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Efficiency of System of Rice Intensification (SRI) and Determinants of Efficiency in the Telangana state

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Abstract: Agricultural development is not only depending on just adoption of technological innovations but also by the efficient use of inputs through innovations. In Telangana, majority of populations depends on agriculture for their livelihoods. Paddy is the major crop and mostly it is cultivated under lift irrigation (tube wells and bore wells). Therefore, lift irrigation led to an additional monetary burden to the farmers and also it has devastating effects on the environment. In this context, system of rice intensification (SRI) is necessary to solve all these problems because it produces yield by using less inputs especially water and this led to efficiency in inputs use. SRI is based on fewcomponents that interact with each other; early and healthy establishment, reduced plant density, improved soil conditions through weeding, and reduced and control water application. According to literature, SRI claimed higher benefits to the farmers by using lesser inputs. Therefore, the paper intends to study the economic, technical and allocative efficiency of the SRI farmers and determinants of these efficiency. SRI farming households and non-SRI farming households from seven villages from central Telangana for the season kharif 2017 have been surveyed. Data on inputs and output (physical and monetary terms) has been collected through the structural pre-tested questionnaires. The stochastic production frontier has been used to analyze the efficiency of the SRI farmers. The study revealed that SRI farmers found to be more efficient compared to the non-SRI farmers. Moreover, among the SRI farmers, early adopters of SRI gained higher efficiencies. Age of the farmer, their family size, education of the farmer and farming experience are the significant determining factors for the higher efficiencies among the SRI farmers.

Key words: Adoption of SRI, Stochastic production function, efficiency and determinants of efficiency.

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1. Introduction

Agricultural development is not only depending on just adoption of technological innovations but also by the efficient use of inputs through innovations. India requires efficient oriented and sustainable methods than the inputs-oriented methods (Chand 2019). In Telangana, most of the population depends on agriculture for their livelihoods. Paddy is the major crop and mostly it is cultivated under lift irrigation (tube wells and bore wells). There are no considerable improvements in the productivity in the recent past and also state tops in the cost of production of paddy in the country (CACP reports for various years and socio-economic outlook 2017 Telangana). Lift irrigation led to an additional monetary burden to the farmers and also it has devastating effects on the environment in the Telangana state. Therefore, present method of paddy cultivation led to unsustainable in agriculture. In the undivided state of Andhra Pradesh, State Agriculture University has been promoting the SRI. It has played crucial role in scaling up the SRI principles since 2006 along with the NGOs. Currently, non-government organizations (NGOs) have been working towards promoting the SRI in the Telangana state.In this contest,system of rice intensification is the answer to the current problems in paddy cultivation. It is claimed higher benefits by using lower inputs. It is the more productive and more sustainable method of rice cultivation (Glover et al. 2011). SRI is an agroecological innovative practice in paddy cultivation for sustainable agriculture. It is based on five components that interact with each other; early and healthy establishment, reduced plant density, improved soil conditions through weeding, and reduced and controlled water application.

Economic efficiency refers to the achievement of a maximum output from a given set of resources; the greater the output relative to the inputs, the higher the level of efficiency. The focus of the stochastic frontier is on measuring the efficiency. It involves use of econometric methods first developed (Schmidt et al. 1977; Meeusen et al. 1977). The stochastic frontier technique allows the fact that deviations of observed choices from the optimum ones are due to two factors: failure to optimize, that is inefficiency (under the control of farmers) and due to random shocks, which are not under the control of the farmers like weather conditions. It is based on the benchmarking that is a unit's performance compared with a reference performance (efficient frontier). The unit's inefficiency can result from the technological deficiencies (technical inefficiency) or non-optimal allocation of resources into the production (Allocative inefficiency). Both technical efficiency (inefficiency) and allocative efficiency (inefficiency) are included in economic efficiency (inefficiency)

The quantification of the efficiencies is useful for the comparisons across the economic units, which indicate the relative efficiency. Measurement reveals variations in efficiencies among the economic units.

The stochastic Production frontier

$Y = f(Xi\,;\beta) + \varepsilon,$

Where Y is the output of the ith firm, X is the inputs used by ith firm, and β is a vector of unknown factor.

The essential idea behind the stochastic frontier model is that ε is a "composed" error term. This is written as $\varepsilon = v - u$

Where v is a two sided ($-\infty < v < \infty$) normally distributed random error that captures the stochastic effects outside the farmers control (for example; weather, natural disasters and luck), measurement errors and other statistical noise. The term u is a one sided (u is greater or equal to zero) efficient component that captures the technical inefficiency of the farmers. The two components v and u are also assumed to be independent of each other.

The stochastic frontier function approach has been used because agricultural crop production exhibits random shocks and measurement errors. Therefore, there is a need to separate the influences of these from the inefficiency factors which are under the control of the farmers. The assumption is that actual output deviation from the potential (frontier) may not be entire under the control of farmers (Hayatullah 2017). Stochastic frontier assumes that the boundary of the production function is defined by "best practice" farm. Therefore, it indicates the maximum potential output for a given set of inputs, and also it gives the observation (farm) specific efficiencies. Potential (best performance) is the boundary, therefore, actual (observed) fall within the potential.

2. Review of literature

Emerging trends like slow and steady decline in the use of animals, declining factor productivity, increasing indirect and direct use of energy in agriculture undermine the resource use efficiency in developing countries in Asia. Promotion of resource conversation technologies, enhancing technology transfer and technology diffusion are required in agriculture. These measures require more education and training of farmers in order to help them understand and use resources efficiently (Prabhakar et al.2009).The growth of agricultural out not only due to technological innovation but also by the efficient use of inputs (Nishmizu and Page, 1982. Surajit Halder et al 2012 used the Timmers's measure of technical efficiency to measure the efficiency of SRI practice. Technical, Allocative and Economical efficiency are higher among the SRI practice. SRI farmers are relatively more technical efficient than the non-SRI farmers, it is due to spacing and early seedling (Mwatete et al, 2015. SRI farmers are technically efficient than non-SRI farmers (B.C.Barah, 2009; Sathya lakshana et al 2013). Economic efficiency is high among the SRI farmers than non-non-SRI farmers. The difference in technology was found to be main contributor to the yield differences (Sivanagaraju, 2006). The higher efficiencies depend on the adoption levels of the SRI components and the experience in adopting the SRI practice (Uphoff 2006). There are studies, which have estimated the efficiency and its determinants in agriculture due to innovations; wheat production under resource saving technologies in agriculture (minimum and zero tillage agriculture) in terms of yield and profitability. Further, minimal and zero tillage practices improve labour productivity, use resources efficiently and improve the soil quality (Rustamova 2016). The hybrid rice technology increases the potential economic efficiency in China, Land size is a determining efficiency in hybrid rice production. Moreover, it found that there is a positive relationship between efficiency and education for hybrid rice production (Xiaosong Xu et al 1998). Land size, seeds, manure, and organic pesticides are determining the efficiency of input use in organic agriculture in Indonesia and age of the farmers has positive effect on technical efficiency (Muhaiminabdul 2016). There is an another study on the technical efficiency and allocative efficiency among the organic farmers and conventional Italian Olive farmers, it finds that organic olive farmers are more efficient than conventional farmers but allocative efficiency is lower in many analyzed farms due to pivotal variables such as land size, capital and labor(Nicola 2014).There is a considerable literature on the efficiency of SRI but less literature on the determining factors for efficiency. Therefore, the measuring the efficiencies and determinants of efficiencies are crucial to know the variables which help in attaining the higher efficiencies among the SRI farmers.

The following objectives have been addressed in this study. to study the farm level efficiencies and levels of efficiencies of the SRI farmers, and to study the determinants efficiencies

3. Methodology

3.1. Sample selection and Study Area

To study the objectives of the study, 113 SRI farmers and 73 Non-SRI Farmers have been selected from seven villages from the central region (bordering villages of erstwhile Warangal and Nalgonda districts) of Telangana state and collected the data on all quantities of inputs used, their costs, and other information regarding the SRI cultivation for the kharif 2017 in July, August, and September 2018 with structured questionnaire.There are 13 villages spread over 7 mandals in three districts where SRI cultivation is promoted by NGOs. For the study, 7 villages are selected. **Jangam district -**Etakalapally and Kodavaturu from Bachapet Mandal, Yanabai from the Lingalaganpur Mandal. **YadradriBhuvanagiri district** –Chandepally and Teryala from Motakonduru Mandal, Singaram from Atmakur Mandal, **Siddipet district –**Marmamula from Maddur Mandal. This is mostly dry region. There are no major irrigation projects in the study area.

3.2. Data set for the Empirical Analysis

For the stochastic frontier analysis, the farmers who got the negative incomes were not considered due to difficulties in running model in the software.There are 165 observations (consists of the 103 SRI farmers and 62 Non-SRI Farmers) which were considered for fitting the stochastic production frontier and stochastic profit frontier in order to derive the efficiency. Therefore, these models were run for the 165 observations.Limitation of the stochastic frontier: The stochastic frontier model enables to derive the efficiency, level of efficiency, and their distribution across SRI and Non-SRI farmers, causes of inefficiency (under control of farmers or due to random variables), but does not talk about the nature of random variables as cause of inefficiency.The SRI observations (103) were considered to see the determinants of the efficiencies in the SRI cultivation, the regression was run to see whether the determining variables are statistically significant or not. Efficiency is the dependent variable and age of the farmer, educational status, membership in SHGs, agriculture as main occupation, credit and livestock, family, extent of land accessed, and irrigated land are considered as independent variables.

3.3. Scheme of Analysis

Stochastic frontier production was run to derive the technical efficiency and economic efficiency. Yield, incomes to the farmers, seeds use, fertilizers use, organic fertilizers use, bullock labor use, family labor use, hired labor use, tractors use and harvester use in quantity and their prices were used to fit the stochastic production frontier to derive the technical efficiency and stochastic profit frontier to derive the economic efficiency. Allocative efficiency can be derived by dividing economic efficiency with technical efficiency. The efficiencies and level of efficiencies have been calculated for the SRI and Non-SRI farmers. In addition, efficiencies and level of efficiencies have been calculated for early and late adopting farmers among the SRI practice. Determinants of technical, economic, and allocative efficiencies of SRI farmers have been calculated by taking the following factors1. Individual characteristics such as age of the farmer, educational status, membership in SHGs, main occupation (agriculture), credit and livestock 2. Household characteristic such as family size, and also 3. Land related characteristics such as extent of land accessed, irrigated land. In addition, the land related variables and non-economic variables have been compared between the top 20 percent of the efficient farmers in the SRI and Non-SRI practice. This enables to identify the contributing variables for efficiency in the SRI cultivation, which will be useful for policy analysis also. Moreover, the land related variables such as extent of land, irrigated land, land under paddy and SRI paddy and non-economic variables have been compared between the top 10 percent efficient farmers and bottom 10 percent efficient farmers in the SRI cultivation. This helps in finding the variables responsible for low efficiency within the SRI cultivation.

4. Adoption of System of Rice Intensification

In the sample villages, more than half of the farmers (55.7 percent) are growing paddy but only 10.7 percent of the farmers are growing SRI paddy. Study covered 186 (about 16 percent) paddy growing households from which 113 (9.6 percent) SRI farming households; almost it covered all SRI households, and 73 (6.2 percent) non-SRI Paddy households.

Table 1. Sample Households Among Cultivating Households in the Study Area

Sl. No	Particulars	Number	Percentage
1	2	3	4
1	Total cultivating households	2097	100
2	Paddy cultivating households in cultivating households	1168	55.7
3	HHs cultivating SRI Paddy among Paddy households	125	10.7
4	SRI Paddy households surveyed	113(90.4 %)	9.6
5	Sample non-SRI Paddy households	73	6.2
6(4+5)	Total Sample Households	186	15.8

Source: Field Survey, 2018

There are 113 SRI farmers of which 48.6 percent are the marginal farmers, 33.6 percent are the small farmers and 17.6 percent are the other farmers (medium and large farmers). As farm size increases, adoption is decreasing in the SRI practice. There are 63non-SRI farmers, in which about 35.6 percent are the marginal farmers, 37 percent small farmers and 27.3 percent are the other farmers (medium and large farmers).

Table 2. Distribution of SRI and Non-SRI Farmers Across Farm Size (area in Acres)

Sl. No	Categories of farmers	SRI Farmers			Non-SRI Farmers			All Farmers
		No. of Farmers	Total Area	Average SRI Area	No. of Farmers	Total Area	Average non-SRI Area	
1	2	3	4	5	6	7	8	9(3+6)
1	Marginal	55(48.6)	29.9(43.6)	0.54	26(35.6)	24.6(20.6)	0.94	81(43.5)
2	Small	38(33.6)	24.6(35.9)	0.64	27(37.0)	36.4(30.7)	1.34	65(35.0)
3	Other	20(17.6)	14(20.4)	0.70	20(27.3)	57.3(48.4)	2.80	40(21.5)
4	**All**	**113(100)**	**68.5(100)**	**0.60**	**73(100)**	**118.3(100)**	**1.62**	**186(100)**

Note: Figures in the parentheses are percentages
Source: Field Survey, 2018

5. Specification of the Model

The estimation of the stochastic production frontier (SPF) requires a particular form of production function. Appropriate functional forms to estimate the stochastic frontier are; Cobb – Douglas production function, CES and translog production functions. Amongthese functions, the Cobb- Douglas production function is mostly used to estimate the stochastic frontier.Therefore, Cobb-Douglas production function has been used for the stochastic frontier analysis. The functional form of this function is given below

$$InYi = \beta o + \beta 1Inx1i + \beta 2Inx2i + \beta 3Inx3i + \beta 4Inx4i + \beta 5Inx5i + \beta 6Inx6i + \beta 7Inx7i + +\beta 8Inx8i + Ui - Vi$$

Where

Sl. No.	Inputs/out put	Production function (per acre)	Profit Function (per acre)
1	Productivity	Quintals	
2	Incomes		Rupees
X1	seeds	Kilograms	Rupees
X2	Fertilizers	Kilograms	Rupees
X3	Organic Fertilizers	Kilograms	Rupees
X4	Bullock Labor	Hours	Rupees
X5	Family Labor	Hours	Rupees
X6	Hired labor	Hours	Rupees
X7	Tractor use	Hours	Rupees
X8	Harvester use	Hours	Rupees
Vi = is the random variable assumed to be independent and identically distributed as N $(0, \sigma v2)$ Ui = is the farm specific technical inefficiency related to variable			

The variables of the model (including u and v) estimated by maximization of log- likelihood estimation. Technical efficiency is estimated through maximum likelihood of the production function with two error terms. Maximum of the log likelihood function offer an approach for selecting the distribution which reflect technical inefficiency. A strict assumption about the distribution of inefficiency term is required when one can use the cross-sectional data. Therefore,half-normal distribution has been used. There are no priori reasons to choose half-normal distributional form over the other distributional forms, because all distributional forms have advantages and disadvantages.

6. Results and Discussion

Production Function Results

To analyze the technical efficiency of the SRI practice and Non-SRI Practice, the variables of the stochastic production frontier have been defined by the above equation. Specifications of the efficiency effects were obtained in table 3. The stochastic model is statistically significant.Seeds and family labor use is statistically significant. The seed use is negatively affecting the productivity. One unit of increase in seed is leading to reduction in 7.9 units of productivity per acre. Whereas the family labor is affecting positively on the unit of the productivity therefore, one unit increase in family labor use has resulted 9.3 units increase in the productivity.

The estimated σu value is positive and 0.27 which is statistically significant. It indicatesthatthere is sufficient evidence to suggest that the technical inefficiencies are present in the data set. The differences between the observed (actual) and frontier (potential) output are due to inefficiencies and not by the variables which are not under the control of the farmers alone. The estimated value σv is also positive and significant indicating that inefficiencies also occurred due to random shocks not in control of farmers.

The gamma value (γ) is 0.80 which indicated that the proportion of the variation in the model due to the variables which are controlled by the farmers. Therefore, the variables which are under the control of the farmers contributed about 80 percent in the total inefficiencies (table 3).

Profit Function Results

The stochastic profit frontier has been estimated to analyze the economic efficiency of the SRI Practice and Non-SRI practice. The variables of the stochastic profit frontier have been defined by the above equation. Specifications for the economic efficiency effects were obtained in table 3. Seeds, family labor, and harvester use are statistically significant. Price paid for seed has positive effect on the net incomes of the farmers. Whereas, family labor prices and harvester use prices have negative effect on the net incomes of the farmers.

The estimated σu value is positive and 1.14 which is statistically significant. It indicates that there is sufficient evidence to suggest that the technical inefficiencies are present in the data set. The differences between the observed (actual) and frontier (potential) output are due to inefficiencies and not by the variables which are not under the control of the farmers alone.

The gamma value (γ) is 0.97 which indicated that the proportion of the variation in the model are due to the variables which controlled by the farmers. Therefore, the variables which are under the control of the farmers are contributed about 97 percent in the total inefficiencies. The gamma value is high becauseit is related to the purchasing inputs and marketing output and not related to the land and production. Therefore, the weather conditions have less affect (less contributing)in the inefficiencies (table 3).

Table 3. Results of the Stochastic Production Function and Profit Function

		Production function			Profit function		
Sl. No		**Coef.**	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
1	2	3	4	5	6	7	8
Number of observations = 165							
Wald chi2(8) = 36.59					Wald chi2(7) = 36.68		
Prob> chi2 = 0.0000					Prob> chi2 = 0.0000		
Log likelihood = 21.2790					Log likelihood = -164.2078		
1	Frontier				Frontier		

2	Seeds	-0.079	0.021	0.000*	0.201	0.082	0.014*
3	Fertilizers	0.011	0.016	0.520	0.016	0.042	0.692
4	Organic Fertilizers	-0.001	0.004	0.862	0.003	0.013	0.811
5	Bullock Labor	0.033	0.019	0.086	-0.025	0.057	0.659
6	Family Labor	0.093	0.029	0.001*	-0.456	0.233	0.04.9*
7	Hired Labor	0.029	0.020	0.143	-0.066	0.080	0.408
8	Tractor Use	0.034	0.028	0.215	-0.071	0.363	0.846
9	Harvester Use	0.029	0.050	0.561	-1.171	0.373	0.002*
10	_cons	2.848	0.197	0.000*	1.886	0.836	0.024*
11	Usigma_cons	-2.552	0.283	0.000*	0.271	0.133	0.042*
12	Vsigma _cons	-3.984	0.329	0.000*	-3.228	0.382	0.000*
13	Sigma_u (σu)	0.279	0.039	0.000*	1.145	0.076	0.000*
14	Sigma_v (σv)	0.136	0.022	0.000*	0.199	0.038	0.000*
16	Gamma (γ)	0.8080			0.9707		

Note: 1. *are the significant
2. Gamma (γ) = σu square / (σu square + σv square)

Sources of Inefficiency in the study area: This is the dry-land area where entire paddy is cultivated under the lift irrigation. Therefore, it may be presumed that uncertainty in the availability of the water is the main cause of randomness and hence source of inefficiency which is not under the control of the farmers.

6.1. Distribution of the Efficiencies

In this section, efficiencies have been compared between the SRI and Non-SRI farmers. Also,theefficiencies between the early and late adopters of the SRI farmers are compared.Table 4 gives the efficiency levels in the SRI practice across farm categories. Average technical efficiency is almost same among the SRI and Non-SRI practice.Moreover, there is not much difference across all farm categories in the SRI practice compared to the non-SRI farm categories. There is no much difference in effect of inputs on output between the SRI and Non-SRI practice. The adoption of SRI components does not have significant effects on technical efficiency, therefore got technical efficiency almost same between the SRI and Non-SRI Practice.

Within the SRI farmers, it is almost same across all categories. The allocative efficiency is high in the SRI practice; it is 0.63 in the marginal farmers, 0.68 in the small farmers and 0.69 in the other farmers.

In addition, among the SRI farmers, it is high in the other farmers followed by small farmers, and marginal farmers. Under SRI practice, farmers are using resources efficiently. Moreover, the other farmers (large farmers) and small farmers are efficient compared to the marginal farmers in the SRI practice.SRI practice found to be economically efficient because its value is 0.55 for the farmers practicing SRI, which is higher than the non-SRI practice, moreover, all categories of the farmers found to be economically efficient. It is 0.57 in the other farmers and small farmers, which is higher compared to the marginal farmers. Therefore, SRI practice is found to be more allocative efficient and economically efficient. Moreover, "other farmers" are allocating resources efficiently, and these farmers found to be more economically efficient under the SRI practice. The imputed cost of the family labour made low allocative efficiency for marginal farmers.

SRI farmers are found to be more efficient becauseof adoption of the components and using less input in the SRI practice.Marginal farmers gained lesser allocative efficiency and economic efficiency because they use higher family labor compared to the small and other farmers.

The average human labor is high (272.4 hours) among the SRI farmers compared to the 256 hours in the Non-SRI Farmers. The family labour use is (179.8hrs) high compared to the hired labor(92.6hrs) in the SRI practice while the family labor is low (120.6) compared to the hired labor(135.4hrs) in the non-SRI farmers. Family labor and hired labor use is high among the marginal farmers in boththe SRI and Non-SRI Practices (table 8 in chapter 5).The use of labour is high among the marginal farmers as they prefer to use labor in place of machinery because they cannot afford it and also they have not used weedicides like the "otherfarmers".There are high percent (48.6 percent) of the marginal farmers among the SRI farmer category compared to the marginal farmers (25.6) among non-SRIfarmercategory (table 5).

Therefore, higher labor use particularly family labor is leading to the lower efficiency among the marginal farmers. Because marginal farming households have more labourtherefore, they used higher family labour. This is causing allocative and economic inefficiencies among the marginal farmers both in the SRI and Non-SRI cultivation.

Table 4. Distribution of Efficiencies Across Farm Categories									
Sl.No.	Efficiencies	SRI Farmers				Non- SRI Farmers			
		Marginal farmers	Small farmers	Other farmers	All	Marginal farmers	Small farmers	Other farmers	All
1	TE	0.80	0.81	0.80	0.81	0.82	0.83	0.82	0.82
2	AE	0.63	0.68	0.69	0.66	0.49	0.56	0.60	0.55
3	EE	0.52	0.57	0.57	0.55	0.41	0.47	0.51	0.46

Table 5 gives the levels of the TE, AE and EE of the SRI practice. More percentage of the SRI farmers is in the low levels of the technical efficiency and across all categories of SRI farmers. High percent (50.5 percent) of the farmers fall in the higher level of allocative efficiency in the SRI practice compared to 29 percent farmers in the non-SRI practice. It is high across all categories of SRI farmers. Moreover, higher percentage of the SRI farmers falls into the higher levels of economic efficiency. Higher levels of economic efficiency are across all categories of SRI farmers.

Table 5. Distribution of Efficiencies Across Farm Categories									
Sl.No.	Level of Efficiencies	SRI Farmers				Non- SRI Farmers			
		Marginal farmers	Small farmers	Other farmers	All	Marginal farmers	Small farmers	Other farmers	All
Technical Efficiency									
1	up to 30	0	0	0	0	0	0	0	0
2	31 to 70	8 (15.7)	7 (20.6)	4 (22.2)	19 (18.4)	3 (14.3)	1 (4.3)	2 (10.0)	6 (9.4)
3	Above 71	43 (84.3)	27 (79.4)	14 (77.8)	84 (81.6)	18 (85.7)	22 (95.7)	18 (90.0)	58 (90.6)
4	All	51 (100)	34 (100)	18 (100)	103 (100)	21 (100)	23 (100)	18 (100)	62 (100)
Allocative Efficiency									
1	up to 30	8 (15.7)	4 (11.8)	1 (5.6)	13 (12.6)	6 (28.6)	3 (13.0)	1 (5.6)	10 (16.1)
2	31 to 70	19 (37.3)	11 (32.4)	8 (44.4)	38 (36.9)	9 (42.9)	13 (56.5)	12 (66.7)	34 (54.8)
3	Above 71	24 (47.1)	19 (55.9)	9 (50.0)	52 (50.5)	6 (28.6)	7 (30.4)	5 (27.8)	18 (29.0)
4	All	51 (100)	34 (100)	18 (100)	103 (100)	21 (100)	23 (100)	18 (100)	62 (100)
Economic Efficiency									
1	up to 30	10 (19.6)	7 (20.6)	2 (11.1)	19 (18.4)	11 (52.4)	6 (26.1)	1 (5.6)	18 (29.0)
2	31 to 70	28 (54.9)	10 (29.4)	9 (50.0)	47 (45.6)	6 (28.6)	13 (56.5)	15 (83.3)	34 (54.8)
3	Above 71	13 (25.5)	17 (50.0)	7 (38.9)	37 (35.9)	4 (19.0)	4 (17.4)	2 (11.1)	10 (16.1)
4	All	51 (100)	34 (100)	18 (100)	103 (100)	21 (100)	23 (100)	18 (100)	62 (100)

Efficiencies have been compared between the early and late adopters of the SRI farmers. Table 6shows that the technical efficiency is high that is 0.85 among the early-adopted farmers compared to the late adopting farmers (0.78). It means the late adopting farmers are not able to achieve technical efficiency but experienced farmers are able to achieve technical efficiency. The allocative and economic efficiencies are high among the early adopters of the SRI farmers.Therefore, early adopters found to be more efficient because their experience helped in allocating resources efficiently. Moreover, to get the higher technical efficiency, they have used best combination of the inputs compared to late adopters.

Table 6. Efficiencies Among the Early and Late Adopters

Sl.No.	Status of Adoption	Technical Efficiency	Allocative Efficiency	Economic Efficiency
1	2	3	4	5
1	Early adopters(N=36)	0.85	0.69	0.60
2	Late Adopters(N=67)	0.78	0.63	0.52
3	All adopters(N=103)	0.82	0.66	0.56

High percent of the early adopters are in higher level of technical efficiency (94.4 percent) compared to the late adopting farmers that is 74.6 percent. High percent of the early adopting farmers in the higher level of allocative efficiency and economic efficiency (see table 6.6.1).

Table 6.1 Levels of Efficiencies Among the Early and Late Adopters

Sl.No.	Level of Efficiency	Technical Efficiency	Allocative Efficiency	Economic Efficiency
1	2	3	4	5
Early adopters(N=36)				
1	upto 30	0(0.0)	4(11.1)	5(13.9)
2	31 to 70	2(5.6)	10(27.8)	16(44.4)
3	Above 71	34(94.4)	22(61.1)	15(41.6)
Late Adopters(N=67)				
1	upto 30	0(0.0)	9(13.4)	14(20.9)
2	31 to 70	17(25.4)	28(41.8)	32(47.8)
3	Above 71	50(74.6)	30(44.8)	21(31.3)

6.2. Determinants of Efficiencies

The following (table 7) factors are determinants of different efficiencies in agriculture and in the SRI paddy cultivation as well. Number of factors islisted as the determinants of technical efficiency but no factor is determining the technical efficiency significantly but the coefficient of the family size, irrigated land, literacy, SHG membership is positive. Therefore, these factors are positively associated with the technical efficiency but there is no statistical evidence that it is determinant of the technical efficiency. Three factors are significantly determining the allocative efficiency. Family size and education level is positively determining AE, it means that those farmers with big family size are likely to get higher AE or likely to allocate resources efficiently. Coefficient of the age of the farmers is negative but statistically significant which means younger farmers are likely to allocate resources better. Literature also revealed that literacy is also the crucial determining factors of allocative efficiency. Here, it is found that literacy is positively determining the allocative efficiency; it means literate farmers are likely to allocate resources efficiently in the system of rice intensification practice. Age of the farmer, Family size, and literacy factors are statistically significant. Age coefficient is negative which means younger farmers are likely to be more economically efficient in the cultivation. The farmers those have big family size and have literacy are the economically efficient in the system of rice intensification practice. Therefore, it clearly indicates that the family size, literacy, and age are the determining the allocative efficiency and economic efficiency of the SRI Practice.

Table 7. Determining Factors of Efficiencies in the SRI Practice

Sl. No.	Factors	SRI (N=103)	
		Coef.	P>|t|
1	2	3	5
Technical efficiency			
1	Age in no. of year	-0.109 (0.084)	0.197
2	Family Size number	0.921 (0.630)	0.147
3	Extent of Land in Acres	-0.914 (0.507)	0.075
4	Extent of land leased in in acres	-0.354 (0.529)	0.505
5	Irrigated Area in acres	1.344 (1.060)	0.208
6	% of irrigated area in total area	-0.064 (0.043)	0.140
7	Educational status (Illiterate = 1, Literate = 2)	0.681 (2.041)	0.739
8	SHG member (yes=1, 2=No)	0.273 (2.758)	0.921
9	Agriculture as main Occupation (yes=1, 2=No)	-1.765 (2.095)	0.401
10	Credit (yes=1, 2=No)	-0.154 (2.163)	0.944
11	Big Ruminants (yes=1, 2=No)	-1.304 (1.967)	0.509
Allocative Efficiency			
1	Age in no. of year	-0.493 (0.212)	0.022**
2	Family Size number	3.348 (1.586)	0.037**
3	Extent of Land in Acres	-0.144 (1.276)	0.910
4	Extent of land leased in in acres	0.666 (1.333)	0.619
5	Irrigated Area in acres	-0.162 (2.669)	0.952

6	% of irrigated area in total area	-0.009 (0.109)	0.931
7	Educational status (Illiterate = 1, Literate = 2)	11.030 (4.992)	0.030**
8	SHG member (yes=1, 2=No)	-12.739 (6.745)	0.062
9	Agriculture as main Occupation (yes=1, 2=No)	-3.483(5.123)	0.498
10	Credit (yes=1, 2=No)	-2.615 (5.290)	0.622
11	Big Ruminants (yes=1, 2=No)	-0.724 (4.810)	0.881
Economic Efficiency			
1	Age in no. of year	-0.437 (0.204)	0.035**
2	Family Size number	3.218 (1.530)	0.038**
3	Extent of Land in Acres	-0.578 (1.231)	0.640
4	Extent of land leased in acres	0.258 (1.285)	0.841
5	Irrigated Area in acres	0.573 (2.573)	0.824
6	% of irrigated area in total area	-0.038 (0.105)	0.714
7	Educational status (Illiterate = 1, Literate = 2)	9.378 (4.833)	0.049**
8	SHG member (yes=1, 2=No)	-10.530 (6.531)	0.110
9	Agriculture as main Occupation (yes=1, 2=No)	-4.536 (4.960)	0.363
10	Credit (yes=1, 2=No)	-1.667 (5.122)	0.746
11	Big Ruminants (yes=1, 2=No)	-1.691 (4.658)	0.717
Note: Figures in the brackets are standard Error			

6.2.1. Endowments of the Top Efficient Farmers

Endowments of top 20 percent efficient farmers of the SRI and Non-SRIpractice:Table6.8 gives the comparison of land related and non-economic endowments between top 20 percent efficient farmers of the SRI and Non-SRI farmers.Among the top technicalefficientSRIfarmers, average irrigated paddy area is high compared to the non-SRI farmers. Higher percent of the farmer's main occupation is the agriculture among the SRI farmers. Average credit for both the groups of farmers is almost same but average institutional credit is low for the SRI farmers. Average livestock is low among the SRI farmers compared to the non-SRI farmers. High percent of the farmers received extension among the SRI compared to the non-SRIfarmers.Even among the farmers achieved allocative and economic efficiencies the above patterns apply, except that the average credit taken from both institutional and institutional is low among the SRI farmers.Therefore, the farmers, with high irrigated area, higher paddy area, more farmerswithmain occupation as agriculture and also who took less credit have attained higher technical, allocative and technical efficient in the SRI practice compared to non-SRIfarmers (table 8).

Table 8. Land Related and Non-economic of the top 20 % Efficient farmers of SRI and Non-SRI							
Sl.No.	Particulars	TE		AE		EE	
		SRI	Non-SRI	SRI	Non-SRI	SRI	Non-SRI
		N=20	N=12	N=20	N=12	N=20	N=12
3	Average Efficiency	0.91	0.91	0.93	0.85	0.82	0.78
4	Average land in acres	3.7	4.6*	4.2	3.4*	4.5	3.5*
5	Average Area Cultivated	3.4	3.9*	3.8	2.7*	4.0	2.8*
6	% of irrigated area	64.3	33.4*	53.6	32.9*	52.1	35.8*
7	% of paddy area in total cultivated	71.9	50.1	54.2	49.4	58.3	52.4
8	% of SRI area in Total paddy area	56.9	NA	66.2	NA	63.4	NA
9	% of farmers in SHG membership	95.0	83.3	95.0	91.7	95.0	100.0
10	% of farmers in NGO member	10.0	0.0	15.0	0.0	10.0	0.0
11	% of farmers main occupation as agriculture	85.0	58.3	70.0	66.7	75.0	66.7
12	Average Credit from Institutional Sources	40667	61250	45167	61833	34200	55167
13	Average credit from Non- Institutional Sources	26538	26667	29286	30000	27813	30000
14	Average Credit taken	44438	44000	45400	55545	38500	51100
15	Average Big ruminants	2.53	3.16	2.6	3.14	2.5	3.16
16	Average Livestock	5.75	7.88	5.58	7.77	5.8	8.5
17	% of farmers received Extension	75.0	66.7	70.0	66.7	70.0	75.0
Note: *s in the table are statistical significant (t- test is done for Average land,Area Cultivated), % of irrigated area, % of paddy area)							

6.2.2. Top 10 percent of top and bottom efficient SRI farmers

The comparison of land related and other non-economic endowments has been done between the top 10 percent and bottom 10 percent farmers among the SRI farmers to identify variables contributing to the SRI practices.Table 9 indicates that farmers with high irrigated land, high percent of paddy area, and high percent of SRI paddy are more technically, efficient. A higher percent of farmerswithmain occupation agriculture have attained higher technically efficiency. The farmers with a lower average credit and high average number of big ruminants are more technically efficient. Therefore, the farmers who lack in the above said variables are not getting better efficiencies though they adopt the SRI practice. Early adopters are more technically efficient. More or less same variables contributed to gain allocative as well as economic efficiencies also. However, practicing core SRI practices like single plant at hill, controlled water management and transplanting young plants are not making much difference in gaining efficiency in production (table 6.9).

Table 9. Land Related and Non-economic Endowments of the Top 10 % and bottom 10% of Efficient Farmers in the SRI Practice

Sl. No.	Particulars	TE (N=10)		AE (N=10)		EE (N=10)	
		top	bottom	top	bottom	top	bottom
1	% of early adopter	30	0	50	20	30	40
2	% practicing core SRI practices	20	30	30	40	20	60
3	Average land in acres	2.6	2.9	4.6	2.6*	3.4	2.8
4	Average Area Cultivated	2.4	2.5	4.4	2.1*	3.3	2.4*
5	% of irrigated area	65.9	52.9*	54.4	60.0	59.6	61.9*
6	% of paddy area in total cultivated	72.6	58.3*	58.6	71.6	60.5	72.3
7	% of SRI area in Total paddy area	71.3	49.2*	68.3	44.3*	67.8	36.8
8	% of farmers in SHG membership	100.0	100.0	90.0	90.0	90.0	90.0
9	% of farmers in NGO member	10.0	10.0	20.0	0.0	20.0	0.0
10	% of farmers maim occupation as agriculture	100.0	60.0	70.0	70.0	80.0	60.0
11	Average Credit from Institutional Sources	48333	47000	34200	76667	25250	85000
12	Average credit from Non- Institutional Sources	27778	16200	30000	16500	24444	23200
13	Average Credit taken	54000	38429	49000	49333	35667	47667
14	Average Big ruminants	2.37	1.83	2.42	2	3	2.25
15	Average Livestock	8.66	10.62	5	3.33	5.42	3
16	% of farmers received Extension	70.0	70.0	80.0	90.0	60.0	80.0

Note: *s in the table isstatisticallysignificant (t - test is done for Average land Area Cultivated), % of irrigated area, % of paddy area)

6.2.3.Adoption of the SRI Components by top 10 percent Efficient Farmers

Only 20 percent of the farmers who followed the age component are among the top 10 percent efficient farmers. About 30 percent of the farmers followed Spacing component are among the top 10 percent allocative and economic efficient farmers, and also 40 percent of the farmers are among top 10 percent technical efficient farmers. About 40 percent of the farmers followed the single plant age a hill are among the top 10 percent technical and economic efficient farmers, and also 50 percent of the farmers are among top 10 percent economic efficient farmers. About 60 percent of the farmer followed the weeding component are among the top 10 percent technical and allocative efficient farmers, and also 80 percent of the farmers are among top 10 percent economic efficient farmers. About 80 percent of farmersthose adopted irrigation component are in higher efficient. Therefore, not only the adoption of SRI components but other factors played important role in achieving the higher efficiencies in among SRI farmers.

About 20 percent pure SRI farmers (grown paddy only through SRI practice) of the farmers got higher technical and allocative efficiency, and also 30 percent of these farmer got higher economic efficient.

All top efficient farmers attended the training/ demonstration programs on SRI practice which were held in villages and outside village. About 80 percent of the farmers motivated from NGOs to adopt the SRI cultivation.

Table 10. Adoption of the SRI components by top 10 % efficient farmers(N=10)

Sl. No.	Particulars	TE	AE	EE
SRI components				
1	% farmers followed Raising Nursery component (below 12 days old)	20	20	20
2	% farmers followed Spacing distance component (25x25 cm and more in square manner)	40	30	30
3	% farmers followed Transplanting component (Single plant at a hill)	40	50	40
4*	% farmers followed Weeding component (weeding by mechanic weeder)	60	80	60
5*	% farmers followed Irrigation component (not flooded always)	80	90	80
Other Particulars				
1	% of pure SRI farmers	20	20	30
2	% of farmers motivated from NGO	80	80	90
3	% of farmers attended training/demonstrations on SRI	80	100	100
4	Average number of times attended in training/demonstration programs	4	2.9	3.3

Note:* not followed exactly as recommended but weeded manually also and given less water

6.2.4. Efficiency and Characteristics of the Farmers Who Adopted All SRI Components

There are only five (4.8 percent) farmers who adopted all the SRI components. Average efficiencies of these farmers are higher compared to the averages of all SRI farmers; 6 percent higher technical, 16 percent higher allocative efficiency and 17 percent higher economic efficiency.

The average cultivated area is about 3.35 acres, among this, more than 70 percent is irrigated land, paddy is cultivated around 60 percent of the land, and 43 percent of this area is under the SRI cultivation.

All farmers have cultivated SRI paddy along with the non-SRI paddy. All these farmers started SRI practice in the early stage. Average age of these farmers is about 41.2 years and their average family size about 4.8. About 80 percent of the farmers are literate farmers, all these farmers have membership in the SHGs and 60 percent of the farmer has membership in the NGOs. About 80 percent of the farmer's main occupation is agriculture. 80 percent of the farmer took credit from which 80 percent of the farmer took credit from informal sources. All the farmers have livestock from which 60 percent farmers have big ruminants. All these farmers attended training/demonstration programs on the SRI which were held in the village and outside the village.

Table11. Efficiency, Land Related and Non-economic Characteristics of the Adopters of all SRI Recommended components(N=5)

Sl. No	Particulars	Averages and percentages
Efficiency		
1	Average Technical efficiency	0.87
2	Average Economic efficiency	0.72
3	Average Allocative efficiency	0.82
Land Related		
4	Average extent of land in acres	3.45
5	Average Area Cultivated	3.35
6	% of irrigated area	70.3
7	% of paddy area	60.5
8	% of SRI area in total paddy area	43
Non-Economic Characteristics		
9	% of the farmers grown SRI and non-SRI paddy	100
10	% of Early adopters	100
11	Average age of the farmer	41.2
12	Average Family Size	4.8
13	% Literate farmers	80
14	% of farmers with SHG membership	100
15	% of farmers in NGO member	60
16	% of farmers main Occupation as agriculture	80
17	% of farmers taken credit from Institutional Credit	20
18	% of farmers taken credit from non-institutions	80

19	% of farmers taken credit	80
20	% of the farmer with big ruminants	60
21	% of the farmer with Livestock	100
22	% of farmers attended training/demonstrations on SRI	100

7. Conclusion

The efficiency of the farmers has been derived from the stochastic production frontier and stochastic profit frontier. It is found that the difference between the actual and potential output (productivity and return) is due to the inefficient use of the variables which are under the control of the farmers.SRI practice found to be more economically and allocative efficient over Non-SRI Practice but technical efficiency is same in boththepractices of paddy. SRI farmers have allocated resources efficiently, which means these farmers are using best combinations of inputs for growing SRI paddy and making net incomes compared to the non-SRI farmers. Higher percent of the SRI farmers are in high level economic efficient category compared to the non-SRI farmers. Among the SRI farmers, early adopted farmers gained higher technical, allocative and economic efficiencies compared to the late adopting farmers; therefore, experience makes them use resources efficiently. Among the SRI farmers, early adopted farmers found to be technically, allocatively and economically efficient compared to that of late adopted farmers. Hence, anexperiencein the SRI farming is leading to higher efficiencies among the farmers.

A comparison of top and bottom 10 percent farmers practicing SRI and non-SRI and within SRI practicing farmers had been made to highlight the variables contributing to efficiency. These may be useful for policy purpose. The analysis shows the farmers, with high irrigated area, higher paddy area, low average age, higher family size, farmerswithmain occupation as agriculture have attained technical, allocative and economic efficiencies. Moreover, early adoption of SRI practices along with all the above factors contributed to efficiency among the SRI practicing farmers. These factors can be built into programmatic interventions to promote SRI cultivation.

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