GIDR WORKING PAPER SERIES

No. 196 : January 2010

Does the System of Rice Intensification Outperform Conventional System? A Case Study of Gujarat

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Working Paper No. 196

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Abstracts of all GIDR Working Papers are available on the Institute's website. Working Paper No 121 onwards can be downloaded from the site.

First Published December 2009
ISBN 81-89023-54-3
Price Rs. 35.00

Abstract

The strategy for attaining the target of four per cent growth during the Eleventh Plan seems to be hinging on the approach that lays its central thrust on improving water use efficiency and attaining higher growth in agricultural production. It is conventional wisdom in agricultural production that to achieve productivity growth either technological innovation or more efficient use of production technologies or a balance of both are required. Given the scenario, where new technological frontiers both in genetically modified technology and production of integrated nutrition and pest management have not been adopted on wider scale, this paper is located in the larger context of the debate about ways to approach limits of economically optimum yield of paddy with available technologies. The objective of this paper is to examine farm level performance of System of Rice Intensification (SRI) method of paddy cultivation as against the traditional method. Howsoever small it is in scale of adoption in the state of Gujarat. The paper will examine the role of NGOs in raising awareness among farmers about the SRI technique as also of agricultural extension services in general. The lessons from the analysis are expected to contribute to the ability of the government to support strategies which would go a long way in increasing returns to farmers.

Keywords : System of Rice Intensification (SRI), extension services, efficiency, NGO

JEL Codes : Q12, Q16, Q69, L31

Acknowledgements

The author wishes to acknowledge Amita Shah and S.P. Kashyap for the encouraging comments and suggestions on an earlier draft. Thanks are also due to R. Parthasarathy for encouraging her to work on the issue of System of Rice Intensification and Tara S. Nair for editorial support. The usual disclaimers apply.

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1. Introduction

While there has been an increasing recognition of the need to achieve four per cent growth in Indian agriculture, the performance during the Tenth Five Year Plan does not provide an encouraging picture. Not only that the growth during the Tenth Plan period was slower than what was targeted, the agrarian scenario was particularly adverse to the poor and those operating under not so conducive agro-climatic conditions. The strategy for attaining the target of four per cent growth during the Eleventh Plan seems to be hinging on the approach that lays its central thrust on improving water use efficiency and attaining higher growth in agricultural production. It is conventional wisdom in agricultural production that to achieve productivity growth, either technological innovation or more efficient use of production technologies, or a balance of both, are required. Schultz (1964) showed that new agricultural technologies have only been partially successful in developing countries due to lack of ability or desire on the part of farmers to adjust input levels resulting from familiarity with traditional agricultural system or presence of institutional constraints. There is considerable agreement with the notion that adoption of farm technologies has positive impacts on income and productivity (Hayami and Ruttan, 1985). However, major technological gains stemming from the green revolution seem to have been largely exhausted across the developing countries. This suggests that attention to productivity gains arising from a more efficient use of existing technology is justified. The presence of shortfall in efficiency means that output can be increased without additional inputs and without need of new technology. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of gains that could be obtained by improving performance in agricultural production with a given technology.

Given the scenario, where new technological frontiers both in genetically modified technology and production of integrated nutrition and pest

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management have not been adopted on a wider scale, this paper is located in the wider context of the debate pertaining to the ways to approach limits of economically optimum yield of paddy with available technologies. The paper is based on the specific case of the western Indian state of Gujarat.

Area under paddy occupies 14 per cent of the total area under food crop in Gujarat and largely cultivated in central and southern Gujarat. Paddy is a water intensive crop and nearly 30 per cent of the water from Ukai Kakrapar reservoir project, which is the largest irrigation project in south Gujarat, is used for paddy production. However, water is not the only input used in crop cultivation. Production of irrigation output is highly correlated with other inputs used in the cultivation of crops. Moreover, increasing demand for water in various sectors is putting pressure on water for irrigation. Thus, any effort to increase productivity gains arising from efficient use of available technology would have its positive implications for use of all inputs. Findings from this study may be useful in other areas of India and parts of Gujarat where paddy is the chief crop or where there is a situation of water stress.

System of Rice Intensification (SRI) is a civil society innovation that was first developed in Madagascar by Father He*nri de Laulanié*, a French Jesuit priest who combined field observations of rice plant performance with a series of experiments over a decade, preceded by an accidental early planting (Stoop et al, 2002). In Gujarat, SRI was first conceptualised as a complementary suite of rice management technique by Aga Khan Rural Support Programme (AKRSP), a Non Governmental Organisation (NGO). SRI was introduced in 2006 by AKRSP with extensive farmer participation to address the issue of crop productivity and natural resource conservation along with suitable packages of agronomic and crop management practices (called resource conserving technologies or RCT).

The objective of this paper is to examine farm level performance of SRI method of paddy cultivation as against the traditional method in a select area in Gujarat. The paper assesses whether farmers in the paddy producing belt of Gujarat are efficient producers of the crop, i.e., do they exhibit technical inefficiency? If so, how do the estimated inefficiency scores vary among farmers producing paddy under the two methods and what are the sources of inefficiency across farmers? As adoption of SRI method is in the nascent stage, farmers have adopted it in small patches of their land.

We do not attempt to compare efficiency of SRI method of paddy cultivation with that of the existing traditional practice. However, understanding of various factors affecting productivity of paddy grown using SRI methods would help us in examining whether there is any room for improvement in the utilisation of existing inputs, given a constant state of technology.

This paper is organised in the following manner: Section 2 briefly discusses the concept of SRI method of paddy cultivation as against the conventional method as also reviews the experience of farmers' who use SRI method in different countries including India. Section 3 discusses analytical tools, data sources and methodology used in the analysis. Results of the analysis are discussed in Section 4. Some reflections about the preferences of farmers are discussed in Section 5. Section 6 presents summary of the major findings and policy recommendations.

2. SRI and Traditional Method of Paddy Farming: A Comparison

SRI is a method for increasing the productivity of irrigated paddy cultivation by changing the management of plants, soil, water and nutrients. It is a system of growing paddy that involves principles that are at times radically different from the traditional ways of growing paddy. One has to look into the elements of SRI separately, even though the ultimate success might lie in the combination of different elements of SRI. The important aspects of SRI are transplanting seedlings, number of seedlings transplanted per hill, spacing of transplanted seeds, water management, soil and nutrient management and weeding. The difference between each of these aspects in paddy cultivated using SRI methods and conventional methods are given below:

Table 1 : SRI and Traditional Methods: A Comparison

Important aspects	Methods of cultivation	
	SRI method	Traditional method
Transplanting young seedlings No. of seedlings transplanted per hill Spacing of transplanted seeds	8-12 days One seed per hill 30*30 cms between seedlings	1 month No specifications followed No specifications followed
Water management Soil and nutrient management Weeding	Alternatively kept wet and dry Fertilisers 4 times and the first weeding starts 10 days after transplantation	Flooded Organic fertiliser As per the need

Source: Field research

2.1 Experiences across Countries

On the footsteps of success of SRI in Madagascar, SRI was promoted vigorously throughout Asia. Figures acquired till the year 2007 depict the beneficial effects of SRI methods in 28 countries. Most recent examples of SRI implementation can be found in countries like Bhutan, Iraq, India and Indonesia (Maheshwari, 2005). Governments of the largest rice producing countries like China, India and Indonesia are now actively promoting this method of rice production.

Experiences from Tripura in India shows that after the implementation of SRI, the cost of production went down by around 20 per cent compared with that achieved by standard methods of cultivation (Uphoff, 2005). On evaluating SRI in a Sichuan village, the China Agricultural University found that SRI reduced water requirements by 45.8 per cent coupled with better yield. In Sri Lanka, an evaluation was done by the International Water Management Institute (IWMI) by comparing 60 each of randomly selected SRI and non-SRI farmers found that on average net returns were higher by 103 per cent for the SRI farmers with an average yield increase of 44 per cent (Rao and Satyanarayana, 2005). With SRI, irrigation water requirements were reduced by about half compared to TF. Returns on crop budgets were even higher, while cost of production per unit of paddy output considerably lower. Average profits of SRI farms were found to be double that of conventional farms. The evaluation of SRI in Cambodia in 2004, showed that over 400 SRI farmers earned a 41 per cent higher grain yield from SRI farms (Uphoff, 2004). In Indonesia, during the wet season of 1999-2000, Central Research Institute for Food Crops (CRIFC) conducted SRI trials at Sukamandi station, and managed a yield of 4.5 tonnes/ha. With SRI methods, yield of other farmers in the locality were found to be around 5.9-6.9 t/ha (Prasad, 2006). Thus, field experiences from the world over have established that wider benefits are gained through SRI management, which has led to its increasing popularity.

The capacity of producing more rice with less input use is crucial for promoting sustainable agriculture and ensuring food security in a developing country like India. Prasad (2006) noted that formal experiments in SRI had started in India in 2002-2003. So far SRI has been adopted in Tamil Nadu, Andhra Pradesh, West Bengal, Jharkhand, Chhattisgarh and Gujarat. It is fast gaining popularity among paddy farmers in several other states in recent times owing to its potential of improving productivity of land, capital, water and labour simultaneously. Prasad (2006) studied 291 respondents which included 67 SRI farmers, 71 neighboring farmers, 77 researchers and 76 extension workers and found that a seed rate of 5 Kg/ha was sufficient to realize a saving of 95 per cent on seeds. They also found that about 50 per cent of water was saved because of an average yield advantage of 2 t/ha.

During experiments in 2003-2004 at the Agricultural College and Research Institute and Tamil Nadu Agricultural University (TNAU), Killkulam, Tamil Nadu, it was found that, on an average, 53 per cent less irrigation water was used in SRI farms (Thiyagarajan, 2002). Similar claims were made by Satyanarayana (2005). PRADAN studied 110 farmers in Jhalda and Balrampur blocks in Purulia district of West Bengal during the 2004 kharif season (Mishra et al., 2006). The study found that SRI plots produced on an average, 32 per cent higher paddy yields, 67 per cent higher net returns and eight per cent reduction in labour requirement even with the partial adoption of SRI. SRI practice saves 60-70 per cent of water used for irrigation during the paddy-growing season (Prasad et al., 2005).

However, these experiments were not without hitches. The high labour requirement has discouraged many to adopt the technology/practice (Ghosh, 2008). Critics pointed out three components of SRI that run against the well-established principles for high crop growth: (a) SRI suffers from poor light interception because of low plant densities; (b) the traditional school is unwilling to accept the hypothesis that the relation between growth and plant water-use can be changed; (c) SRI might face a serious challenge in obtaining sufficient mineral nutrients from organic sources to achieve high yields. Hence, there remains the serious question on whether SRI is really beneficial to farmers. The results have so far been mixed (Table 2).

Table 2: Aggregated Database of Experiments where SRI was Concurrently Evaluated against Accepted Best Management Practices (BMP)

Source	Location	Setting	SRI yield (t ha^{-1})	BMP yield (t ha^{-1})	SRI yield deviation (%)[1]	Comment
Uphoff and Randriamiharisoa (2002)	Madagascar (Anjomakely)	Farmer field	10.4	3.0	245	Good soil
Uphoff and Randriamiharisoa (2002)	Madagascar (Anjomakely)	Farmer field	6.4	2.0	213	Poor soil
BRRI (http://ciifad.cornall.edu/sri/countries/bangladesh/bangrisrifnl.pdf	Bangladesh (comilla)	Exp. station	5.3	4.4	22	
Shengfu et al. (2002)	China (Anqing)	Exp. station	12.2	10.0	21	
Nissanka and Bandara (2004)	Sri Lanka (Hinguraggoda)	Exp. station	7.6	6.9	10	
Qingquan (2002)	China (Yunshun Co.) cult.	Unreported	12.0	11.7	2	Pei'ai cultivation
Duxbury (Personal communication)	Bangladesh (Rajshahi)	Exp. station	10.0	9.8	2	2002 Boro
Sheehy et al. (2004)	China (Guangdong)	Exp. station	7.2	7.2	_1	
Evans et al. (2002)	Nepal (Bhairawa)	Exp. station	5.4	5.7	_5	

Source: Field research

Evaluation of SRI is difficult as it is still evolving and remains more of a set of ideas than a complete technology. SRI is spreading because of its versatility and capacity to increase income of farmers. Though higher yield and less water usage are the most evident features of SRI, many other socio-political and agronomic considerations are also driving its spread around the world. With the help of NGOs, farmers are encouraged to make their own improvements in SRI methods and share their experiences within the farming community. This paper attempts to estimate the technical efficiency of paddy cultivated using the SRI and conventional methods and to understand the factors affecting the yield in rice cultivation under these two sets of practices. The analysis will throw light on their potential to increase the yield of paddy cultivation.

[1] SRI yield deviation from BMP= ((SRI t ha^{-1} / BMP t ha^{-1}) -1)*100;

3. Methodology

3.1. Analytical tools and limitations

The measurement of efficiency in paddy farming in developing countries is extensively discussed in the literature. Generally, these studies estimate efficiency using the single equation production frontier models utilizing cross sectional or panel data. A stochastic frontier has been widely used in developing countries to estimate technical efficiency (Battese 1992; and Coelli 1995).

Production function of the farmer sets the outer limit on the observed level of output or yield produced using input in such a way that no observed value of output is expected to lie above this function. If y = f(X) wherein X represents inputs and Y output or yield, then a firm is said to be technically efficient if $Y^0 = f(X^0)$. Bhende (2000) found that Farrell and others have estimated a deterministic parametric frontier by specifying homogenous Cobb Douglas (C-D) production function. He stated that most of the studies assume Cobb Douglas (C-D) or Translog specifications at farm level. Apart from the production input related outcome, sources of efficiency differentials have been frequently highlighted. Many of the studies examine factors explaining differences in level of efficiency of farmers which are generally attributed to managerial and socio-economic variables. Though analysis of technical efficiency is a fairly conventional theme in agricultural productivity analysis, it could still yield useful contextual evidence.

$\ln Y_i = \alpha_0 + \beta_i \ln (X_i) + \mu;$ - - - - - - - - - — - - - - - - - - - (1)

where Y_i = output or yield or dependent variable
X_i = various inputs or independent variable
μ = error term

This function in the log form can be written as
$Y=f(X)\ e^{\mu}$, μ d" 0

where Y_i represents the actual output for the i^{th} sample (production) unit; Xi is a vector of inputs and β is a vector of parameters that describe the transformation process; f (.) is the frontier production function and μ is a one-sided (non-negative) residual term. If the production unit is inefficient, its actual output is less than the potential output.

Bhende (2000) in his paper described that at first, above equation is estimated using OLS technique to yield best linear unbiased estimates of β_i coefficients. The intercept α_0 is then corrected by shifting the function until no residual is positive and one becomes 0. This is done by adding highest error term of the function to the intercept. The new production function with shift in intercept is the frontier production function and it gives the maximum potential output or yield that can be obtained by using a given level of inputs. This can be written as

$\ln Y_i^* = \alpha_0^* + \beta_i \ln (X_i) + \mu$; where Y^* denotes frontier output, α_0^* denotes corrected intercept, β_I denotes estimated parameters and X_i denotes independent variables.

The Timmer's measure of technical efficiency of farmer 1 is the ratio of actual output to the potential output on the production function i.e., Y_i / Y_i^* where Y_i denotes actual output of farm i and Y_i^* indicate potential output on farm with given inputs.

$TE = Y_i / f(X_i; \beta) = \exp(-\mu_i)$ - - - - - - - - - - - - - - - - - - -(2)

The deterministic model described above provides a common production frontier for all farmers under study and the farmer's efficiency is derived by comparing their performance with that of common production frontier. However, the limitation of this method is that it fails to take into account exogenous factors which are beyond the control of the farmer. The stochastic frontier model proposed by Aigner, Lovell and Schmidt (1977) and later used by many scholars including Bhende (2000) is free from this criticism. They have modeled composite error terms while estimating stochastic frontier. The symmetric component permits random variation of the frontier across farmers and captures the effects of measurement errors, other statistical noise and random shocks which are beyond control of farmers. A one sided component captures the effect of technical inefficiency. Number of comprehensive review of literature on frontier production such as Greene (1993), Battese and Corra (1977); Jondrow et al., (1982) are available.

This study makes an attempt to study technical inefficiency of farmers using SRI and traditional method of paddy cultivation in lines with Bhende (2000). Moreover, we used C-D form to study socio economic factors that affect technical inefficiency of SRI and traditional method of paddy cultivation by farmers. In this paper we use the functional form C-D production function to determine the production possibility frontier. C-D production function is easy to calculate and hence preferred over other production functions. Moreover, it has the ability to test production flexibilities statistically and to obtain sufficient number of degree of freedom even where data is very few etc. C-D production function facilitates calculation of the input use rates of the farm. Thus, it introduces a different point of view about the productivity concept of the farm and determines the input use efficiency putting forth the function of the outputs obtained based on the inputs used. Production frontier thus calculated, represents a production function of the regime wherein production function sets a limit or outer bound on the observed levels of output or dependent variable in such a way that no observed value of output is expected to lie above the production function. The efficiency coefficient for paddy cultivated using SRI method and conventional method would help us know whether yield varies between SRI and conventional method of rice cultivation. The production frontier used here is of the following specification:

$$\ln Y_i = \alpha_0 + \beta_1 \ln(\text{Seed}) + \beta_2 \ln(\text{Fertiliser}) + \beta_3 \ln(\text{Water}) + \beta_4 \ln(\text{Hired labour}) + \beta_5 \ln(\text{Bullock cost}) + \beta_6 \ln(\text{Tractor cost}) + v_i + \mu_i \quad (3)$$

where the subscripts i refers to the i^{th} farmer;
ln denotes natural logarithm;
Y denotes yield of paddy (in kg/ha);
Seed denotes quantity of seed (in kg/ha);
Fertiliser denotes quantity of chemicals and pesticides used (in kg. /ha);
Water denotes number of watering;
Hired labour denotes hired labour (man days/ha);
Bullock cost denotes cost on of bullocks used (Rs/ha);
Tractor denotes cost on tractor use (Rs/ha)
μ_i denotes non positive random variable (Ue"0) that captures the technical inefficiency of the farmer.
v_i denotes statistical random term.

U_i measures the shortfall in output Y_i from its maximum value given by the stochastic frontier. It takes the value 0 when the farmer is efficient and is less than 0 when he is inefficient in his production. The Maximum Likelihood Estimation (MLE) enables us to obtain the maximum possible output function. It is assumed that μ and v are independent and μ follows truncated half normal distribution with mean μ and variance σ_μ^2 and v is a two–sided ($-\infty<V<\infty$) normally distributed random error ($v \sim N[0, \sigma v^2]$)

that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters), measurement errors, and other statistical noise

This new function is known as the individual-specific stochastic production frontier function. In order to estimate equation (3), we consider a half normal distribution for u_i (after empirical verification). The likelihood function for this model is:

$L = -N \ln \sigma$ - constant $+ \Sigma [\ln \Phi (-\varepsilon_i \lambda / \sigma) - 1/2 (\varepsilon_i/\sigma)^2]$;
where, $\lambda = \sigma_\mu / \sigma_v$, $\sigma^2 = \sigma_v^2 + \sigma_\mu^2$ and f is the cumulative standard normal distribution function and $\propto i = (v_i - u_i)$; σ_u and σ_v are standard deviations of the residuals μ and v respectively. The estimated parameters of MLE provides maximum possible output frontier and mean technical efficiencies (Bhende 2000; Kalirajan et al., 1985). Following Bhende (2000), technical efficiency is calculated by using the conditional mean of exp $(-\mu_i)$, given by the distribution of the composite error term $\propto_i$ or $(\mu + v)$.

Some other important parameters of the model are:
$\sigma^2 = \sigma_\mu^2 + \sigma_v^2$, $\lambda = \sigma_\mu/\sigma_v$ (>0) and $\Upsilon = (\sigma_\mu^2 / \sigma_v^2)$ as used by Jondrow et al., (1982). A significant σ (and λ) would indicate the significant variations in the output levels. The λ term with value above one would indicate that output variations due to inefficiency are higher than that due to random factors. A zero value of Υ would indicate that the deviations from the frontier are due entirely to the noise and, in this case, the OLS estimates of the model are equivalent to the MLE results. A value of one would indicate that all deviations are purely due to differences in TE across farms.

Frontier production function as defined by $\ln Y_i^* = \alpha_0^* + \beta_i \ln (X_i) + v_i + \mu_i$ has been defined as a neutral shift from the actual production function by the amount of its technical inefficiency (Bhende, 2000). MLE is calculated using FRONTIER Version 4.1c (written by Coelli (1995) and can be downloaded from *http://www.uq.edu.au/economics/cepa/frontier.htm).*

Further, attempt is made to examine factors causing inefficiency and integrate the natural and socio economic variables for explaining the observed efficiency differentials. Breusch-Pagan-Godfrey test is used to test for heteroscedasticity. This is performed by squaring error term and dividing each error term squared by the mean error term to obtain V_i^2. Then, V_i^2 is regressed against the dependent variables. The level of significance of F value would throw light on heteroscedasticity. Having confirmed the presence of homoscedasticity, we then, estimated value of technical efficiency of individual farmer in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the firm. Technical inefficiency is, therefore, defined as the amount by which the level of production for the firm is less than the frontier output.

Variations in efficiency estimates at the household level can arise due to a number of farmer-specific characteristics, such as age of the farmer, training received, labour days, quantity of paddy sold in the market and so on. In the surveyed village, variations in yield are, thus, modeled as a function of these farmer specific characteristics.

The inefficiency model (U_i) is defined by $U_i = a + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + V_i$; where Z_i is a vector of explanatory variables associated with technical inefficiency and δ is the corresponding vector of parameters to be estimated. V_i is a random error term and is defined by the truncation of U_i such that $V_i \geq -Z_i \delta$ which preserves the condition of $Ui \geq 0$. Empirical studies have estimated stochastic frontiers and predicted farm level efficiencies using these estimated functions, and then regressed the predicted efficiencies upon farm-specific variables (such as training, age, etc) in an attempt to identify some of the reasons for differences in predicted efficiencies between firms in an industry. The model used in this paper is a variant of the Huang and Liu model as the variable 'hired labour days' is included both in the stochastic production model and as a determinant in the model used to calculate inefficiency. A similar approach has been applied by Battese and Coelli (1995), Battese and Broca (1997) and Madau (2005). Battese and Coelli (1995) explain that inclusion of a variable in both the stochastic frontier and the inefficiency effects is possible when the inefficiency effects are stochastic.

Some of the limitations of this study are

- Data limitation in computing the production possibility. Most of the unobserved information impacting efficiency is rainfall, agro-ecological elements, geographical parameters; economic features like availability of credit, marketing and transport and so on which remain more or less unexplained.
- The inconsistency in the assumptions about the distribution of the inefficiencies. In the first stage, the inefficiencies are assumed to be

independently and identically distributed (iid) in order to estimate their values. However, in the second stage, the estimated inefficiencies are assumed to be a function of a number of firm specific factors, and hence are not identically distributed unless all the coefficients of the factors are simultaneously equal to zero (Coelli et al.,1998).

- Technology assumed to be given.
- As farmers are experimenting with SRI method of paddy cultivation, inferences from study cannot be used to generalize the results.

3.2 Data Source and Methodology

Since 2007, AKRSP (I) has tried raising awareness about the SRI method of paddy cultivation among tribals of Dediapara, Umarpada, Songadh and Mandavi talukas of South Gujarat. They had provided training and extension services to 756 farmers spread across four clusters (Sagbara cluster = 148 farmers; Dediapada cluster = 263 farmers; Mandavi cluster = 223 farmers and Netrang cluster = 122 farmers). Clusters were formed by group of small farmers residing in nearby villages and adopting SRI method of paddy cultivation.

We had carried out baseline study to understand actual adoption rate in Dediapara and Mandavi clusters - clusters with highest number of farmers adopting SRI technique. Farmers in Dediapada and Mandavi clusters were residing in talukas of Dediapada, Umarpada, Songadh and Mandavi. From the baseline study, it was found that out of 416 farmers trained in SRI methods only 237 farmers cultivated paddy using SRI technique in both these clusters. The rest did not adopt SRI method of paddy cultivation due to several reasons like land being not leveled, unavailability of adequate water supply, lack of information, field remaining water logged, and shortage of labour.

The current study was the follow-up study of this baseline study. We selected fifty per cent of the total farmers (i.e. 119 farmers) adopting SRI method of paddy cultivation. They belonged to 13 villages of Dediapada, Umarpada, Mandavi and Songadh talukas of Gujarat. As SRI is in the nascent stage, 119 farmers were experimenting with this method by allocating small patch of land for growing SRI paddy while in the rest of the land; paddy using traditional methods is grown. Detailed primary survey using a questionnaire was carried out to study the farmers' socio economic characteristics in detail in addition to cost of cultivation, yield and returns, other agronomic and irrigation related details of paddy cultivation using SRI method and traditional method. Efforts were also made to understand farmers' views about the advantages and pitfalls of SRI and identify technical, socioeconomic and policy issues constraining the adoption of SRI method of cultivation.

4. Results and Discussion

4.1 Results of the Analysis

As is presented in Table 3, 151 hectares of the area are owned and cultivated by farmers in the study area. Of the total cultivated area, 55 per cent is irrigated. Out of the total area under various crops, 53 per cent of the area (80 hectares) is under paddy crop. Out of total paddy crop cultivated, 62 per cent is irrigated and the rest is rainfed.

Of the total paddy crop, 67 per cent of paddy area is grown using traditional methods of paddy cultivation and in the rest 33 per cent of paddy area that accounts for 26.8 hectares of land, SRI method is practices. Farmers are experimenting with the new method of paddy cultivation in small patch of land and the rest of the land is utilised for growing paddy using traditional method. Over the years, returns from these experiments would motivate them to adopt SRI method in bigger plots of their land.

Despite differences in accessibility of water for irrigation, in all study areas, farmers have grown paddy using both these methods. Percentage of irrigated area under SRI method of cultivation is higher than area under conventionally cultivated paddy. This is expected as availability of water is essential for growing paddy using SRI technique of cultivation.

Table 3: Land under Irrigation and Paddy Cultivation in the Study Village

Particulars	Details	N
Land Area		
Land owned (in ha.)	151.2	119
Land cultivated (in ha.)	**151.2**	119
Irrigated to total cultivated area (%)	55.1	119
1. Total area under Paddy (in hectares)	**80.2**	
Area under paddy to total cultivated area (%)	**53.1**	
% to total irrigated area under paddy	61.7	153
% to total unirrigated area under paddy	38.3	84

table contd...

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2. Total Area under SRI method of Paddy Cultivation (hectares)	**26.8**	119
Percentage of total area under paddy		
SRI (%)	33.4	119
Traditional (%)	66.6	119
Irrigated (% to total area)	**70.5**	**84**
Unirrigated (% to total area)	**29.5**	**35**
3. Area under Traditional Method of Paddy Cultivation (hectares)	**53.4**	**119**
Irrigated (% to total area)	57.3	69
Unirrigated (% to total area)	42.7	49

Note: Figures in parentheses indicate number of observations

Source: Field research.

Table 4 provides a comparative picture of two methods in terms of the major factors that affect yield like seed quantity, quantity of chemicals and pesticides, manure, number of watering, hired labour days, and number of hired bullock days

Table 4: Descriptive Statistics Relating to the Factors that Affect Paddy Yield by Method of Cultivation

Variables	SRI method			Traditional method		
	N	Mean	Standard deviation	N	Mean	Standard deviation
Variables used in the Analysis						
Yield (kg/ha)	119	3150	1677	119	1897	1599
Seed quantity (kg/ha)	119	8.31	4.63	119	44.3	39.11
Quantity of chemicals and pesticides (kg/ha)	109	74.2	50.4	101	109.6	91.4
Number of watering (in number)	76	3.04	0.39	71	2.08	0.31
Hired labour days (man days per hectare)	104	31.59	33.48	110	30.81	31.75
Bullock cost (Rs/ha)	119	1163	714	119	1143	744
Tractor cost (Rs/ha)	90	1892	494	99	1341	165
Cost of other important variables (Rs./ha)						
Cost on seed	119	120	122	119	945	977
Cost on manures	80	1517	1216	61	1528	1405
Cost on organic manures	14	897	1691	7	1385	2090
Cost on chemical fertilisers	109	450	361	100	618	431
Cost on pesticides	12	545	441	6	370	239
Cost on watering	76	2059	1691	71	1509	1195
Cost on hired labour	104	2053 {20.1}	2176	110	2002 {23.7}	2063

Note: Figures in { } indicate percentage of cost on hired labour to total cost of production.

Source: Field research.

Survey results indicated that the average yield of paddy cultivated using SRI method is 3150 kg/ha while that of conventionally cultivated paddy, 1897 kg/ha (Table 5). In order to test the statistical vigour of these differences between two methods of cultivation, paired 't' test was carried out on all the important indicators. As per the tests differences in quantity of seed used, quantity of chemical fertilisers and pesticides used, number of watering, cost on tractor, yield, gross returns and net returns were statistically significant while that of total hired labour days, cost on bullocks and input cost were insignificant. Thus, we can now say with confidence that farmers cultivating paddy under SRI gain 66 per cent more yield compared to those who follow traditionally cultivation practices. Paddy being the staple food of the farmers of study area, out of the total produce, a significant quantum – close to 98 per cent in the case of SRI farms and 92 per cent for others - is stored for home consumption. Thus, any intervention made to increase the yield of paddy has the potential to answer food security problems of the area.

Among all cost components, labour on an average alone accounted for about 20 and 23 per cent of the total cost respectively of SRI and conventionally cultivated paddy (Table 5). However, there is no significant difference between man-days of hired labour between two practices. It was also observed that SRI incurs less cost on seed, chemical fertilisers and pesticides and use increased number of watering compared to traditional practices and these differences were found to be statistically significant. In the later part of the paper, farmers have also reported that SRI requires less chemical fertilisers. As larger area under paddy cultivated using SRI method was under irrigation, the use of pesticides was high and statistically significant compared to that cultivated using conventional method. As the number of households using pesticides is less, one has to treat this observation with a caution. SRI being irrigated also has its impact on high and statistically significant cost difference on tractor use in SRI cultivated paddy. Same was also observed for use of hired man days in SRI method but the difference was not statistically significant (Table 5). However, discussion with farmers gave an indication that the high labour requirement has discouraged many farmers to adopt the technology/practice in other parts of their land. On the other hand, Ghosh, (2008) had also noted that increased labour cost in weeding, transplanting and other related activities is well repaid to farmers in terms of higher yield of crop. However, in this study, our data did not validate the statement made by farmers on high use of man days of hired labour.

The average seed use in SRI was nearly 36 per cent less than that cultivated using traditional method. Thus, the difference in mean of total quantity of seed used in both these methods was nearly 82 per cent less and statistically significant in SRI method than traditional method. It was felt that awareness raising exercises carried out by NGO on level of usage of seed in cultivating paddy using SRI technique has resulted in decrease in use of this input. This has reduced cost on seed but no impact was visible in water charges. Unlike stated in literature, water consumption in paddy cultivated using SRI method was higher than traditional method. As no specified number of watering was specified by implementing agency and farmers were experimental with this method, we believed that farmers were cautious and consequently used more watering than needed. It is here that role of extension services is beneficial in guiding farmers to judiciously use water resource. This observation is contrary to evidence observed by Reddy, et al. (2005). They have observed that water requirement for SRI is almost half that of the traditional paddy.

Table 5: Difference Between Means of SRI and Traditional Methods for Important Variables

Details	SRI method		Traditional method		Difference in mean	% difference in mean of SRI from traditional method	t statistics
	Mean	N	Mean	N			
Seed (kg/ha.)	8.31	119	44.3	119	-36.4	-81.5	-9.9***
Quantity of chemical fertilisers and pesticides (kg/ha.)	74.2	109	109.6	100	-35.4	-32.3	-4.4***
Number of watering (number)	3.1	76	2.1	71	0.97	46.15	8.1***
Total hired labour days (man days/ha)	31.59	104	30.81	110	0.78	2.53	-0.32
Cost of Bullocks (Rs/ha.)	1163	119	1143	119	20	1.8	0.295
Tractor Charges (Rs/ha.)	1892	90	1341	99	551	41.1	2.9**
Yield (kg/ha.)	3150	119	1897	119	1253	66.1	7.55***
Total input cost (Paid-up cost in (Rs/ha.)	8922	119	7814	119	1108	14.2	-0.597
Gross Return (Rs/ha.)	26830	119	14850	119	11980	80.7	9.121***
Net Returns (Rs/ha.)	17908	119	7036	119	10873	154.5	1.93**

Note; *** and ** Significant at the 1% and 5% level respectively
Source: Field research.

When input costs were compared with gross returns from paddy cultivation, it was evident that gross output per hectare of paddy cultivated using SRI method is significantly higher than that produced with conventional techniques of cultivation. While comparing the net returns per hectare of land, it was observed that SRI method yields of 155 per cent more than the conventional method. Moreover, the differences in net returns between both these methods were also found to be statistically significant. Additional costs in labour use, tractor use, water charges and pesticides use are offset by the increase in yield and returns realised from the SRI method.

We have used quantity of seed used per hectare of land, quantity of chemical fertilisers and pesticides used per hectare, watering per hectare, hired labour days per hectare, bullock cots per hectare and tractor cost per hectare as input variables in the frontier production function. The parameters were estimated using both double log and maximum likelihood methods. The estimates are presented in Table 6.

The OLS estimates of C-D function show that independent variables like quantity of seed is significantly related to yield of paddy cultivated with both techniques. However, the relationship is negative in the case of traditional method. Quantity of chemicals and fertilisers has a positive and significant relationship with the yield of paddy cultivated using only SRI technique. Per hectare tractor cost is positively and significantly related with both techniques but watering is negatively and significantly related to yield in the SRI technique.

The chosen variables explain nearly 80 and 91 per cent respectively of the variations in paddy yield using SRI and traditional methods (Table 6). The calculated F values for both the methods are statistically significant implying good model fit. The summation of elasticity coefficients (“$ß_{is}$) of all independent variables using OLS is less than one (0.32) for traditional method showing decreasing returns to scale. These results indicate that given technical knowledge, capital equipment and other aids of production remaining the same, if all inputs are applied in the cultivation of land causes in general a less than proportionate increase in the amount of output produced unless it happens to coincide with an improvement in art of cultivation. With the continuous use of land, its fertility goes on diminishing therefore output goes on diminishing for paddy grown using traditional methods. As a result marginal cost of producing a unit of output of paddy using traditional method increases for the farmer. Crop cultivation along with high valued crops with long gestation period would help to improve productivity of land. Conservation of soil by way of leveling and farm bunding along with alternatives for ways to diversify from agriculture to non agricultural activities would go a long way in increasing productivity of land and reducing marginal cost of cultivation. On the contrary, summation of elasticity coefficient of all independent variables for SRI method shows increasing returns to scale (1.16). These results suggests that judicious use of fertilisers, proper weeding and tilling in growing paddy using SRI method results in improving the fertility of the soil which has the positive impact on improved yield. Consequently, marginal cost of producing paddy using this improved method would decrease for the farmer.

MLE estimates of the production frontier were comparable with those obtained from double log method. The output elasticity with respect to seed was 0.49 and -0.63 for SRI and traditional method of paddy cultivation respectively meaning thereby that 10 percent increase in area under paddy results in roughly 5% increase in output for SRI and 6 percent decline in the output for traditional method of paddy. Similarly one per cent increase in the use of fertiliser and pesticides would result in 0.3 percent increase in output for SRI and 0.5 percent decline in the output for traditional method of paddy.

Table 6: Estimates of Stochastic Frontier for SRI and Traditional Method of Paddy Cultivation

Variables (in log)	SRI method		Traditional method	
	Double log ß Coefficient	MLE ß Coefficient	Double log ß Coefficient	MLE ß Coefficient
Constant	3.343**	3.804**	1.836	2.065
	(2.975)	(0.220)	(1.492)	(0.292)
Seed (kg/ha)	0.486**	0.490**	-0.738***	-0.637**
	(2.049)	(0.158)	(-4.455)	0.749)
Quantity of chemicals and pesticides (kg/ha)	0.295**	0.344**	-0.498*	-0.540*
	(2.056)	(0.207)	(-1.898)	(0.144)
Watering (number)	-0.190	-0.231	0.299*	0.201*
	(-1.292)	(-0.161)	(0.294)	(0.516)
Hired labour days (days./ha)	0.174	0.113	0.195**	0.114*
	(1.506)	(0.113)	(2.454)	(0.209)
Tractor cost (Rs/ha)	0.393**	0.485**	1.061***	1.355**
	(2.022)	(0.311)	(4.908)	(0.137)
σu^2		**0.0617**		0.0418
σv^2		**0.0012**		0.0002
σ^2		0.227		0.264
$\sigma u^2 / \sigma^2 (\Upsilon)$		0.500		0.847
R^2	0.797		0.913	
F/log likelihood	7.088***	-0.781**	12.643***	-0.136**
LR test		0.913*		0.384*

Note: Figures in parentheses indicate‘t’ values

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

Source: Field research.

The estimates of ã which is the ratio of the variance of farm specific TE to the total variance of output is 0.50 for SRI method of paddy cultivation and nearly 0.85 for traditional method of paddy cultivation and is significant, indicating that 50 percent and 85 percent respectively for both methods, the differences between observed and frontier output is primarily due to factors which are under the control of the farms. The sigma square on the other hand was 0.23 and 0.26 for both the methods and significant, indicating that the difference between the observed output and the frontier output is not due to statistical variability alone but also due to technical inefficiency. It was also observed that intercept in MLE method is higher compared to that estimated using double log technique. However ß Coefficient or slope of inputs are more or less closer to that obtained using double log. Thus this indicates Hick's neutral technical change in the case of both the methods of paddy cultivation.

The likelihood ratio test of one sided error gives a value of .91 and .38 for both the method of paddy cultivation implying that the use of stochastic frontier is justified.

4.2 Technical Efficiency

Technical efficiency (TE) is defined as the maximum possible increase in output with the same bundle of inputs. Thus, technical efficiency can be viewed as redistribution of the current resources to increase production to its maximum. Efficiency scores presented in Table 7 show that the average yield oriented efficiency score for farmers cultivating paddy using SRI method is 0.74 which is greater than farm households that follow traditional techniques (0.69). This implies that on an average, the yield for farmers using SRI method of cultivation is 74 per cent of the frontier output and the yield on all farms adopting this method taken together can be increased by 26 per cent through a more effective use of the input bundle, given the present state of technology.

It is also observed from Table 7 that nearly 30 per cent of the sample households cultivating paddy using SRI technique have achieved a TE of 80-90 per cent of the total potential. There are 35 per cent of the sample households that operate at levels between 70-80 per cent of the potential. Nearly 5 per cent of the sample households are operating at levels greater than 90 per cent of the potential.

Our analysis indicated that technical efficiency of farmers cultivating paddy using conventional method ranged from 39 per cent to 99 per cent for the households in the sample, with an average of 69 per cent. This means that if an average efficient farmer is to achieve the TE level of his most efficient counterpart, he is likely to realise a 30 per cent savings in cost i.e., 1- (69/99)). Similarly for the least efficient farmers, this potential would result in 61 per cent saving in the cost (1-39/99). With the same hypothesis, if the least efficient farmer is to achieve TE of average efficient farmer, he would potentially realise a cost saving of 43 per cent (1-(39/69)). To delve deep into this aspect, one could regress the efficiency scores against a vector of explanatory variables.

Table 7: Estimated Technical Efficiency of Farm Households by Method of Cultivation

Range of Technical Efficiency	SRI method		Traditional method	
	% of households	N	% of households	N
< 0.60	23.5	28	20.3	24
0.60-0.70	6.7	8	17.8	21
0.70-0.80	34.5	41	41.5	49
0.80-0.90	30.3	36	18.6	22
Greater than 0.90	5.0	6	1.7	3
Total	100.0	119	100.0	119
Mean efficiency	**0.74**		**0.69**	
Minimum efficiency	0.50		0.39	

Source: Field research.

In order to understand the determinants of technical inefficiency, we have regressed variables like farmer's age, returns from marketed surplus, use of hired labour hours per hectare and attendance in training programmes against the efficiency scores (Table 8). We have tested and dropped some variables like status of leveling of land, average land holding, seed types, talukas, sources of irrigation, tenancy and share of non-agricultural income from the estimation as they did not show any significance. The double-log regression model was used to estimate the parameters shown in Table 8.

Table 8: Regression Result: Factors Affecting Technical Efficiency Farm Households

Variables	SRI method			Traditional method		
	ß Coefficient	Standard error	t values	ß Coefficient	Standard error	t values
Constant	0.141**	0.134	0.102	0.820***	3.721	0.220
Age of the farmer (years)	-0.005**	0.001	3.654	0.002	-0.881	0.003
Paddy sold in the market (Rs/ha)	0.030	0.078	-0.381	0.001	-0.040	0.037
Hired labour days (man days/ha)	0.095*	0.125	0.765	0.293*	-1.889	0.155
Attended training programme on SRI cultivation (dummy)	-0.098*	0.046	2.149	-0.116*	1.915	0.061
R^2	0.835			0.656		
F	4.228*			2.864*		

Note: ***, **, * Significant at the 1%, 5% and 10% level respectively
Source: Field research.

It may be noted that attending training on SRI method of paddy cultivation turned out to be positive and significant factor explaining technical efficiency for both sets of farm households.

Continuous interaction with farmers with respect to various activities of cultivation would train them to cultivate their land more efficiently. It may be noted that hired labour hours is included in both the stochastic production model and as a determinant of inefficiency. As explained by Battese and Coelli (1995) a variable can be included in both the stochastic frontier and the inefficiency effects when the inefficiency effects are stochastic. Inefficiency effects were tested and found to be stochastic. Hired labour days influence both the structure of production – where it measures the response of yield to labour use - and the error component where it captures inefficiency. Inclusion in the latter is for those farmers who have engaged hired labour in various activities of crop cultivation. This emphasises the importance of use of hired labour to farms cultivating paddy using SRI paddy. This was evident from high percentage of hired labour cost to total input cost in Table 5. Discussion with farmers suggested that as SRI method of cultivation requires better ways of carrying out various agricultural operations, more than a required number of labour is engaged in carrying out these activities mainly transplanting, weeding and watering.

The negative and statistically robust relationship between use of hired labour in the household and TE for both the methods of paddy cultivation and paddy cultivated using SRI method supports the notion that households utilise hired labour above the point where the marginal value product of labour is equal to the wage rate. So efforts made to decrease hired labour in SRI cultivated paddy farm will result in an improvement in TE.

Table 9 shows that there is a divergence between recommendations provided by the implementing agencies for various agricultural operations and methods actually adopted by farmers. This could have been one of the major reasons for the existing gap between the potential and actual efficiency in paddy cultivation using SRI methods. Table 9 elaborates on the reasons for some households not following the recommended practices.

From a policy perspective, SRI method has a greater potential to reduce labour use compared to paddy cultivated using traditional methods. This would necessarily bring about an improvement in the technical efficiency. Training is crucial for farmers cultivating paddy by SRI method because it involves numerous aspects of cultivation. Negative but significant relationship between training received by farmers and inefficiency confirms this assessment. It was found that with training on various aspects of cultivation there was a marked improvement in cultivation of paddy using traditional methods as well. Elasticity coefficient with respect to technical efficiency shows that age of farmers growing paddy using SRI methods will pay more dividends in terms of an increase in TE with respect to various inputs than that in households cultivating paddy using traditional methods (Table 8). This substantiates our discussion with farmers who stated that some of the aspects of cultivation in SRI method were not new to them as their forefathers followed those practices. Thus prior knowledge about various aspects of SRI method of cultivation by farmers belonging to older generation has helped them in adopting this method easily.

The results of the study indicate the presence of technical inefficiency, which captures 83 per cent and 65 per cent of the differential between observed and best practice output. The presence of inefficiency indicates that through a redistribution of the current input bundle, farmers can improve their paddy cultivation in both the methods of production. Sources of inefficiency show that training of farmers is imperative in reducing technical inefficiency of cultivating not also paddy using SRI methods but also traditional methods as well. Conditions of uncertainty have deleterious effects on efficiency in production, where farmers adopt a sub-optimal mix of inputs conditioned by vagaries of water availability. Training would help farmers adopt strategies to minimize the risk of uncertainties. Hence training should be provided to farmers on best practice techniques that incorporate application/use of inputs common in production process.

Further, paddy cultivated using SRI methods ranked the highest in terms of efficiency scores. There is no doubt that net returns earned by farmers cultivating paddy using SRI methods would encourage farmers to adopt the better method of crop cultivation. However, this transfer of knowledge about the new technique requires efforts in training and awareness raising exercises. This calls for an improvement in extension services. Besides higher allocation of funds for research and development is needed so that crop diversification could be facilitated.

Table 9: Percentage Distribution of Households Reporting Actual and Recommended Methods of Carrying Out Various Agricultural Activities

Details	% of Households
Attended the training programme	
Yes	66.9 (79)
No	33.1 (39)
Total	118*
1. Recommended: Preparing seedbed	
Making a Puddle or *Gaadi*	100 (119)
Method actually followed: Preparing seedbed	
Making a Puddle or *Gaadi* as suggested	77.3 (92)
Making bunds	22.7 (27)
Reasons for the difference between method of carrying out the activity and actually carried out	
Was not aware of any such method	13
Shortage of time	10
Was aware about the requirement but did not know how to do	4
Total	27
2. Recommended: Distance between Rows and Plants	
9 inches	100.0 (119)
Method actually followed: Distance between Rows and Plants	
As per the recommendation i.e., 9 inches	74.8 (89)
Without measurement	5.0 (6)
Less than required*	11.8 (14)
More than required**	8.4 (10)
Reasons for the Difference between method of carrying out the activity and actually carried out	
Was not convinced	26.7 (8)
Input related constraints/marker did not work/labour shortage	30.0 (9)
land is less so greed of sowing more	16.7 (5)
Total	100.0 (30)
3. Recommended: Average Quantity of seed used (kg/ha.)	
Average quantity of seed recommended	5.18 (119)
Average quantity of seed used by farmers	8.3 (84)
Reasons for the Difference between method of carrying out the activity and actually carried out	
Was not convinced with the recommended quantity and used more to minimize uncertainty	70.6 (84)
4. Recommended: Average Quantity of fertilisers used (kg/ha.)	
Average quantity of fertilisers recommended	26 (119)
Average quantity of fertilisers used by farmers	74 (85)

Note: * indicates non-response from one household

Figures in parentheses indicate number of observations

Source: Field research.

4.3 Alternative Uses of Land under SRI Method of Paddy Cultivation

Training and awareness raising exercises carried out by NGO played a significant role in motivating farmers to adopt SRI method of cultivating paddy. As farmers were experimenting with the new method, scale of growing paddy using SRI method remained small (in nearly 27 hectares of land). However, this discussion would remain incomplete if we do not examine the alternative costs and returns forgone by choosing to cultivate paddy using SRI technique. Table 10 indicates that prior to adopting SRI methods; nearly 97 per cent of cultivated area was under paddy using traditional methods. From earlier analysis, we have noticed that net returns from SRI cultivated paddy was higher than the traditional practice. This suggests that change in method of growing paddy has fetched farmers' better returns. Hence, intervention in the form of training and capacity building of farmers for adopting SRI approach by implementing agency would increase returns earned by farmers.

Table 10: Area, Yield and Gross Returns of Various Crops before Adopting SRI Method

Crops	Area under crops (% to total)	Number of observations (N)	Yield (kg/ha)	Gross Returns (Rs./ha)
			Mean	
Traditional paddy (area=26.0 ha.)	97.4	114	1455	8782
Vegetables Bottle guard (area=0.5 ha.)	1.9	3	1063	16935
Red gram (area=0.1 ha.)	0.4	1	1000	10004
Jowar (area=0.1 ha.)	0.3	1	1113	11131
Total (area=26.7 ha.)	**100.0**	**119**	**1439**	**9017**

Source: Field research.

Even when benefits of paddy cultivation using SRI method were perceived to be significant, farmers showed lack of willingness to adopt the new method of paddy cultivation in their whole land. An attempt was made to understand the reasons behind this. Nearly 71 per cent of farmers explained that their land was not leveled and so was unsuitable for paddy crop using SRI methods (Table 11). SRI method of paddy cultivation if integrated with soil and water conservation methods would assist farmers in cultivating SRI paddy in unleveled tract of land.

Table 11: Percentage Distribution of Households Reporting Reasons for not Cultivating Paddy Using SRI Methods in the Area Bigger than the Current Area

Details	% to total	N
Land is rocky	10.2	11
No irrigation facility	18.5	20
Land not leveled	71.3	77
Total	100.0	108

Source: Field research.

5. Some Reflections from Farmers' Preference

To assess farmers' own perceptions regarding their experience with SRI method of paddy cultivation, we asked them whether they would like to continue cultivating with SRI. Nearly, 87 per cent of farmers reported that they would prefer to grow paddy using the SRI method to traditional method of paddy cultivation in future. When asked about the reasons for their preference, nearly 80 per cent farmers reported that despite higher cost on pesticides and bullocks and tractors used in cultivating paddy, yield and net returns are higher under SRI. While discussing with farmers, it was noted that as the adoption of SRI method of cultivation was in the fledgling stage, farmers did not follow all the advices provided by the implementing agency. Once they are convinced about the quantity of inputs used, some of the costs like that on pesticides have the potential to get reduced.

However, improved yield in SRI method was attributed to efforts involved in soil preparation, transplanting, weeding and so on. Thus, high labour cost did not deter farmers from adopting SRI approach, whereas, low weeding cost motivated some to cultivate paddy using SRI method (Table 12). About 12 per cent of the sample farmers indicated their preference for combining both the methods. Inadequate irrigation facilities has been stated as an important reason that forces farmers to stick to the traditional method of paddy cultivation in some of their plots, while using other plots with better water availability for growing paddy using SRI approach.

Table 12: Percentage Distribution of Households by Reasons for the Preference for Different Methods

Particulars	**Total (%)**
SRI	87.4 (104)
Traditional Paddy	0.8 (1)
Combination of SRI and traditional variety	11.8 (14)
Total	**100.0 (119)**
Reasons for preferring paddy using SRI method of cultivation	
More yield and greater gross returns even when some of the input costs are high	79.8 (83)
Less weeding cost	20.2 (21)
Total	**100.0 (104)**
Reasons for preferring paddy using Combination of Traditional and SRI method of cultivation (N)	
More yield and less input cost	2
Lack of adequate irrigation facility	7
Land not leveled	5
Total	**14**

Note: Figures in parentheses indicate number of observations
Source: Field research.

Table 13 shows that other than 13 percent of farmers adopting SRI method of paddy cultivation, rest require easy availability of inputs, guidance in various activities of growing paddy and so on. Support for providing irrigation facilities formed the prime need of farmers cultivating paddy using SRI methods.

One of the reasons stated by implementing agency for adopting SRI method of cultivation was that it improves soil fertility. An examination into the perception of farmers regarding this corroborated this view. Nearly 69 per cent of farmers under the study believed that standing water in paddy fields using traditional method of cultivation deteriorates soil fertility while another 31 per cent of farmers believed that there is no significant change in soil fertility using traditional methods of cultivation. As against this, nearly 92 per cent of the farmers believed that SRI method of paddy cultivation uses less fertiliser and thus improves soil fertility. This perception was in line with the actual average input costs incurred by farmers in farming.

Table 13: Responses of Households on Need for Support System and the Soil Fertility for Paddy Cultivated using SRI and Traditional Methods

Details	Method of Paddy Cultivation	
	Traditional Method	SRI Method
1. Support system for farmers		
Do not require any support	92.3 (108)	12.6 (15)
Need to provide irrigation facilities	2.6 (3)	27.7 (33)
Financial support to level their land	--	19.3 (23)
Easy input availability	5.1 (6)	29.4 (35)
Guidance in growing crops and way to get better returns	--	10.9 (13)
Total (N)	**117***	**119**
2. Soil fertility		
Soil fertility deteriorates	68.9 (82)	
Improves soil due to less fertiliser use	--	91.6 (109)
Weeding at required time improves productivity	--	0.8 (1)
No change	31.3 (37)	7.6 (9)
Total (N)	**119**	**119**

Note: Figures in parentheses indicate number of observations
* indicate non response from 2 households
Source: Field research.

6. Summary and Policy Recommendations

Paddy cultivated using SRI method has shown significant increase in yield and returns compared to paddy cultivated using conventional methods. The socio-economic conditions of farmers in the study area compel them to concentrate more on increasing economic returns from paddy cultivation which is their staple food. By analysing the preference of farmers and actual benefits obtained by adopting the new method of paddy cultivation, it is clear that motivation and awareness raising exercises conducted by the implementing agency have had positive impact on changing farmer's method of cultivation in favour of SRI method. However, element of risk still plays a major role in absorbing knowledge about the use level of seeds and fertilisers, which results in turn in deviation from the recommended quantity of these inputs by farmers. Also, farmers who have not been able to level their land due to shortage of funds fail to take benefit of a better method of cultivation. It is no exaggeration to state that significant potential still exists to increase net returns of farmers by reducing cost of inputs. On the basis of the findings from the present study of decreasing returns to scale, we intuitively conclude that given the technical knowledge of farmers, capital equipment and other aids of production with farmers, if all inputs are applied in the cultivation of land causes in general a less than proportionate increase in the amount of output produced. There is a need to resolve the situation of increasing marginal cost of producing every output by conserving soil health by way of leveling and farm bunding along with alternative ways of diversifying activity of households from agriculture to non agricultural activities, which would go a long way in increasing productivity of land and reducing marginal cost of cultivation. Agricultural extension services should be directed towards building awareness about the proper use of inputs and helping them in using improved quality of inputs. Promotion of the resource conservation method of cultivation like SRI requires multi dimensional and integrated effort. All these suggest that there is a need to devise a strategy to envelop this programme with agricultural extension services, soil and moisture conservation programmes, non-farm employment programmes and so on.

As SRI method is used on an experimental basis in the study area, it is too early to compare its yield and returns obtained with that of paddy cultivated using conventional methods. However, this paper made an attempt to show the direction of growth along with the factors affecting this growth. It has also tried to throw light on the fact that the intervention needs to ensure that the expected net benefits from cultivation actually accrue to the farmer. Although a single study on particular crop grown in small area of a region is insufficient. But the strategy can safely be applied to all crops and the area which may be more or less similar to the study area. An NGO named Pradan, motivated by the wider applicability and innovation of SRI, is encouraging farmers to adopt this method of cultivation in growing sugarcane and wheat crop. However, in this study area, continuous follow-up of households adopting the new method of paddy cultivation would give clear evidence about actual benefits accrued from it. Against the backdrop of increasing demand for food and its inextricable linkage with dwindling water resources, process innovations as carried out in SRI need to be encouraged.

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