System of Rice Intensification (SRI) method of rice cultivation in West Bengal (India): An Economic analysis

Surajit Haldar[1], Honnaiah[2] and G Govindaraj[3]

[1] Scientific Officer, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh-502324, India, H.Surajit@cgiar.org, surajitecon@gmail.com

[2]Associate Professor, Department of Agricultural Economics, University of Agricultural Sciences, Bangalore- 560065, Karnataka, India, honnaiahtb@yahoo.com

[3] Scientist, PD_ADMAS, IVRI Campus, Hebbal, Bangalore-560024, Karnataka, India, mggraj74@gmail.com

Selected Poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

System of Rice Intensification (SRI) method of rice cultivation in West Bengal (India): An Economic analysis

Abstract

The economic analysis of System of Rice Intensification (SRI) vis-à-vis conventional method of rice cultivation was assessed in Bardhaman district of West Bengal during 2009-10. The cost-returns analysis of SRI method revealed that the cost of raising nursery for one ha main field transplantation was comparatively lower (Rs 954 and Rs 995) than conventional method (Rs 3654 and Rs 4503) in *kharif* and *rabi* season, respectively. However, cost of cultivation in SRI method was comparatively higher in *kharif* (Rs 44833), but less in *rabi* season (Rs 43862) as compared to conventional method (Rs 40627 and Rs 44853 in *kharif* and *rabi*) of rice cultivation. The total return per rupee of total cost was higher in SRI method (1.58 and 1.92) than in conventional method (1.25 and 1.37) in both the seasons. SRI farmers were found to be technically more efficient than conventional rice farmers. The probability of adoption increases as the literacy level increases and farmers located far away from canal. Difficulties in management practices like water management, intercultural operations along with lack of skilled labour and water scarcity especially in *rabi* season were the major factors constraining the adoption of SRI method.

Keywords: system of rice intensification, efficiency, logit analysis

Introduction

The history of agriculture is the history of intensification. Intensification follows successful innovations. It was innovation in the yields that is Green revolution in the mid-sixties that catalysed a metamorphosis from the conditions of food shortage to one of self-sufficiency and beyond making India in the process, a world leader in the number of agricultural commodities. Rice production at global level has increased from 605 million tonnes in 2004 to 696 million tonnes in 2010, where 90% of the same is produced and consumed in Asia only (FASTAT, 2010). Among all the countries, India is the second biggest rice producing country after China which produced 89.13 million tonnes in 2010-11. In India, rice is an important ingredient of household food-basket, yet its yield level is low, stagnant and uncertain (Barah, 2009).The enhancement in rice production has been mainly due to high yielding varieties, while harvested rice area for the corresponding period has expanded from 31 m ha to about 44 m ha, accounting for only 42 percent increase. However, to maintain the present level of self-sufficiency, India needs to produce 115 million tonnes of rice by the year 2020 which can be brought either by horizontal or vertical expansion (Department of Agriculture, GOI, 2011). In India, the green revolution was oriented towards high input usage particularly fertilizers, irrigation and plant protection chemicals. As a result of excessive use inputs, the cost of cultivation has escalated. Besides inefficiency in resource use, the yield also stagnated in many parts of rice growing regions in India. There is little scope to increase in the area, hence increase in production and productivity with an improvement in efficiency of production through technological breakthrough to meet the growing demand. Hence some improved management practices like SRI was implemented in many parts of India.

System of Rice Intensification

The System of Rice Intensification (SRI) is a system of production of rice. SRI is considered to be a disembodied technological breakthrough in paddy cultivation. It involves the application of certain management practices, which together provide better growing condition for rice plants, particularly in the root zone, than those for plants grown under conventional practices. This system seems to be promising to overcome the shortage of water in irrigated rice. Developed in Madagascar during 1980s by Father Henride Laulanie, SRI at present being in practice in countries viz., Cambodia, Indonesia, Laos, Myanmar, Philippine, Thailand, Vietnam, Bangladesh, China, India, Nepal, Sri Lanka, Gambia, Madagascar, Mozambique, Sierra Leone, Ghana, Benin, Barbados, Brazil, Cuba, Guyana, Peru and USA. Synergistic interaction leads to much higher yields in SRI than conventional methods. It offers increased land, labour and water productivity. In fact, SRI is a less water consuming method of rice cultivation when compared to rice cultivation in farmers' method, semi dry method and rotational method of rice cultivation in Krishna western delta command area of Andhra Pradesh (Radha *et.al.* 2009). Thus, SRI can be a most suitable method of rice cultivation to poor farmers who have relatively more labour than land and capital.

SRI method differs from the conventional method of rice cultivation as given below.

1. Nursery Management: Firstly, raised seed bed prepared by a well mixture of FYM and soil either on polythene covers, banana sheaths etc. or on soil itself. Secondly, seed rate five kg per hectare is sufficient as against 50 to 62.5 kg in conventional method. Thirdly 8 to 12 days aged seedlings transplantation with two small leaves

and seed attached to the plant as against 25 days and above in conventional method of rice cultivation.

2. Transplanting to main field: Seedlings should be removed carefully from the nursery without disturbing the roots of the plant along with seed and single seedling should be transplanted per spot in the main field. Water in the main field should be drained out before transplanting.
3. Wide spacing: Wider spacing of 25 x 25 cm in square pattern should be maintained for better aeration and for easy intercultural operations due to line plantation with the help of rotavator as against 50 to 60 hills per square meter in conventional method.
4. Weeding: Naturally weed growth is more in SRI fields because there is no stagnated water. Weeding should be done with rotary weeder/ conoweeder for at least four times with an interval of 10 days starting from tenth day after planting. It churns the soil and the weeds are incorporated in the soil, which in turn serves as organic manure. It helps in increased soil aeration and soli health.
5. Water management: The soil should be kept moist but not to break the soil also not saturated by providing alternating wetting and drying.
6. Manure and fertilizer: Application of more of organic manures i.e. 8 tonnes per ha should be used and apply fertilizer based on soil test results.

Problem statement

West Bengal is an important rice growing state in India. Rice is grown in 57.20 lakh hectares with the production of 147.20 lakh tonnes of paddy during 2007-08.

Renowned as rice bowl of West Bengal, Bardhaman district cultivated 6.35 lakh hectares of rice with the production of 27.8 lakh tonnes in 2007-08. The productivity of rice in this district is 4385 kg/ha which is higher than the state average productivity level (2593 kg/ha). Of late, the shortage of water has become a hindering factor for rice cultivation. Hence concerted efforts were made to introduce water saving technique like SRI method of rice cultivation in major rice growing districts of West Bengal. Presently, in 15 districts of West Bengal, SRI method is being practiced mainly to combat water shortage in rice cultivation. Keeping in view of the above issues, an attempt was made to study the comparative economics of SRI method rice cultivation vis-a-vis conventional method.

It was hypothesised that

a) SRI method of rice cultivation is more profitable than conventional method.
b) Return per rupee of expenditure is significantly higher in SRI method compared to conventional method

Methodology

In West Bengal state, the highest rice producing Bardhaman district was selected purposively. Random sampling technique was adopted for selecting blocks, villages and farmers. In Bardhaman district four blocks (Ausgram-1, Ausgram-2, Bhatar, Galsi-I) were selected randomly. In each block 15 farmers were randomly selected constituting 60 farmers each under SRI and conventional method of rice cultivation. Thus 120 sample farmers were interviewed personally with structured schedules. The farm management cost concept (Cost A1, Cost A2, Cost B, and Cost C) was used for evaluating crop profitability. Production function analysis was employed to analyse efficiency of rice production.

Timmer's measure of technical efficiency

Timmer's measure of technical efficiency was employed to measure the efficiency of rice cultivation in different method of rice cultivation. Along with this, the allocative efficiency, economic efficiency was also used by using value of the marginal product (VMP) and marginal factor cost (MFC) concept.

Logistic regression analysis

The education level of the sample respondents and frequent contact with extension agent influences adoption of any new method over conventional method of rice cultivation (Regassa *et al*. 2003, Anjugam *et al*. 2008 and Senthilkumar *et al*. 2008). Against this background, to know the factors influencing adoption of SRI method of rice cultivation, binary logistic regression was used.

Let Y_i = dependent variable, where Yi =1 for farmers who adopted SRI method, 0 Otherwise; X_i = independent variable determining Y; U_i = The error term (the variability in Y that are not captured through Xs in the model).

The independent variables considered were age of the sample respondents (X_1), Educational level of the farmer in years (X_2), Per capita income of the sample respondents in Lakh Rs (X_3), Membership; 1, if the respondent has membership in a co-operative or any other financial organization, 0 otherwise (X_4), Contacts; 1, if the respondent has frequent contact with extension agent, 0 otherwise (X_5) and Distance of the farm from the canal in kms (X_6).

If P_i = probability that Y_i = 1, i.e., probability that the farmer adopted SRI method, then, 1 – P_i = probability that Y_i = 0 i.e., the probability that farmer does not adopt SRI and continue conventional method of rice cultivation.

Consider Pi to be a logistic function of Zi, given by

$$P_i = \frac{1}{1+e^{(-Z_i)}} \text{ -- (1)}$$

where, Z = A + ∑ Bi Xi =L* (L* is called the logit which follows logistical regression)

and $(1-P_i) = \frac{1}{1+e^{(Z_i)}}$ -- (2)

Therefore, $P_i / (1-P_i)$ is called the odds ratio, which indicates the ratio of the number of chances in favour of farmers' willingness to adopt SRI method to willingness to go for conventional method. Taking logarithm of this odds ratio to the base e, we get,

Log $P_i / (1-P_i)$ = z = A + ∑ B_i X_i -- (3)

Or L* = z = A + ∑ B_i X_i --- (4)

Here, L* is called the logit, it follows logistical regression.

For better interpretation of β coefficients, antilog of the β's was calculated where the function assumes the following form-

$$\left(\frac{P_i}{1-P_i}\right) = e^{\beta_1+\beta_2 X_i + U_i} \text{ --------------------------------------- (5)}$$

The variables and their expected signs are summarized in table 1.

Table 1: Variables used in the logit analysis and their expected signs

Independent Variables	Description of the variables	Expected sign
Age	Age of the respondent (in years)	-
Education	No of years of schooling	+
Per capita income	Per capita income of the respondent (in Rs)	+
Membership	1, if the respondent has membership in a co-operative, 0 otherwise	+
Contacts	1, if the respondent has frequent contact with extension agents, 0 otherwise	+
Distance	Distance of the farm from the canal (in km)	+

Dependent variable: 1, if the farmer has adopted SRI method, 0 otherwise

Expected sign explains the hypothesis made on the variables. Age of the respondent is hypothesized to have negative influence on adoption of SRI method. Farmers from higher age group may be more conservative and they do not want to switch their farming system from conventional to SRI. Education is supposed to have positive influence, because with the increase in educational qualification the awareness about SRI increases. With the increase in per capita income the farmer has option to go for mechanization in his farm and hence he can adopt improved technique like SRI method of rice cultivation. If a farmer has membership in any co-operative, which facilitates credit or any other means financial support, is hypothesized that it will have a positive influence on adoption of SRI method. With the increase in the distance from the canals it is hypothesized that the probability of adoption of SIR method is more.

Results and Discussion

There are differences in nursery management between conventional and SRI methods in both *kharif* and *rabi* seasons. The resource use pattern and expenditure made also differs across methods, by seasons hence the results of rice nursery management were analysed separately.

I) Nursery management

The input use pattern and cost incurred on different inputs in nursery management of both the methods is presented in Table 2. In SRI method nursery area (120.5 and 117.3 square meter) was about one forth as compared to the conventional method (575.3 and 565.6 square meter) in *kharif* and *rabi* seasons respectively. Conventional farmers have used 42.27 kg of seed per hectare where it was only 8.72 kg for SRI method in *kharif* season and the same type of application is observed in case of *rabi* season. Therefore SRI farmers saved Rs 542 and Rs 550 respectively over conventional method. The application of nitrogenous and potashic fertilizer is about one third (4.23 kg and 4.27 kg in *kharif* and 4.72 kg and 4.06 kg in *rabi* seasons) in case of SRI method and there is zero application of phosphoric fertilizer vis-a-vis conventional method.

The major expenditure on nursery preparation was on labour. In conventional method the labour cost was higher (Rs 2066 and Rs 2717 in *kharif* and *rabi* respectively), compared to SRI method (Rs 564 and Rs 582). The SRI farmers had saved total labour cost of Rs 1502 and Rs 2135 respectively in *kharif* and *rabi* seasons over conventional method of rice cultivation.

The major reason for low level of input use in SRI was due to short duration nursery (8 to 12 days) as compared to conventional method (25 days). The volume of water use and expenses incurred on the same was also less in SRI method because the seed bed were to be just irrigated to keep optimum moister level and not to flood the seedbed. The higher nursery cost (Rs 3654 and Rs 4503 per hectare) was observed in the case of conventional farmers as against (Rs 954 and Rs 995 per hectare) for SRI farmers in *kharif* and *rabi* seasons, respectively. This was mainly due to more quantities of most of the input resources used in conventional nursery management. As SRI farmers raise their nursery bed in their homestead only, there is no much application of fertilizer in nursery field. There was no inorganic source of P fertilizer as SRI farmers had applied rice husk ash that provides necessary phosphorus nutrient to the seedlings. This resulted lower cost in SRI nursery management. The duration of nursery was also less in SRI, which might have limited the chance of using more quantities of plant protection chemical and human labour.

Table2. Input use pattern and cost of raising nursery for rice cultivation

Sl. no.	Particulars	Kharif				Rabi			
		Conventional		SRI		Conventional		SRI	
		Qty	Value	Qty	Value	Qty	Value	Qty	Value
1.	Area (sq meter)	575.25		120.45		563.6		117.3	
2.	Seed (kg)	42.27	686	8.72	144(542)	41.73	692	8.36	142(550)
3.	FYM (tonnes)	0.29	98	0.07	24(74)	0.29	94	0.07	24(70)
4.	Rice husk ash (tonnes)	0	0	0.32	71(71*)			0.34	78(78*)
5.	N (kg)	11.82	179	4.23	36(143)	16.62	210	4.72	40(170)
6.	P(kg)	4.39	125	0.00	0(125)	4.31	108	0.00	0(108)
7.	K (kg)	11.71	193	4.27	57(136)	15.96	212	4.06	54(158)
8.	PPC (ml)	212.43	261	15.6	37(224)	208.20	281	15.29	35(246)
9.	Mendays	12.7	1048	4.10	342(706)	17.18	1545	4.08	338(1207)
10.	Bullock pair	1.98	494	0.50	140(354)	1.97	507	0.62	158(347)
11.	Machine hours	1.37	524	0.20	82(442)	1.82	665	0.22	86(579)
12.	Total labour cost		2066		564(1502)		2717		582(2135)
13.	Electricity and fuel charges		46		22(24)		290		40(250)
14.	Total cost		3654		954(2700)		4503		995(3508)

Note: 1. Nursery area is for transplanting one hectare.
2. Figures in parentheses are saving in SRI method over conventional method in rupees.
3. * indicates excess in SRI method over conventional method in rupees.
4. Qty- Quantity

II) Costs and returns structure in conventional and SRI method of rice cultivation

The profitability aspect of both the methods of rice cultivation in the study area has been analysed by computing per hectare costs and returns. The patterns of inputs used in both the methods of paddy cultivation in kharif and rabi seasons are depicted in Table 3 and 4.

The results indicated that cultivating paddy in *kharif* season under conventional method were found to use more of seeds (42.27 kg), N fertilizer (133.72 kg), P fertilizer (58.50 kg), K fertilizer (67.50 kg) and plant protection chemicals (1958.56 ml) as against 8.72 kg of seed, 121.30 kg of N fertilizer, 53.74 kg of P fertilizer, 56.96 kg K fertilizer and 896.51 ml of plant protection chemicals by SRI farmers. However, SRI farmers used 156.50 Mendays of human labour, 16.73 pair days of bullock labour, 4.62 hours of machine labour and 8.93 tonnes of farmyard manure, which were more against 158.20 Mendays of human labour, 15.75 pair days of bullock labour, 4.18 hours of machine labour used by conventional farmers

In *rabi* season the same pattern of input use can be seen in conventional and SRI method of rice cultivation but the extent of application of inorganic fertilizer in both the methods (115.02 kg of N, 53.40 kg of P and 60.53 kg of K in conventional and 105.05 of N, 45.13 kg of P and 55.58 kg of K in SRI method) was less in *rabi* season as compared to *kharif* season. The usage of plant protection chemical in conventional and SRI method is also less in *rabi* season as because of less diseases and pest infestation.

The per hectare cost in SRI cultivation in *kharif* season (Rs 40627) was higher than conventional method (Rs 39493), whereas in *rabi* season the cost of cultivation was lower in SRI method (Rs 43862) compared to conventional method (Rs 44853). The similar findings were also recorded by Uprety in Nepal (2004) and Vishnudas in Kerala (2006). High labour cost was major reason for higher per hectare cost of SRI paddy cultivation, whereas more expenditure on human labour (Rs 12892 in *kharif* and Rs 14778 in *rabi*) in SRI paddy was because of more number of labour required for careful transplantation of single seedlings and the frequent intercultural operation using rotary weeder. The higher expenditure made on bullock and machinery labour (Rs 4271 and Rs 1828 in *kharif* and Rs 4164 and Rs 1412 in *rabi*) is necessary in SRI method because of more number of levelling operation, line transplantation etc. Thus it proves the hypothesis that labour input use is higher in SRI method as compared to conventional method. The amount spent on FYM (Rs 3126 and Rs 2891 in *kharif* and *rabi* respectively) was high in case of SRI method as compared to conventional method (Rs 1532 and Rs 1463 in *kharif* and *rabi* respectively) as more quantities of FYM are applied in SRI method of paddy cultivation as recommended. However, expenditure incurred on fertilizer (Rs 3830 and Rs 3455 in *kharif* and *rabi* respectively) in SRI paddy was less when compared to that in conventional method (Rs 4263 and Rs 3907 in *kharif* and *rabi* respectively).

Table 3: Per hectare input use pattern in conventional and SRI method of rice cultivation in *kharif* season

(values in Rs)

Sl. No.	Particulars	Conventional		SRI		Percentage change
		Quantity	Value	Quantity	Value	
1.	Variable cost					
2.	Seeds	42.27	686(1.74)	8.71	144(0.36)	78.96
3.	Fertilizer					
4.	N	133.72	1674(4.24	121.3	1519(3.74)	9.29
5.	P	58.50	1701(4.31)	53.74	1563(3.85)	8.13
6.	K	67.50	888(2.25)	56.93	749(1.84)	15.67
7.	Farmyard manure	4.35	1523(3.86)	8.93	3126(7.69)	-105.29
8.	Plant protection chemical	1958.56	3556(9.00)	896.51	1755(4.32)	50.65
9.	Human labour	158.20	13075(33.11)	156.50	12892(31.73)	1.40
10.	Bullock labour	15.75	3938(9.97)	16.73	4271(10.51)	-8.46
11.	Machine labour	4.18	1616(4.09)	4.62	1828(4.50)	-13.10
12.	Electricity and fuel charges		438(1.11)		203(0.50)	53.78
13.	Total working capital		29095(73.67)		28048(69.04)	3.60
14.	Interest on working capital @ 6%		1746(4.42)		1683(4.14)	3.60
15.	Total variable cost		30840(78.09)		29731(73.18)	3.61
16.	Fixed cost					
17.	Land revenue		18(0.05)		18(0.05)	0
18.	Rental value of land		7604(19.25)		9852(24.25)	-29.57
19.	Depreciation on machinery		761(1.93)		670(1.65)	11.97
20.	Interest on fixed capital @ 11 %		270(0.68)		356(0.88)	-32
21.	Total fixed cost		8653(21.91)		10896(26.82)	-25.93
22.	Total cost of cultivation		39493		40627	-2.87

Note: 1. Figures in parentheses are percentages to total cost.

2. Percentage change indicates Percentage change in expenditure to SRI method over conventional method.

Table 4: Per hectare input use pattern in conventional and SRI method of rice cultivation in *rabi* season

(values in Rs)

Sl. No.	Particulars	Conventional		SRI		Percentage change
		Quantity	Value	Quantity	Value	
1.	Variable cost					
2.	Seeds	41.73	692(1.54)	8.39	142(0.32)	79.45
3.	Fertilizer					
4.	N	115.02	1426(3.18)	105.05	1315(3.00)	7.77
5.	P	53.4	1685(3.76)	48.13	1399(3.19)	16.97
6.	K	60.53	795(1.77)	55.58	731(1.67)	8.12
7.	Farmyard manure	4.18	1463(3.26)	8.26	2891(6.59)	-97.61
8.	Plant protection chemical	1758.65	3264(7.28)	741.28	1480(3.37)	54.66
9.	Human labour	183.5	14929(33.29)	169.6	14778(33.69)	1.01
10.	Bullock labour	18.02	4590(10.23)	16.33	4164(9.49)	9.29
11.	Machine labour	4.8	1895(4.22)	3.57	1412(3.22)	25.49
12.	Electricity and fuel charges		1361(3.03)		487(1.11)	64.21
13.	Total working capital		32101(71.57)		28800(65.66)	10.29
14.	Interest on working capital @ 6 %		1926(4.29)		1728(3.94)	10.29
15.	total variable cost		34027(75.86)		30528(69.60)	10.29
16.	Fixed cost					
17.	Land revenue		18(0.04)		18(0.04)	0
18.	Rental value of land		9438(21.04)		12045(27.46)	-27.62
19.	Depreciation on machinery		1098(2.45)		914(2.08)	16.77
20.	Interest on fixed capital @ 11 %		270(0.60)		356(0.81)	-32
21.	total fixed cost		10825(24.14)		13334(30.40)	-23.18
22.	Total cost of cultivation		44853		43862	2.21

Note: 1. Figures in parentheses are percentage to the total cost.
2. Percentage change indicates percentage change in expenditure to SRI method over conventional method.

There exists considerable difference in the cost incurred on seed materials between the two methods mainly due to the very less quantities of seed used in SRI method of rice cultivation. Expenditure made on plant protection chemical was Rs 3556 and Rs 1755 in conventional and SRI method in *kharif* season, respectively. The pests and disease incidence was less in SRI method especially brown plant hopper damage was less, which was major pest in paddy in the study area in *kharif* season. In rabi season also the expenditure made on plant protection chemical was less in SRI method (Rs 1480) as compared to conventional method (Rs 3264). The expenditure incurred on irrigation in terms of electricity and fuel changes for SRI method (Rs 203 and Rs 487) was less than that of conventional method (Rs 483 and Rs1361) in *kharif* and *rabi* season respectively. The number of irrigation and volume of water required in SRI method was also less.

It was worth noting that even with high seed rate and more number of hills per meter square, the yield level (5.23 and 6.39 tonnes per ha) was less in conventional method then that of SRI method (6.47 and 8.31 tonnes per ha) in *kharif* and *rabi* season respectively (Table 5). This was mainly because of more number of effective tillers per meter square in SRI paddy that results more yields per unit area. Though, per hectare cost of cultivation was higher in SRI compared to conventional method in *kharif* season, the gross returns (Rs 64036) realized was higher for SRI method compared to conventional method (Rs 49423), mainly because of higher paddy yield harvested in method. Whereas in *rabi* season the cost of cultivation was lower but gross return per hectare was higher in SRI method as compared to conventional method. Thus it proved that the hypothesis of SRI method of rice cultivation is more profit than conventional method. It could be further noticed that unit price of the paddy output and by-product realized by the farmer was higher in SRI method as compared to conventional method. It was due to the output (paddy and straw) under SRI was of superior quality than conventional method and some farmer even sell SRI produced output for seed purpose that fetches higher per unit return. The gross returns per rupee of total cost in conventional method was Rs 1.25 against 1.58 in case of SRI method in *kharif* season and the same was Rs 1.37 in conventional and 1.92 in SRI method in *rabi* season, because of high gross returns in SRI method of rice cultivation (Table 6).the similar findings were also recorded by Anjugam et al (2008) in Tamil Nadu. Thus it proves the hypothesis that return per rupee of expenditure is significantly higher in SRI method compared to conventional method.

Table 5: Paddy output in kharif and *rabi* season

Sl. No.	**Particulars**	**Conventional**			**SRI**		
		Quantity (tonnes/ha)	Price (Rs /tonne)	Value (Rs /ha)	Quantity (tonnes/ha)	Price (Rs /tonne)	Value (Rs /ha)
	Kharif season						
1.	Main product	5.23	9125.43	47726	6.47	9349.47	60491
2.	By-product	3.77	450.17	1697	5.17	685.69	3545
3.	Total			49423			64036
	Rabi season						
4.	Main product	6.39	9265.80	59208	8.31	9665.50	80320
5.	By-product	4.53	472.65	2141	6.29	635.20	3995
6.	Total			61350			84316

Table 6: Cost - return structure in paddy cultivation (Rs /ha)

Particulars	**Kharif**		**Rabi**	
	Conventional method	SRI method	Conventional method	SRI method
Total cost	39493	40627	44853	43862
Total returns	49423	64036	61350	84316
Total returns per rupee of total cost	1.25	1.58	1.37	1.92

III) Technical and allocative efficiency in conventional and SRI methods of rice cultivation

The coefficients of multiple determinations (R^2) were 0.84 and 0.87 for estimated production function of conventional and SRI method in method *kharif* season and it was 0.80 and 0.81 for the same in *rabi* season. The high and significant F values indicated that Cobb-Douglas production function was adequate in explaining 84 per cent and 87 per cent of the variation in output in conventional and SRI method in *kharif* season, where as it is 80 per cent and 81 per cent for the same in *rabi* season due to variation in the resources included in the model. The constant returns to scale were noticed in both the methods since sum of elasticity coefficients were nearly one.

The elasticity coefficients in the case of conventional method practiced in *kharif* season indicates that the paddy output was significant and positive and significantly influenced by labour requirement. In SRI method practiced in *kharif* season, coefficients like labour and plant nutrients were positive and significant. In *rabi* season plant protection chemical with respect to both the method was significant and positive, implying importance of the input resource in production process.

To analyse the scope for intensification of resources in both methods, the marginal value products (MVP) of resources are compared with the respective marginal factor cost (MFC). The MVP and MFC ratios for different resources for both the season are furnished in Table 7 respectively for conventional and SRI method. The MVP-MFC ratio for labour (1.41 and 1.78) and plant nutrients (2.68 and 1.73) were more than one in both the methods in both the seasons, whereas the ratio for seed (0.82 and 0.40) was less than one in both the methods in both the seasons. But in *rabi* season MVP-MFC ratios for plant nutrients (1.33 and 1.73) and plant protection chemicals (1.35 and 1.57) were more than one in SRI than conventional methods. So there is a scope for increasing per hectare returns by increasing the usage of plant nutrients and plant protection chemicals.

Table 7: MVP and MFC ratios of resources in *kharif* and *rabi* season

Inputs	Conventional			SRI		
	MVP	MFC	Ratio	MVP	MFC	Ratio
Kharif season						
Seed (Rs)	0.82	1	0.82	0.42	1	0.42
Labour (Rs)	1.14	1	1.14	1.78	1	1.78
Plant nutrients (Rs)	2.68	1	2.68	1.73	1	1.73
Plant protection chemicals (Rs)	0.87	1	0.87	1.13	1	1.13
Rabi season						
Seed (Rs)	0.94	1	0.94	1.61	1	1.61
Labour (Rs)	1.46	1	1.46	1.07	1	1.07
Plant nutrients (Rs)	1.33	1	1.33	1.73	1	1.73
Plant protection chemicals (Rs)	1.35	1	1.35	1.57	1	1.57

The technical efficiency in conventional and SRI method was worked out by using Timmer method. The distribution of sample farmers according to different technical efficiency rating along with average technical efficiency for both the methods is presented in Table 8. The average technical efficiency for conventional and SRI farmers was 0.73 and 0.79 in *kharif* season where in *rabi* season it was 0.72 and 0.65 respectively. About 13.33 per cent conventional and 18.00 per cent SRI farmers were found to operate at technical efficiency rating between 0.71 and 0.75 in *kharif* season. In *rabi* season 20.00 per cent of conventional and 10.00 per cent of SRI farmers were found to operate at technical efficiency rating between 0.71 and 0.75. Where, About 10.00 per cent of conventional farmers in both the season and 20.00 per cent 4.00 per cent SRI farmers in *kharif* and *rabi* season were operating at technical efficiency rating above 0.90 respectively. The similar types of result were also recorded by Basavaraja et al (2008) and Kumar et al (2005).

Table 8: Distribution of farmers according to technical efficiency rating

Sl. No.	Per cent Technical Efficiency Rating	Kharif		Rabi	
		Conventional	SRI	Conventional	SRI
1	<= 70 %	12(40.00)	12(24.00)	14(46.67)	34(68.00)
2	71-75%	4(13.33)	9(18.00)	6(20.00)	5(10.00)
3	76-80%	6(20.00)	9(18.00)	2(6.67)	5(10.00)
4	81-85%	4(13.33)	5(10.00)	3(10.00)	1(2.00)
5	86-90%	1(3.33)	5(10.00)	2(6.67)	3(6.00)
6	90% and above	3(10.00)	10(20.00)	3(10.00)	2(4.00)
	Average technical efficiency	0.73	0.79	0.72	0.65

Note: Figures in parentheses indicate per cent to total

The average allocative efficiency and economic efficiency of conventional farmers and SRI farmers are presented in Table 9. It could be inferred from the table that in *kharif* season allocative efficiency of conventional farmer (0.46) was less than that of SRI farmers (0.55), and the economic efficiency was more in case of SRI farmer (0.43) as compared to conventional farmer (0.34). Whereas in *rabi* season the allocative efficiency and the economic efficiency was less in SRI method as compared to conventional method. In both the methods farmers were operating at less allocative efficiency than the technical efficiency.

Hence it can be concluded that by overcoming the inefficiency (both technical and allocative) in conventional and SRI method of rice cultivation, the profits could be increased in the study area. Hence, more concerted efforts are needed to improve efficiency in both the methods of rice cultivation.

Table 9: Technical, allocative and economic efficiency of rice cultivation

(in percentage)

Sl. No.	Particulars	Kharif		Rabi	
		Conventional	SRI	Conventional	SRI
1	Technical efficiency	0.73	0.79	0.72	0.65
2	Allocative efficiency	0.46	0.55	0.68	0.56
3	Economic efficiency	0.34	0.43	0.49	0.36

IV) Factor influencing adoption of SRI method of rice cultivation

Binary logistic regression was run using SPSS 12.0 software and the results obtained are presented in Table 10.

Table 10: Results of logit analysis for adopting SRI method

Variable	Co-efficient	Significance	Exp(B)	P
Age	-0.532	0.175	1.702	0.630
Education	0.283***	0.009	39.723	0.430
Membership	10.724***	0.000	513.74	0.998
Per capita income	3.682*	0.071	0.753	0.975
Contacts	5.734**	0.024	0.03	0.029
Distance	2.393***	0.004	10.945	0.916
Constant	19.704**	0.017	0	
- 2 Log likelihood	26.83			
Negelkerke R^2	81.5			

Note: ***, ** and *denote significance at 1, 5 and 10 per cent level of significance respectively.

Experience in farming in terms of age of the respondents was found to have negative but statistically insignificance. Farmers from higher age group may be more conservative and they do not want to switch their farming system from conventional to SRI. Education is influencing positively and the coefficient is highly significant. Thus it implies that as the number of years of education increases, the farmers are keener to adopt new technique like SRI than others. On the other way if year of education increased by one year than probability of adopting SRI increases by 0.43. The similar types of results were also recorded by Sitadevi and Ponnarsai (2009) in Tamil Nadu, Anjugam et al (2008) and Barah (2009) in Tamil Nadu. The distance of canal from the farm is also having positive significant influence on adoption of SRI. As the distance increases the farmers are more efficient in using their input resources like water in production of rice. In another way if distance from canal increases by one kilometre than the probability of adopting SRI increases by 0.916. Therefore those farmers who are far away from canals, adoption level is higher than others With the increase in per capita income the farmer are more devoted to their farm to go for mechanization, therefore they are adopting more SRI than others Having membership in co-operative or any other financial organization increases the probability of adoption SRI method than others

V) Constraints in SRI method of rice cultivation

The constraints in adoption of SRI method of rice cultivation were elicited from farmers and the same is presented in Table11. The difficulties to do management practices were ranked first (0.81), whereas lack of water availability (0.78) especially in *rabi* season was the second most constraint. The non-availability of skilled labour (0.69) followed by non-availability of machine and tools (0.68) required for intercultural operation and other purposes and lack of cooperation from neighbour farmers (0.65) are other important constraints in SRI method of rice cultivation.

Table 11: Estimates of relevance ranking for constraint analysis in SRI method

Sl. No.	Particulars	Coefficients	Rank
1.	Difficult to do management practices	0.81	1
2.	Lack of water availability	0.78	2
3.	Non availability of skilled labour	0.69	3
4.	Non availability of machines and tools	0.68	4
5.	Lack of cooperation from neighbour farmers	0.65	5
6.	Lack of guidance from department officials	0.55	6
7.	Lack of confidence in taking new technique	0.53	7
8.	Non availability of pesticides	0.52	8
9.	Non availability of cash or credit	0.52	9
10.	Non availability of FYM	0.51	10

Summary and conclusion

It can be concluded that besides the less resource use, the profitability (return per rupee) in SRI rice cultivation is higher vis-a-vis conventional method. Hence the farmers have to be educated and empowered through training and demonstrations. The efficiency level (both technical and allocative) in SRI is higher compared to conventional methods. Logit regression analysis indicated that, educational level, distance from the canal increases the probability of adopting the SRI method. The relevance ranking analysis indicated difficulties in management practices like water management and intercultural operation, lack of water availability especially in *rabi* season and unavailability of skilled labour were major constraints to SRI method adoption. Hence appropriate interventions like empowering farmers through training and demonstrations with proper guidance from extension personals has to be made for larger adoption in the study area.

References

Anjugam, M., Varadharaj, S., Padmarani, S. 2008. Cost-Benefit Analysis of SRI Technique in Paddy Cultivation. Department of Agricultural Economics, Tamil Nadu, Coimbatore.

Barah, B.C. 2009. Economic and Ecological Benefits of System of Rice Intensification (SRI) in Tamil Nadu. Agricultural Economics Research Review. 22, 209-214

Basavaraja, H., Mahajanshetti, S. B., Sivangaraju, P. 2008. Technological Change in Paddy Production: A Comparative Analysis of Traditional and SRI Method of Cultivation. Indian Journal of Agricultural Economics. 64, 629-640.

FASTAT, 2010, Washington D C.

GOI, Department of Agriculture, 2011, New Delhi.

Kumar, L.R., Shrinivas, K., Singh, S.R.K. 2005. Technical Efficiency in Rice Farms under Irrigated Conditions of Northwest Himalayan Region- A Non-Parametric Approach. Indian journal of Agricultural Economics. 60, 483-493.

Radha, Y., Reddy, K. Y., Rao, G. S., Chandraand, S. R., Babu, G.K. 2009. Water-saving Rice Production Technologies in Krishna Western Delta Command of Andhra Pradesh – An Economic Analysis. Agricultural Economics Research Review. 22, 397-400.

Sitadevi, K., Ponnarsi, T. 2009. An Economic Analysis of Modern Rice Production Technology and its Adoption Behaviour in Tamil Nadu. Agricultural Economics Research Review, 22, 341-347.

Uprety, R., 2005, Economic Analysis of System of Rice Intensification (SRI) Methods in Morang District of Nepal, Main Season. DADO Morang, Biratnagar, Nepal.

Vishnudas, C.K. 2006. SRI Trials in Wayanad- Experiences of RASTA. LEISA India, 8, 16-17.