SYSTEM OF RICE INTENSIFICATION (SRI) Economic and Ecological Benefits of Improved production practice for Food Security and Resource Conservation

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ABSTRACT : Being the important ingredient of food basket of the common people, the declining productivity of rice and its per capita availability is a policy concern, which has a global connotation. System of rice intensification (SRI) is a relevant innovation, which increases production, reduces yield gap and ensures the household food security for the vulnerable section of small and marginal farmers. It has also tremendous potential for resource conservation; and important aspect for sustainability. The paper attempts to quantify the benefits of SRI and compare its performances with that of conventional practice of cultivation of rice. The relevant information gathered from the state of Tamil Nadu, which is a fore runner in promotion of SRI in India. The four districts of Tamil Nadu representing distinctive features of irrigation system and 58 farmers are selected for the detailed farm survey. Agriculture is dominated by the small farmers having a tiny farm of average size less than 1.4 ha of over 90% of the farmers. Hence, to produce more food from less land and other inputs for livelihood is a necessity. As a pre-requisite of SRI promotion, the farmers' motivation is gauged in a perception survey, which revealed that most of the farmers were aware of SRI, who have perfected its crucial principles. Estimated indicators of success clearly vindicated that the innovative practice has several socio economic as well as bio-physical benefits, including, increase in productivity, input saving and conservation of precious resources. The return to SRI is reasonably high at Rs.14875 per hectare to Rs. 17629 (equivalent US$309 to US$370) across the districts as compared to corresponding figure of Rs.9263 to Rs.14564 (US$192 to US$ 303) under conventional practices. Higher return is attributed to increase in production as well as substantial reduction in cost of cultivation. The most impressive is the savings in water (22% to 39% saving) and seed (as high as 92% saving) resulted to distinctive benefit-cost ratio. The organic supplementation due to compost, green manure and weed incorporation, enhanced soil microbial activities and aeration, often uncounted, the use of solar energy by the plant and time saving due to early transplantation, are some of the uncommon advantages of SRI. The gains to women labour engaged in specialized operations such as transplanting, harvesting and weeding indicate gender equity. In addition, SRI provides opportunity for employment of the idle family labour in rabi (post monsoon) season. The novelty of SRI is that research is inexpensive as the innovation is farmer based and invariant to crop variety (unlike modern method, variety needs not be new and input intensive technology). The estimated technical efficiency using DEAP also clearly show that SRI is more efficient (both in term of TE and economic efficiency). Therefore, having proven tangible benefits, appropriate strategy for upscaling the adoption is a sine-qua-non to achieve sustainable national as well as household food security. The successful models of SRI need to be integrated for generalization. In the changing scenario, given the general acceptance of the practice and willingness to accept, the needed preparedness for implementation of the policy to scale up the adoption will go a long way.

INTRODUCTION

Rice is an important ingrédient of household food-basket, yet the yield level has been low and production uncertain in India. The operational holding-size is shrinking, and land and water resources are being degraded. And therefore, some innovative rice production practice is needed to meet its growing demand due to population pressure. Under this scenario, the System of Rice Intensification (SRI) may be an appropriate practice to produce more food with less inputs. The origin of SRI is traced to a small island country, the Madagaskar, which was under the severe grip of hunger and malnutrition during the 1980s. In search of a solution to the food crisis, Fr. Henry de Laulanie rediscovered this novel small landholdings-oriented practice of SRI (Laulanie, 1993). SRI is actually an amalgamation of refined and intensive management practices for rice production at farmers' fields. The conservation of land, water and biodiversity, and utilization of the hitherto ignored biological power of plant and solar energy, are the novelties of SRI. On account of its growing global acceptance, SRI has emerged as a movement among farmers. More scientific research on varietals selection, effective realization of genetic expression of the plant, wide spacing and ideal crop geometry, transplanting of tender seedlings, conjunctive use of water, akin to the concept of aerobic rice, zero tillage, weed management, pest and disease management, etc. have helped in accelerating adoption of SRI. These research findings have been noted by several research institutions, including IRRI, CRRI, DRR, WASSAN, WARDA, ICRISAT, IWMI, SAUs and NGO)

The present study has evaluated the performance of SRI at farmers' fields with the following specific objectives:

- To evaluate the economic and ecological advantages of SRI in relation to conventional practices for rice cultivation in Tamil Nadu,
- To quantify the impact of input savings (land, water, farmers' time and seed) on production efficiency under SRI practices, particularly among the small farmers,
- To identify the factors influencing adoption of SRI and to examine the factor use efficiency, and
- To derive policy imperatives and strategies for a wider scaling up of SRI.

1. DATA AND METHODOLOGY

The state of Tamil Nadu is a forerunner in the promotion of SRI in India. A detailed farm survey was conducted during 2006-07 in four important districts of Tamil Nadu. The selected districts represent the distinct features of irrigation system, viz. Tanjore and Coimbatore have well irrigation; Kanchipuram has canal irrigation and Ramanathapuram is a rainfed district (the Tamil Nadu IAMWARM project has been implemented in these districts)[1]. The sample for the study consisted of 15 SRI and 15 non-SRI farmers in each of the districts, except Ramanathapuram, where the number of SRI farmers was only 13.

The distribution of sample farmers in various farm-size categories, viz. marginal (< 1ha), small (1-2 ha), medium (2-4 ha) and large (>4 ha) is shown in Table 1. The sample consisted of 17 per cent marginal farmers, 47 per cent small farmers, 28 per cent medium

[1] World Bank 2006 (T amil Nadu project); Tamil Nadu Irrigated Agriculture Modernization and Water Bodies Restoration and Management Project, TN - IAMW ARM.

farmers and 9 per cent large farmers. Technical efficiency, allocative efficiency and economic efficiency of SRI was computed using the Frontier production function approach. The small and marginal farmers are especially targeted in SRI, as they have limited access to non-farm opportunities and hence, the enhanced food production on sustainable basis is crucial for them.

Table1: Distribution of sample SRI farmers in various districts ***of Tamil Nadu***

Farm size	District			
	Coimabtore	Kanchipuram	Ramnathpuram	Tanjore
Marginal	5	1	2	2
Small	5	7	9	6
Medium	3	6	2	5
Large	2	1	-	2
Total	15	15	13	15

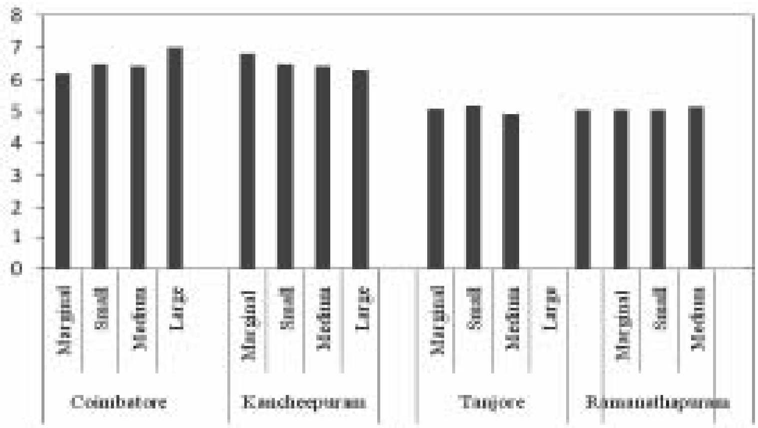
1.1. Bio-physical Benefits of SRI

- SRI farmers use 5-8 kg seed in SRI as compared to 40-50 kg under conventional practices. This seed cost saving is important for hybrid rice, as its price is almost ten-fold of the price of non-hybride rice.
- The farm survey has clearly shown that SRI yield is uniformly high across various farm-size categories (Figure 1). The yield varies from 5t/ha to 7.5 t/ha under SRI as compared to the reported average of 3.45 t/ha in 2005-06. This implies that the small farmers benefit from increase in the yield under SRI.
- More importantly, water saving due to alternate drying and wetting system even at constant yield attracts SRI more in the areas where water is a premium (rainfed areas). The irrigation as measured by number of irrigation days has also shown a substantial saving of water in SRI as compared to conventional practice. The average water saving is 37 per cent, which varies from 22 per cent to 38 per cent across various farm-size categories. Negligible inter-farm variation implies equity in water use. At the aggregate level, the unit water savings amounted to a substantial water economy. As much as 2-3 MCM of water can be saved per season.

Given acute scarcity of precious water, the water so saved may be used to irrigate more areas and/or more crops.

- SRI insists on the use of organic manure, green manure and other biological sources for nutrient supplementation. Thus, the use of expensive fertilizers and other agro-chemicals is minimized, which is a cost-saving advantage and makes SRI a brand organic product.
- It has been observed that incidence of pests and diseases is less in SRI due to sturdy and hardy stem and leaves, that repel specific insects.
- Proper use of conoweeders incorporate weeds into the soil, whereby the decomposed biomass enriches the organic contents in soil. The four compulsory weedings in SRI improve soil aeration, invigorate microbial activities and promote a healthy root system.
- SRI is the most suitable option in the *rabi* season, which is relatively risk-free. In addition, it also provides opportunity for more employment of family labour, which remains idle during the season.

Figure 1. Average yield of SRI by farm-size category in Tamil Nadu (t/ha)



2. ANALYSIS AND DISCUSSION

2.1 Socio-economic Benefits

The cost and returns for SRI and non-SRI farms have been presented in Table 2. The farmers derive multiple benefits from SRI such as higher yield, less input-cost and high income as compared to non-SRI farms. On the whole, the combined effect of reduction in cost and higher yield has resulted in increase in net return to the extent of over 31 per cent. The average cost of production (paid out cost) has been worked out to be Rs 269 per quintal of rice under SRI practice and Rs 365 per quintal under normal practices, an advantage of 26 per cent in cost of production.

Table 2 : Comparison of costs and return with and without SRI in Tamil Nadu (per hectare)

Particular	Coimbatore		Kanchipuram		Ramanathapuram		Tanjore	
	SRI	Non -SRI	SRI	Non -SRI	SRI	Non - SRI	SRI	Non -SRI
Seed cost in (Rs.)	504	1800	187	2250	562	2160	217	1575
Labour Cost (Rs.)	9546	12705	7988	11990	4960	9111	10715	11524
Yield ton	6.52	6.07	6.54	5.41	5.10	4.25	5.06	4.76
Total cost (Rs)	16774	20283	16604	18938	11589	15953	16699	19010
Gross income (Rs.)	33329	34848	34233	32325	27745	25216	31575	31653
Net income (Rs.)	16555	14564	17629	13386	16155	9263	14875	12643
Cost (Rs./q)	261	335	257	350	229	376	331	400
Benefit Cost Ratio	1.99	1.72	2.06	1.71	2.39	1.58	1.89	1.67
No. of irrigation	24	34	25	34	25	32	20	33
% saving	28		27		22		38	
%Adoption of SRI	45		18		20		59	

A comparison has shown that SRI has higher B-C ratio than that of the conventional practice across the districts. The increase in production with reduced cost is the most important trait of SRI, which has induced adoption of SRI by the farmers. Farmers have also realized that the conservation of water and soil ensures long-term sustainability. On account of early transplanting of 8-12 days old seedlings vis-à-vis 30-40 days old in the case of conventional practices, SRI practice reduces the length of growing period. The land vacated at least for 20 days due to early harvest, can potentially enhance crop diversification and crop intensity.

Equitable gender participation: It is an important aspect, which is particularly observed in specialized operations such as transplanting of tender seedlings, harvesting and weeding. Women labourers find the ergonomically manufactured weeders more user-friendly. Moreover, skilled labourers earn higher wage in specialized operations. The use of family labour is higher in SRI which varies from 38 per cent to 49 per cent of total labour-use, while the same varies from 7 per cent to 37 per cent under the conventional practice.

Table 3. Comparison of yield with and without SRI across farm-size in selected districts of Tamil Nadu (t/ha)

Farm-size	Coimbatore		Kanchipuram		Ramanathapuram		Tanjore	
	SRI	Non-SRI	SRI	Non- SRI	SRI	Non- SRI	SRI	Non-SRI
Marginal	6.20	5.95	6.83	5.08	4.03	5.10	4.7	
Small	6.48	6.06	6.48	5.46	5.08	4.25	5.18	4.9
Medium	6.42	6.17	6.42	5.34	5.16	4.38	4.95	4.71
Large	7.00	6.3	5.25	5.03	4.8			

The increase in yield has been found to vary from 4 per cent to 26 per cent due to adoption of SRI across farm-size groups (Table 3). The yield across farm size is neutral to scale under both practices. However, the yield is 15-20 per cent higher for farmers in SRI than non-SRI practices.

2.1.1 Technical Efficiency

The measurement of efficiency is a derivative of the input-output relationship at a particular point of time. As the efficiency measure is expected to reflect the overall capability of resource management, frontier production function based measure of efficiency is more suitable. The frontier production function sets the standard against which the efficiency is measured.

Assume the input vector (I,W) produces Q so that the production frontier is given by Equation (1):

$Q = f(I, W)\, e^{v-u}$ …(1)

The constant return to scale is given by Equation (2):

$1 = f(I/Q, W/Q)$ …(2)

which is characterized by the unit-isoquant given by Q′Q in Figure 2. Now assume that the firm uses input (I′,W′) to produce output Q′. By definition, Q′ can not lie on the left hand side of Q′Q. Let the point A denote the output Q’ with the input vector (I′, W′). The technical efficiency of the firm is defined as:

OB/OA …(3)

Figure 2: Technical Efficiency

Alternatively, 1 - (OB/OA) represents the inefficiency which

indicates the limit to increase or decrease the
input set (I ′, W ′) without reducing the output. The measure of technical efficiency, based on the concept of frontier production function, is also akin to the concept of total factor productivity rather than that of usual factor shares.
The firm derives maximum benefit of technology if the point A lies on the isoquant, which implies OB=OA.

The $TE_i = \exp(-U_i) = \frac{\exp(X_{ij}\beta + V_{ij} - U_i)}{\exp(X_{ij}\beta + V_{ij})}$ production technology of a firm is represented by a Stochastic Frontier Production Function (SFPF) as Equation (4):

$Y_{ij} = \exp(\beta X_{ij} + V_{ij} + U_{ij})$ …(4)

where i=1,2,....., N(farm), j=1,2,........, T(time), Y = Yield (t/ha), X = Input vector (consisting of seed, fertilizer, labour, manure, irrigation and bullock and tractors), β = Parameter vector, V = Random variable iid $N(0, \sigma^2)$, and U = Random variable truncated at zero of iid $N(\mu,\sigma^2)$.

The presence of the term U ensures that there are non-negative random variables which are associated with technical efficiency. Using the above model, the technical efficiency of the ith farm may be defined (Battese and Coelli, 1992; Schmidt, 1985) as per Equation (5): i.e. or

(5)

Thus, for unknown parameters, it can be shown that

$$TE_i = E\{\exp(-u_i/\varepsilon_i)\} = \frac{1-\Phi\left[\sigma_u^* + \gamma\varepsilon_i/\sigma_u^*\right]}{1-\Phi\left[\gamma\varepsilon_i/\sigma_u^*\right]}\exp\left(\gamma\varepsilon_i + \frac{1}{2}\sigma_u^*\right)$$

$$\mu_i^* = \frac{\mu\sigma_v^2 - \sigma^2 T_i \bar{E}_i}{\sigma_v^2 + T_i\sigma^2}$$

$$\sigma_i^* = \frac{\sigma^2\sigma_v^2}{\sigma_v^2 + T_i\sigma^2}$$

$$\bar{E} = \frac{1}{T_i}\sum_{1}^{T} E_{it}$$

where, Φ(.) represent the distribution function for the standard normal variable.

Technical efficiency, allocative efficiency and economic efficiency were estimated using Data Envelop Analysis Program (DEAP) in linear programming framework (Coelli, 1996). The results have been presented in Table 4.

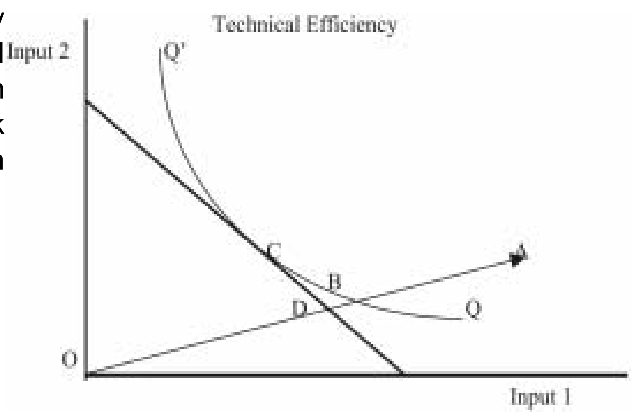


Table 4: Summary Input output information of rice cultivation under SRI by farm size across the districts in Tamil Nadu

District	Seed	Total Fertilizer	Labour	Manure	Irrigation (days)	Pesticide	Bullock, Tractor
Coimbatore							
Marginal	44.0	535.0	192.0	1.350	62.0	1.35	11.5
Medium	40.0	525.0	189.2	1.375	62.5	1.33	11.7
Small	40.0	530.0	189.5	1.350	61.5	1.30	11.0
Large	45.0	600.0	198.8	1.250	61.3	2.81	12.5
Kanchipuram							
Marginal	12.5	412.5	247.5	1.250	60.0	1.25	7.5
Medium	12.5	460.4	244.2	1.354	61.7	1.33	9.6
Small	12.5	471.4	239.6	1.411	62.1	1.39	7.5
Large	12.5	437.5	245.0	1.500	62.5	1.25	12.5
Ramanathapuram							
Marginal	37.5	381.3	192.5	1.563	62.5	1.00	8.8
Medium	37.5	393.8	197.5	1.563	62.5	0.69	11.3
Small	37.5	383.3	176.4	1.556	62.5	0.74	8.9
Tanjore							
Marginal	7.5	381.3	187.5	1.922	48.8	0.44	8.8
Medium	7.5	385.0	184.0	1.950	50.5	0.75	7.0
Small	7.5	402.1	170.4	1.823	50.0	0.58	10.0
Large	7.5	456.3	186.3	2.500	55.0	0.94	10.0

The farmers using SRI practices are more efficient as compared to farmers using conventional practices for the cultivation of rice across different farm-size groups in the selected districts. The sample farm distribution across efficiency class has been presented in Table 5. The SRI farms have demonstrated higher efficiency (technical as well as economic efficiency) as compared their counterparts under conventional methods.

Table 5. Number of SRI and non-SRI farmers in various efficiency classes in four districts of Tamil Nadu

	Districts	Efficiency class (%)					
		< 50	51-60	61-70	71-80	81-90	91-100
		Technical efficiency					
SRI	Coimbatore				-	-	15
	Kanchipuram				-	2	13
	Ramanathapuram				-	5	8
	Tanjore				-	2	13
Non SRI	Coimbatore		-	6	-		
	Kanchipuram		-	-	11		
	Ramanathapuram		4	4	4		
	Tanjore		3	6	-		
		Allocative efficiency					
SRI	Coimbatore				-	5	10
	Kanchipuram				-	1	14
	Ramanathapuram				-	8	-
	Tanjore				-	8	7

Non SRI	Coimbatore	**-**	**-**	**12**	**3**		
	Kanchipuram	**-**	**-**	**15**	**-**		
	Ramanathapuram	**1**	**5**	**7**	**2**		
	Tanjore	**-**	**-**	**11**	**4**		
		Economic efficiency					
SRI	Coimbatore				**-**	**9**	**6**
	Kanchipuram				**-**	**8**	**7**
	Ramanathapuram				**8**	**2**	**-**
	Tanjore				**3**	**6**	**6**
Non SRI	Coimbatore	**-**	**6**	**9**			
	Kanchipuram	**-**	**5**	**10**			
	Ramanathapuram	**8**	**7**	**-**			
	Tanjore	**6**	**9**	**-**			

Technical efficiency for 49 SRI farmers have exhibited higher efficiency, which falls in the 91-100 per cent class while the same for the non-SRI farmers is mostly in the lower efficiency classes, viz. 7 farmers in 51-60 per cent TE class, 16 in 61-70 per cent TE class and 22 in the 71-80 per cent efficiency class.

3. SUMMARY AND CONCLUSIONS

The SRI has proven ability to increase rice production by 26 per cent or more depending on the extent of adherence to its basic principles. More importantly, SRI saves up to 40 per cent water due to alternate drying and wetting system, which is considered a unique advantage of SRI[2]. The farmers are convinced of the benefits of SRI and hence its adoption is spreading in a larger spatial dimensions. A few distinctive patterns and models have emerged in recent years, which provide required road map for wider adoption. The lessons learnt from the scenario analysis of these models will be useful for designing effective interventions and strategies for various areas.

3.1 **Policy Implications**

- SRI, which has emerged as an important alternative strategy in water-scare situations, needs carefully designed supportive interventions, including R&D investments (Thyagarajan, 2004).
- In developing strong SRI research networks, active participation of the line departments should be assured.
- Awareness should be generated about SRI through mass media, *Kisan Vigyan Kendras*, extension departments, etc.
- Being a low external input technology, SRI offers an opportunity to create a broad, ‘SRI Organic Rice’, which has significant market potential.

[2] It is evident from farmers’ participation in the e-debate and SRI network (http://groups.google.com/group/sriindia/; sriindia@goglegroup.com).

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