productivity of SRI and non-SRI methods of rice cultivation (LHS). This is a measure of percentage change in output per acre between the SRI cultivation and non-SRI cultivation. The summation of the first term (neutral technology) and the second term (non-neutral technology) on the right-hand side of the decomposition model represents the productivity differences between the SRI and the non-SRI method. This is attributable to the difference in technology (the cultivation practices). The third term provides the productivity difference between the two methods. This is attributable to the differences in the input use between the two methods.

In order to examine whether the parameters of the production functions defining the two methods of paddy cultivation are different, which has an essential component of decomposition analysis, intercept and slope dummies are introduced into the log linear production function, which is specified as follows.

$$\ln Y = \ln A + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + cD + d_1[D_1 \ln X_1] + d_2[D_2 \ln X_2] + d_3[D_3 \ln X_3] + d_4[D_4 \ln X_4] + d_5[D_5 \ln X_5] + d_6[D_6 \ln X_6] + d_7[D_7 \ln X_7] + u$$

Where, Y, $X_1, X_2, X_3, X_4, X_5, X_6, X_7$ and u are the same as defined already.

D = Intercept dummy which takes value '1', if it is SRI method and value '0' otherwise,

$D_1 \ln X_1$, $D_2 \ln X_2$, $D_3 \ln X_3$, $D_4 \ln X_4$, $D_5 \ln X_5$, $D_6 \ln X_6$ and $D_7 \ln X_7$ are slope dummies of $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, $X_6$ and $X_7$ respectively taking value '1', if it is SRI method and value '0' otherwise.

In order to examine the difference in the structural relationship in the parameters defining the production functions for the two methods, (SRI and non-SRI cultivation) the log–linear production functions for the two methods as also pooled (both SRI and non-SRI) are estimated using the above model. The parameters so estimated are presented in Table 1.

The estimated production function explains 89.60 per cent variation in paddy output due to variation in the resources for pooled data showing a good fit of the model. The coefficients of the intercept dummy and slope dummies are significantly different from zero. This leads one for the rejection of the hypothesis that production parameters defining the SRI method and non-SRI method are same. The positive estimates of intercept and slope dummy co-efficient for all resources imply that the output under SRI method is significantly higher than that of non-SRI method for the given level of resources. This result further lends support to accepting the hypothesis that yield levels are significantly different between SRI and non-SRI cultivation. The estimates also imply the larger elasticity coefficients of production with respect to each input under SRI method as compared to non-SRI method. This result thus offers the needed justification for decomposing the factors contributing to productivity difference between SRI and non-SRI methods of paddy cultivation.

In order to do decomposing the productivity difference between SRI and non-SRI methods of paddy cultivation, the parameters of the per acre production functions and the mean levels of inputs use for the two methods are essential. Hence, the production functions for SRI and non-SRI methods are estimated separately. The results of this exercise are also provided in Table 1. As could be seen from the table, 72.60 per cent of variations in paddy output under SRI method and 78.4 per cent of variations in paddy output under non-SRI method were explained by the independent variables, included in the model.

**Table 1**
**Estimated Production Functions with Intercept and Slope Dummies**

| Sl. No. (1) | Particulars (2) | Pooled (3) | SRI (4) | Non-SRI (5) |
|---|---|---|---|---|
| 1 | Intercept | 0.2307 (0.1348) | 0.4266 | 0.3148 |
| 2 | Seeds | 0.0887* (0.0305) | 0.4552** (0.0851) | 0.0887* (0.0332) |
| 3 | Fertilizer | 0.1596* (0.0542) | 0.2846** (0.0850) | 0.1596* (0.0564) |
| 4 | Farmyard manure | 0.2206** (0.0503) | 0.0357* (0.0216) | 0.2206** (0.0514) |
| 5 | PPC + misc. Expenditure | 0.0136** (0.0713) | 0.0634* (0.0151) | 0.0136** (0.0727) |
| 6 | Human labour | 0.2505** (0.0617) | 0.1606** (0.0527) | 0.2505** (0.0639) |
| 7 | Machine Labour | 0.0590** (0.257) | 0.0646** (0.374) | 0.0590* (0.284) |
| 8 | Bullock Labour | 0.0508* (0.0282) | 0.0243* (0.0250) | 0.0508** (0.0299) |
| | **Dummy** | | | |
| | (a)Intercept | 0.3257** (0.0973) | | |
| | (b) Seeds | 0.0450** (0.0216) | | |
| | (c) Fertilizer | 0.0846** (0.0457) | | |
| | (d) FYM | 0.0357** (0.0.306) | | |
| | (e) PPC+ misc. Expenditure | 0.0696** (0.0306) | | |
| | (f) Human labour | 0.0489* | | |

| | | | | |
|---|---|---|---|---|
| | | (0.0237) | | |
| | (g) Machine Labour | 0.0274** (0.0130) | | |
| | (h) Bullock Labour | 0.0356** (0.0213) | | |
| | R2 | 0.896 | 0.726 | 0.784 |
| | F-value | 76.98** | 24.42** | 28.07** |

***Note*:** Figures in parentheses are standard errors * and
** denote Significant at 5 and 1 per cent level, respectively.

The constant term (intercept) in respect of SRI method is higher than that of the non-SRI method. This indicates that there is an upward shift in production function due to technological changes embedded in SRI. The production elasticity coefficients of all the variables seeds, fertilizer, FYM and expenditure made on plant protection chemicals (PPC) and miscellaneous expenditure, human labour, machine labour, bullock labour are all positive and significant both in the estimates pertaining to non-SRI and SRI methods. The output elasticity coefficients of seeds, fertilizer, PPC and miscellaneous expenditure and machine labour are greater under SRI method as compared to non-SRI method.

Paddy output under SRI method would increase by 0.45 per cent and 0.28 percent for every one per cent increase in the use of seeds and fertilizer respectively. With regard to human labour, the elasticity coefficient is 0.16 which denotes that one per cent increase in the use of human labour leads to 0.16 per cent increase in output under SRI method. The paddy output under SRI method would increase by 0.06 per cent each for every one per cent increase in PPC and miscellaneous expenditure and machine labour. Thus, the major contribution to output under SRI method comes from seeds and fertilizer. In respect of non-SRI method, the variables that bear the values of co-efficient that are greater as compared to the values for SRI estimates are human labour, FYM, bullock labour and seeds. The paddy output would increase by 0.25 per cent, 0.22 per cent, 0.05 percent and 0.08 percent for every one per cent increase in the use of human labour, FYM, bullock labour and seeds respectively. The major contributors to output under non-SRI method are human labour and farm yard manure.

In sum, it may be stated that the major inputs that influence productivity under SRI include seeds, fertilizer and human labour. The result of the exercise shows that there is an upward shift in production function due to technological changes embedded in SRI.

The difference in productivity between SRI method and non-SRI method of cultivation is decomposed into consistent sources using the decomposition model. The results of the exercise are presented in Table 2. At the outset it may be noted that there is no much discrepancy between the observed difference (37.53 per cent) and the estimated difference (37.48 per cent) in the productivity of SRI and non-SRI methods. It could also be inferred that technology and input use together contributed to the total productivity difference to the extent of 37.53 per cent. In that, technology alone accounts for 34.27 per cent. This indicates that paddy productivity could increase by 34.27 per cent if the farmers switch over from non-SRI method to SRI method with the same level of resource use. It may be stated that an increase in productivity due to technological improvement (the SRI technique) is brought out through a shift in the scale and/or slope parameters of the production function.

**Table 2**
**Decomposition of Output Difference between the SRI and the non-SRI Methods**

| Sl.No. (1) | Source of output difference (2) | Percent contribution (3) |
|---|---|---|
| I. | Observed difference in output $[\ln Y_s - \ln Y_t]$ | 37.53 |
| II. | Source of contribution | |
| 1. | Due to difference in technology $[\ln A_s - \ln A_t] + \sum_{i=1}^{7} [b_{si} - b_{ti}] \ln X_{ti}$ | 34.27 |
| 2. | Due to difference in input use $\sum_{i=1}^{7} b_{si} [\ln X_{si} - \ln X_{ti}]$ | |
| a. | Seeds | -22.09 |
| b. | Human labour | 8.34 |
| c. | Machine labour | 2.06 |
| d. | Bullock labour | 0.81 |
| e. | Fertilizer | -1.33 |
| f. | FYM | 17.28 |
| g. | Expenditure on PPC and miscellaneous items | 3.27 |
| | Due to all inputs | 3.94 |
| 3. | Estimated difference in output | 37.48 |

It could be observed from the table that the contribution in input use between SRI and non-SRI cultivation to the productivity difference is very less as 3.94 per cent. Relatively large quantity of seeds used helps to increase paddy yield by 22.09 per cent under non-SRI cultivation. As far as SRI cultivation is concerned, use of relatively large quantity of resources such as FYM, human labour and PPC plus miscellaneous expenditure causes a yield increase by 17.28 per cent, 8.34 per cent and 3.27 per cent respectively. This indicates that SRI farmers obtain higher output by spending relatively more on these inputs as compared to non-SRI farmers.

The above analysis may be summed up as follows.

- Output under SRI method is significantly higher than that of non-SRI method of cultivation for a given level of resources.
- The major inputs that influence production under SRI are seeds, fertilizer and human labour.
- Technology and input together contributed to the productivity difference to an extent of 37.53 per cent. Out of this, technology alone accounts for 34.27 per cent. This means that paddy productivity could increase by 34.27 per cent if farmers switch over from non-SRI to SRI method with same level of resources use.
- There is an upward shift in productivity function due to technological changes embedded in SRI. These findings are in conformity with the findings of the studies of Basavaraja, Mahajanashetti and Sivanagaraju (2008), Pathak (2010) and Durga and Kumar (2013).

### 5.2 Estimation of Technical Efficiency

**Stochastic Frontier Production Function**

In this study, an attempt is made to measure the efficiency of SRI cultivation by using stochastic frontier production function following an earlier study specific to technical efficiency of SRI cultivation. (Durga and Kumar, 2013). Stochastic parametric method decomposes the random errors into error of farmer's uncontrollable factors, the dependent variable as also farm specific inefficiency. The deterministic and non-parametric methods have drawbacks as they force all outputs to a frontier yet sensitive to outliers. If large, it distorts efficiency measurements.

Variations in the technical efficiency of individual farms are due to factors which are controlled by farmers. In the frontier analysis, yield in tonnes per acre is taken as the dependent variable and the independent variables included are seed in kg/acre, quantity of fertilizers used (kg/acre), irrigation charges, PPC, machine labour (hours/acre), bullock labour days and human labour days per/acre.

The Stochastic Cobb-Douglas Production Frontier is fitted as follows,

$$\ln YD = \ln \beta_0 + \beta_1 \ln SEED + \beta_2 \ln FR + \beta_3 \ln IRR + \beta_4 \ln PPC + \beta_5 \ln HL + \beta_6 \ln PPC$$
$$+ \beta_7 \ln ML + \beta_8 \ln BL + Vi - Ui$$

Where,

YD = Yield of rice (tonnes/acre)
SEED = Seed (kg/acre)
FR = Fertilizer quantity (kg/acre)
IRR = Irrigation cost (in rupees)
HL = Human labour (days/acre)
PPC = Plant protection chemical (cost in rupees/acre)
ML = Machine labour (hrs/acre)
BL = Bullock labour (days/acre)
*Vi* = Statistical disturbance term
*Ui* = Farmer-specific characteristics related to production efficiency

$$|Ui| = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$$

Where,

$Z_1$ = Age of farmer (years)
$Z_2$ = Farming experience (years)
$Z_3$ = Education level of the farmer (1= illiterate, 0= otherwise)
$Z_4$ = Farmers contact with extension agents (1= illiterate, 0= otherwise)

The above model is used to estimate technical efficiency of sample farmers under the study. The estimates of stochastic frontier production function for SRI and non-SRI sample farms under the study are presented in the table 3.

It may be observed from the table that the co-efficient (which denote production elasticity) of all the variables included for both SRI farm and non-SRI farms are positive and significant. But the significance level to the extent of one percent and five percent is taken into consideration here. As such, the co-efficient of seeds, fertilizer, PPC and machine labour of SRI farms are significant bearing values of 0.519, 0.353, 0.574 and 0.781 respectively. These imply that one percent increase in each of variables seeds, fertilizer, PPC and machine labour could increase the paddy yield under SRI by 0.52 percent, 0.35 percent, 0.57 percent and 0.78 percent respectively. As far as SRI farms are considered, these variables influence the paddy output significantly.

**Table 3**
**Estimated Stochastic Frontier Production Function for SRI Farm and non-SRI Farm**

| **Variables** | **SRI farm** | **Non-SRI farm** |
|---|---|---|
| | **Regression coefficient** | **Regression coefficient** |
| **Frontier production function** | | |
| Constant | 1.259<br>(7.314) | 0.955<br>(4.306) |
| Human Labour (hrs) | 0.457*<br>(8.022) | 0.307**<br>(2.583) |
| Seed (kg/ha.) | 0.519***<br>(2.927) | 0.486**<br>(1.763) |
| Fertilizer (kg/acre.) | 0.353***<br>(2.249) | 0.324**<br>(1.151) |
| Irrigation cost | 0.325*<br>(1.854) | 1.329**<br>(4.218) |
| PPC | 0.931**<br>(0.574) | 0.517*<br>(0.322) |
| Machine labour (hrs) | 0.781**<br>(0.351) | 0.587**<br>(0.463) |
| Bullock labours (hrs) | 0.235*<br>(0.522) | 0.0243*<br>(0.329) |
| **Technical inefficiency effects** | | |
| Constant | 1.324<br>(1.925) | 1.257<br>(1.389) |
| Age (years) | -0.736<br>(-0.913) | -1.253<br>(-2.328) |
| Education (years) | 0.921**<br>(2.584) | 0.319*<br>(1.238) |
| Farming experience (years) | 0.235<br>(0.593) | 0.563*<br>(1.369) |
| Income (Rs) | -0.956*<br>(-1.896) | -0.569**<br>(-1.236) |
| **Diagnosis Statistics** | | |
| Sigma-square (σ2) | 0.0864** | 0.928*** |
| Gamma (γ) | 0.931** | 0.787* |
| Log- likelihood | 39.16 | 21.09 |
| LR test | 6.27 | 14.62 |
| Mean technical efficiency (%) | **95.33** | **78.07** |

N= 60
**Note:** Figures in parentheses indicate estimated 't' values.
***significant at 1% per cent level; **significant at 5% per cent level; *significant at 10% per cent level

Among the other farmer specific characteristics variables included in the model pertaining to SRI farms, education and income turn out to be significant but the sign of co-efficient is positive in the case of education and negative in the case of income. It could be inferred that years of education has a positive influence on productivity. Similar observation could be made for non-SRI sample farm also. The co-efficient of income in the estimates both SRI and non-SRI is negative and significant. Income level seems to influence the productivity negatively in general.

The values of log-likelihood function for the full stochastic frontier model and the OLS fit are estimated to be 39.16 and 27.19 respectively. This indicates that the generalized likelihood-ratio statistic for testing the absence of technical inefficiency effect from the frontier is estimated to be LR = 6.27 and reported as the "LR" test of the one-sided error. The degrees of freedom for this test are calculated as q + 1, where q is the number of parameters; thus q = 5.

The log likelihood ratio test indicates that inefficiency does not exist in the data set and therefore, null hypothesis of no technical inefficiency in SRI may be rejected. The estimated parameters of human labour, seed, fertilizer, PPC machine labour are significant and they have greater influence in SRI yield. This means that the use of the recommended doses of these inputs would result in an increase in production. Similar findings were observed by again Basavaraja, Mahajanashetti and Sivanagaraju (2008), Pathak (2010) and Durga and Kumar (2013).

In order to examine the technical efficiency, the percentage distribution of farms accordingly to their technical efficiency is given in Table 4.

**Table 4**
**Frequency Distribution of SRI and non-SRI Farms based on Technical Efficiency**

| Technical Efficiency Classes (percent) | No. of SRI Farms | No. of Non-SRI Farms |
|---|---|---|
| 45-50 | - | 3 (5.00) |
| 51-55 | - | 6 (10.00) |
| 56-60 | - | 2 (3.33) |
| 61-65 | - | 9 (15.00) |
| 66-70 | 2 (3.33) | 4 (6.67) |
| 71-75 | 3 (5.00) | 4 (6.67) |
| 76-80 | 2 (3.33) | 9 (15.00) |
| 81-85 | 7 (11.67) | 7 (11.67) |
| 86-90 | 12 (20.00) | 2 (3.33) |
| 91-95 | 29 (48.33) | 8 (13.33) |
| 96-100 | 5 (8.33) | 6 (10.00) |
| Total | 60 (100.0) | 60 (100.0) |
| **Mean technical efficiency** | **95.33** | **78.07** |

**Note:** Figures in parentheses indicate per cent of each category to total

The variations in the levels of technical efficiency of SRI farms range between 66.02 percent and 98.03 percent with mean efficiency of 95.33 percent. The mean level of technical efficiency indicates that, 8.23 percent of SRI farms are falling short of the maximum possible frontier level of technology. About 8 percent of the farmers belong to the most efficient category (96 to 100), while only 2 percent belonged to least efficient category (66 to 70).

The majority, constituting 68.3 per cent of the SRI farms, belong to efficiency groups falling between 86 and 95 percent. Among non-SRI farms, variations in the levels of efficiency range between 45.01 per cent and 98.27 per cent with the mean efficiency of 78.07 percent.

The distribution mean level of technical efficiency indicates that, 60 percent of nosn-SRI farms are falling short of the maximum possible frontier level of technology. It is clear from these data that the paddy yield could be increased through adoption of SRI technology. The analysis reveals that while majority (60 per cent) of non-SRI farmers fall short of the maximum possible frontier level technology majority of SRI farmers (68 per cent) take position under most efficient categories. As, such the hypothesis, technical efficiency of SRI farmers is more than the non-SRI farmers is accepted. It also indicates the possibility that rice yield could be increased through adopting SRI method. This is in line with earlier studies (Durga and Kumar, 2013, Max Xlur Alan, 2015, Mwatete et al.2015, Maridjo et al. 2016)

## VI. CONCLUSION

The study has made a detailed economic analysis of technology and paddy cultivation with inference to SRI cultivation under a comparative framework in the study area. The study has elicited the resource use and technical efficiencies of SRI cultivation in the study area. The study reveals that the estimated parameters of human labour, seed, fertilizer, PPC, machine labour are significant which indicate their influence on SRI yield. Use of additional quantum of these inputs would result in obtaining additional output. In terms of technical efficiency, relatively more SRI farmers take position under most efficient categories. The study also indicates that there is a possibility of increasing rice yield through adopting SRI method. However, in the study area, scaling up seems to be an issue as many farmers still adopt non-SRI methods. In order to address this, the study suggests the recently developed and promoted approach of farmer field Schools which is a more effective approach to extend science based knowledge and practice. (Senevirathne, et al. 2021). More research studies on the technical efficiency of SRI need to be conducted across different agro-climatic zones and across seasons of crops.

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