

Potential of System of Rice Intensification (SRI) to Contribute to the Policy Objectives: Paradigm of Three-Tier Approach in Southern Telangana—A Case Study of Narayanpet

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Abstract

A programme effort for SRI impact assessment has been undertaken in 20 project villages in the Narayanpet block. The villages have been pooled under four clusters, for which quantitative and qualitative analyses have been carried out on water usage, input cost, plant growth, farmer group collectivization, gross and net returns of SRI, and conventional paddy cultivation. The result shows that significant water saving was achieved for SRI, *i.e.*, 8586 m³·ha⁻¹ under tubewell irrigation over conventional. This approximation has served as an auxiliary to the number of pumping hours and number of irrigation days that have been reduced for SRI. Less utilisation of water and distance maintained in SRI has benefited in reducing the biotic and abiotic stress caused by snails and nutrient deprivation, respectively. The total yield for a sampled number of SRI farmers has been found to have a 22% increase for the total expenditure difference of Rs. 6153, *i.e.*, 13% less than conventional paddy farmers, which highly impacts the SRI farmers' net income, *i.e.*, 69% more than the conventional returns. The SRI method has a lower labour deployment of 8 people/ha than the conventional method, which requires 16 people/ha with a constant price of Rs 250/person. Input cost saving in these two categories has ranked top and has fetched maximum production efficiency among the others. The seed cost at a fixed price of 32 Rs/kg was significantly (87%) reduced for SRI as 8 kg per ha was required rather than the conventional that required 62 kg/ha. Social benefits were listed based on the qualitative analysis and were transformed using the theory of planned behaviour.

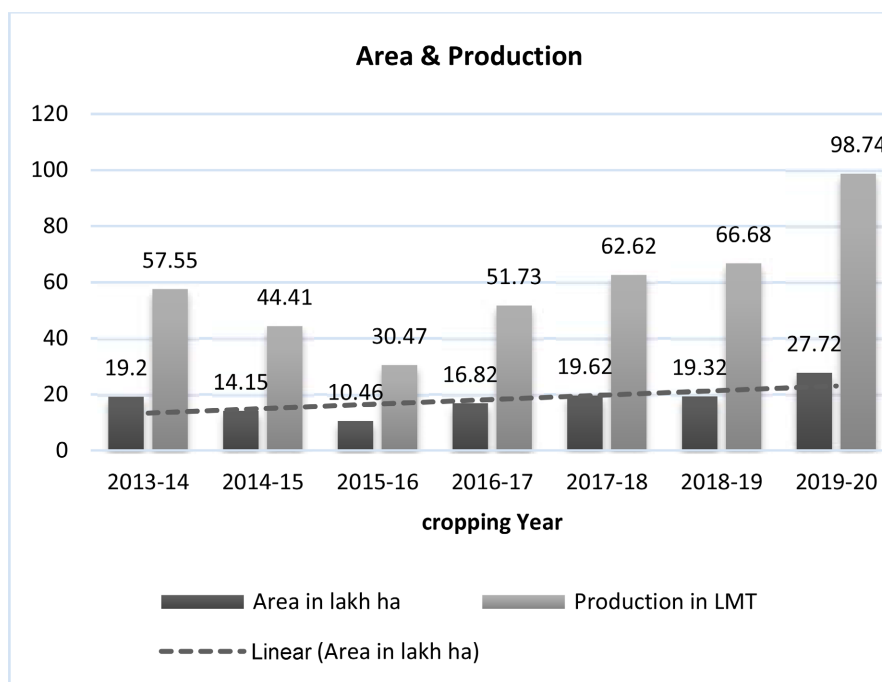
Keywords

System of Rice Intensification, Water Usage, Productivity, Plant Growth,

1. Introduction

Rice is a predominantly grown staple crop in the southern parts of India, which constitutes about 2.77 million ha with a production of 98.74 lakh metric tons, making Telangana stand out at ninth position in the area and eighth position in production [1]. Production has been increasing for the past five years, despite the fact that the amount of an area was fairly marginalised during 2017-2018 (see **Figure 1**). The estimated area has increased remarkably to eight lakh ha during 2019-2020, which is attributable to the irrigation facilities provided by the Government of Telangana through 38 major and minor projects, along with mission Kakatiya, Kaleshwaram lift irrigation scheme (KLIS), and tank system [2]. However, the productivity has been remained stable or decreased due to poor linkage of irrigation and drainage systems under government programmes like the National Food Security Mission (NFSM), whose foremost strategy relies on hybrid rice technology and fertilizer application, *i.e.*, macro and micro. Second, captivation of Conventional management practices by the farmers and policy-driven non-farm mechanization [3].

Narayanpet block comprises 27 villages with a gross cropping area of 167,911 ha, of which the net paddy cropping area is 19,500 ha during Kharif and 10,314



Source: Directorate of economics and statistics, 2021.

Figure 1. Telangana rice crop area and its production for a period of eight years from 2013-2020.

ha in Rabi [4]. The cumulative difference between Kharif and Rabi is 9186 ha, owing to the fact that the majority of the area (55%) is classified as rainfed, with 85% of the red sandy loam soils having poor water retention capacity and thus surface runoff. Rice is grown as a short-duration crop for about 120 days, having been transplanted in puddled fields after 20 - 25 DAS at a seed rate of 60 - 70 kg-ha⁻¹. Since 2018, the Telangana government has been providing free electricity for nearly 23 lakh pump sets 24 hours a day, allowing farmers to pump 8 - 9 hours per day [5]. According to a baseline survey conducted for 6800 farmer households by the watershed organisation trust from 2018 to 2021, only 1519 HH (22.3 percent) are accessed for bore wells and cultivated in the offseason, whereas rainfed households must migrate for daily wages because nearly 350 HH (7 percent) prefer working as daily labour. The Watershed Organisation Trust (WOTR) has been implementing sustainable agricultural activities under the project "Rural Livelihood," supported by the Axis Bank Foundation (ABF), to strengthen the rural poor economically across the Narayanpet block while maintaining ecological integrity. As part of this, SRI (System of Rice Intensification) is a crop intensification method introduced in 2008 with a great emphasis on water limitation. Consequently, this practice has bagged its excellence for good yield despite some perceptions that need to be amended. Although its stretch has slackened to a large extent in the state, it is important to witness the experiences of most areas for its utmost capacity to contribute to policy objectives. In particular, it is significant to consider to what extent SRI will contribute to rainfed areas for the productivity of water in an era where climate change extremities are making it more urgent.

This article compares the SRI and conventional management practices concerning environmental, economic, and social impacts. The data taken here is from the 2019-2020 season. The SRI has been promoted in 24 out of 27 project villages over the past two years by mobilization of FGs with support from the NGO called Watershed Organization Trust (WOTR).

2. Methods

The system of rice intensification as explained above consists of a series of practices that begin with systematic land preparation followed by Harrowing and leveling as conventional practice. Transplanting seedlings of 8 - 16 (DAS) old *i.e.* two-leaf stage at 25 cm (length × breadth) in a square spacing method with an elastic tape-marked rope. One to three seedlings per hill, alternate wetting and drying (AWD) irrigation followed by mechanical weeding (1 - 3) using a rotary weeder before canopy closure.

These practices are followed by 410, 600, and 720 farmers in the years 2019, 2020, and 2021, although some variations in irrigation supply, respectively. Water level held at saturation level and irrigation need is usually recognized by means of hairline cracks appearing on the surface, whereas in some fields the water level is kept up to 2 cm above the soil surface. In any case, the water re-

gime followed in SRI is markedly different from conventional practice in which the inundation of water is a common phenomenon.

Implementation of SRI during the initial stages of the project in 2019-2020 was skeptical and however, was successful by the formation of 211 farmer groups with 20 members in each group. The promoting organization has also been extending its services through farmer field schools (FFS) for capacity building on green manure, soil reclamation, Integrated pest management (IPM), and integrated nutrient management (INM) practices which enhance the soil and crop health, thereby good production. This study undertaken was not completely random sampled or control-treated but it was an effort of the program to understand the environmental, economic, and social impacts of practice on farmer economic viability. A total of 120 farmers were selected for sampling as every 60 farmers for SRI and conventional practice have been drawn from 20 project villages and there was no full listing of farmers under conventional practice hence no random selection was made. However, the inclusion of farmers in comparative analysis is made because they are similar to SRI farmers in terms of land-holding, soils, farmer group they belong to, and education.

Total 120 farmers were pooled under 4 clusters as each cluster contains 5 villages and those practices and results are studied were thus comparable (**Table 1**).

SRI data was collected during the crop season, whereas conventional data was collected at the end of the season. The total mean area under the sampled rice crop was 0.27, of which SRI constitutes approximately 0.14 (**Table 2**), which is non-significant to conventional practice because the farmers sampled for this study are small to marginal landholders who are highly ambiguity intolerant during the project's early days. As a result, SRI practice was implemented in a very small amount of land, *i.e.* 0.025 - 0.050 acres, for which they have observed impeccable results, as explained in this article whereas for an area expansion in subsequent years is not depicted. This study has investigated the Environmental impacts by measuring the number of pumping and irrigation hours as proxy variables for water saving in SRI and conventional management practices. Economic impacts measured were based on cost savings on seed quantity, fertilizer application, and labor deployment, which are directly proportional to the net returns on production efficiency. Congenial relations among adjacent field

Table 1. Showing the number of villages and farmers that have been quantified for comparative analysis.

S.no	Cluster	No of villages	No of farmers	
			SRI	Conventional
1	I	5	15	15
2	II	5	15	15
3	III	5	15	15
4	IV	5	15	15

Table 2. Showing landholding details of the sampled farmers.

	SRI		Conventional		Total		Comparison of means	
	Mean	SD	Mean	SD	Mean	SD	Significant difference	F statistic
Total sampled area in Ha	0.14	0.10	0.40	0.26	0.27	0.18	1.07	6.29
Total area under paddy in Ha	0.23	0.19	0.45	0.32	1.01	0.29	6.23	2.83

farmers are among the social benefits that have led to behavioural changes in the farmer groups. The data estimates were derived from the collection of 323 baseline data points and interviews with 16 Farmer groups. The difference between SRI and conventional practice was analysed using standard statistical tools, and technical options within the SRI from which the results were extracted were considered for policy implications.

3. Results and Discussion

Environmental impacts

Table 3 displays the findings from rabi 2019, Kharif, and rabi 2020 based on interviews with two farmer groups (20 members in each group comprise the same size of the bore wells operated by a 5HP submersible motor) and four cluster coordinators. The amount of water used to irrigate one hectare was calculated using the borewell discharge capacity of 3 lit/sec, which is a crude approximation, so a margin of error has been considered. However, the significant difference found between SRI and conventional practice was during the active tillering stage at around the first and second weeding and booting (Panicke development) to flowering stage serves as a reasonable approximation and auxiliary to the estimated pumping hours and irrigations. These findings are consistent with [6] [7] in which the potential of SRI serves in reducing the quantum of

Table 3. Indicating the water application in SRI and conventional paddy.

S. no	Growth stage	No of pumping hours		No of irrigations		Water req. in m ³ .ha ⁻¹		Cumulative water req. in m ³ .ha ⁻¹	
		SRI	Conventional	SRI	Conventional	SRI	Conventional	SRI	Conventional
1	Land preparation	108	106	9	9	1166.4	1144.8	1166.4	1144.8
2	Nursery (period of 24 days)	18	21	29	33	194.4	226.8	1360.8	1371.6
3	Active tillering to Panicle initiation (period of 60 days)	364	540	33	45	3931.2	5832	5292	7203.6
4	Booting to flowering (30 days)	360	480	12	16	3888	5184	9180	12,387.6
5	Maturity & Harvesting (30 days)	191	216	16	18	2062.8	2332.8	11,242.8	14,720.4
	Total	1041	1363	99	121	11,242.8	14,720.4	28,242	36,828

water based on the number of irrigations and pumping hours, whereas measuring water volumetrically at the field level was not accurately feasible. Water application during land preparation was not significantly different because no water-saving technology was adopted.

Figure 2 depicts the water applied at each growth stage of a crop, with the cumulative water requirement for SRI being less at active tillering to panicle initiation without compromising tiller count, which may be due to a reduction in soil hypoxia, which further facilitates root proliferation [8] [9].

SRI paddy, on the other hand, had a much taller and stronger root system than the conventional weak root system (**Figure 3**). This could be due to improved nutrient access and increased soil biota, which are facilitated by timely weed management and soil loosening with the help of a cono weeder (a mechanical practice carried out between the rows of SRI paddy fields every 15 days) [6] [10]. This operation is convenient only in fields with plant spacings ranging from 20×20 to 25×25 cm, and it also allows for easy identification of pests and diseases.

According to a farmer named Ramulu from one of the project villages called Abhangapur: The severity of the snail attack at the collar region of the SRI paddy was reduced during the first 30 - 45 DAT, which is normally a susceptible stage for snail attack because paddy leaves are very slender. This could be related to the fact that less water was used for SRI, causing snails to hibernate.

Economic impacts

The ultimate derivative for capital gains is resource optimization at the farm level, which can be achieved only if one can keep up with their records. **Table 4**

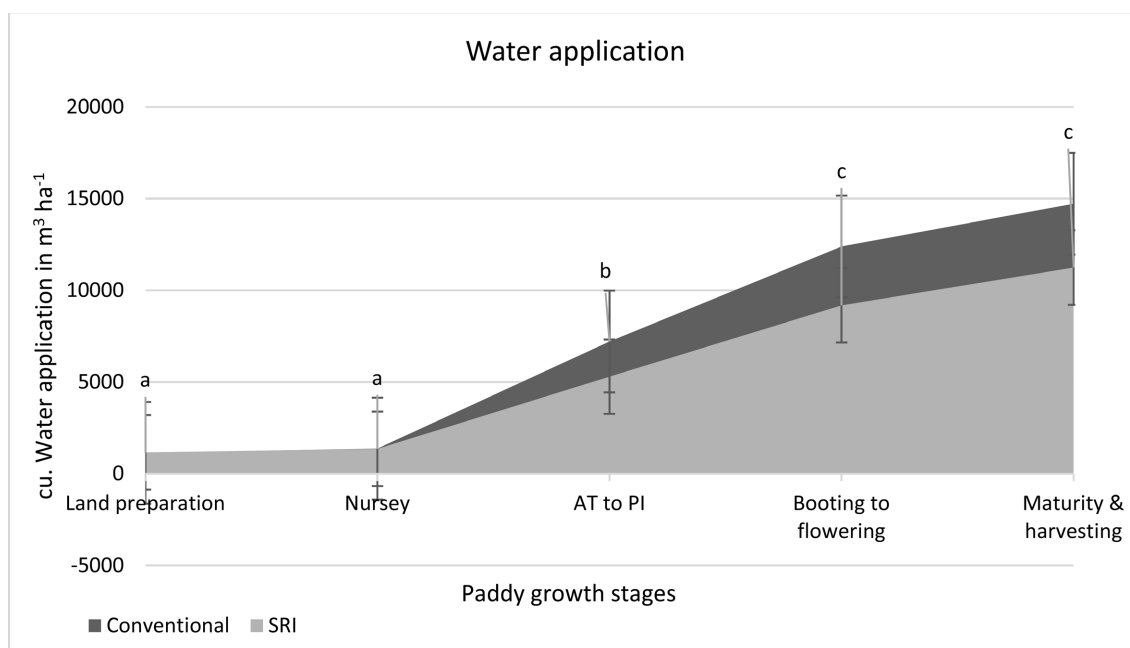


Figure 2. Water applied at each growth stage of a crop: different letters indicate the significant difference whereas the same letters indicate the non-significant difference between SRI and conventional plots.



Figure 3. A cluster coordinator named Srinivas reddy showing a difference between the root growth of SRI (holding in his right hand) and conventional paddy (left hand).

Table 4. Shows the expenditure incurred on SRI and conventional cultivation of paddy.

S. no	Practice	Expenditure incurred (Rs·ha ⁻¹)		Difference of SRI over conventional		F statistic
		Conventional mean	SRI mean	Capital	%	
1	Field preparation	7900	7900	0	0	0
2	Nursery	1984	256	-1728	-87	60.06
3	Transplanting	10,000	11,250	1250	13	1.26
4	Weeding	5000	2000	-3000	-60	8.15
5	Fertilizers and pesticides	9725	7050	-2675	-28	3.70
6	Harvest	11,900	11,900	0	0	0
	Total	46,509	40,356	-6153	-13	0.60

shows the expenditure incurred on each crop cultivation category and the majority of the input cost, *i.e.* 13 percent more spent on conventional paddy for the net returns, *i.e.* 69 percent more received for the SRI, with a 99 percent significant difference (see **Table 5**). In particular, the seed cost at a fixed price of 32 Rs/kg for SRI was significantly (-87 percent) lower as 8 kg per ha was required as opposed to 62 kg/ha for conventional. Labour deployment for weeding has usually been more for direct-seeded without puddled fields than transplanted puddled fields regardless of the distance maintained between the rows. However,

Table 5. Indicating the cost-benefit analysis of conventional and SRI cultivation of paddy.

S. no	Particulars	Conventional	SRI	Variation of SRI over Conventional	Comparison of means	
					F value	Significant difference
1	Total expenditure (Rs/ha)	46,509	40,356	-6153 (-13%)	0.60	0.41
2	Total grain yield (t/ha)	4.03	4.90	0.87 (22%)	1.48	0.01
3	Total straw yield (t/ha)	2.0	1.4	-0.6 (-30%)	2.11	0.00
4	Grain value (Rs/ha)*	77,376	94,080	16,704 (22%)	1.48	0.01
5	Straw value (Rs/ha)**	10,875	7875	-3000 (-28%)	1.90	0.00
6	Net returns (Rs/ha)**	42,117	61,224	19,107 (69%)	2.53	0.00
7	Gross returns (Rs/ha)*	88,626	101,580	12,954 (24%)	1.52	0.01

Notes: Parameter marked with an asterisk (*) are statistically significant ($P < 0.05$), (**) are highly significant ($P < 0.001$).

the SRI method requires less labour deployment as 8 people/ha as opposed to the conventional required 16 people/ha at a constant price of Rs. 250/person. Input cost savings in these two categories have ranked first and have yielded the highest production efficiency among the others. Whereas fertilizer and pesticide application came in second place with a -28 percent capital difference for SRI over conventional and required careful attention to the modification of quantities in SRI that the farmer was unaware of.

Harvesting costs were calculated for both cases based on the number of machinery hours used by farmers who used this method. Farmers who have adopted manual harvesting with the assistance of labour deployment have not been included, but the consequences are discussed.

Manual harvesting is advantageous in terms of proper cutting, which leaves field residue with less height and allows secondary tillage operations to be performed with ease and without straw being scattered in the field. However, labour availability, cost, and field conditions all play a significant role in implementation, whereas the machinery practice saves time but leaves more residue, affecting farmer time and traction efficiency.

Table 5 compares the grain and straw yields of SRI and conventional paddy, as well as expenditure and returns per ha. The significant difference found for grain value, net and gross returns was calculated at a fixed grain price of 19,200 t-ha⁻¹. Total yield for a sampled number of farmers found a 22 percent increase for the total expenditure difference of Rs 6153, *i.e.* 13 percent less over conventional paddy farmers, which has a significant impact on SRI farmers net income, *i.e.*, 69 percent higher than conventional returns. The fact that the SRI straw yield is lower than the conventional paddy yield indicates an improved harvest index (HI) ratio, which may contain some error due to difficulties in converting local measurements into a quantifiable total, but the results are consistent with farmer observations of the cultivation period. **Figure 4** depicts a graphical representation of the capital difference between SRI and conventional paddy for the

parameters calculated in **Table 5**.

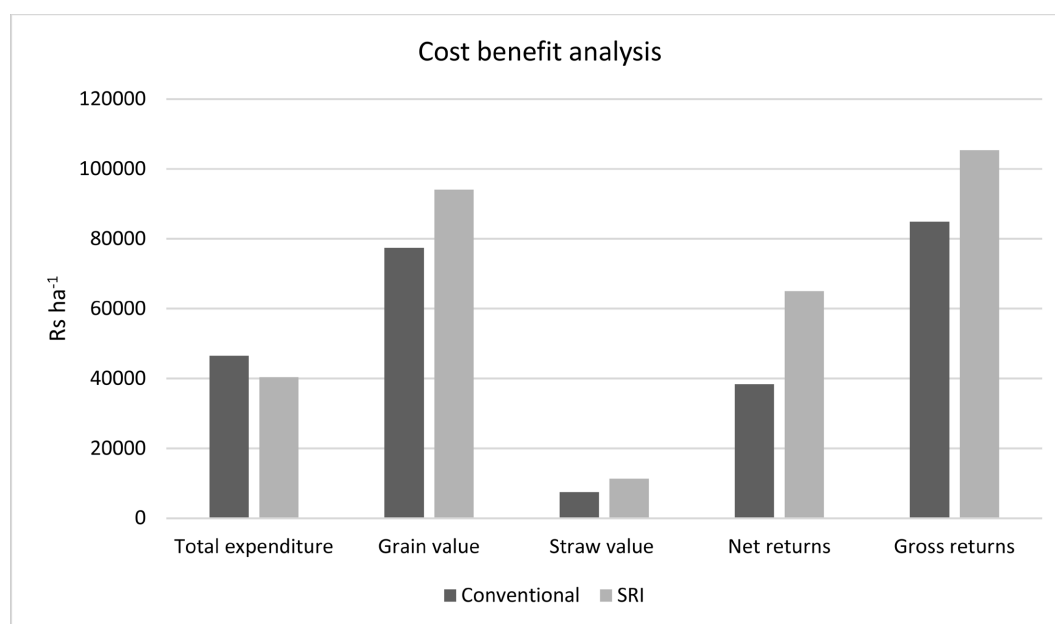


Figure 4. Representing the total amount spent on SRI and conventional paddy for which net and gross returns are received ha⁻¹.

Social impacts

In the project location, the promoting organisation has 211 functional farmer groups, with a total of 4220 farmers actively involved in sustainable agricultural interventions. A qualitative survey of 20 farmer groups was conducted to assess the effects of SRI on FGs collectivization (which includes significant savings, investment, utilisation, learning, and congenial relations) that strengthen their economic viability. This study classified adopters as low, partial, and full based on the adaptability of the SRI at the level of extent (**Figure 5**). Accordingly, benefits were captured and analysed for seven farmer groups classified as low adopters shown in **Figure 5**. This means that the farmer group members who

Table 6. Demonstrates farmer group collectivization and behavioural change as a result of SRI implementation: adapted from theory of planned behavior/reasoned action [11]. Note that an asterisk (*) denotes indecisiveness, a (**) denotes conferring responsibility to, and a (***) denotes assertion before and after implementation.

S. no	Component	Category		
		Low	Partial	Full
1	Financial savings in the group (Rs)	5000 - 6000	15,000 - 20,000	20,000 - 60,000
2	Expenses in (Rs)	32,000 - 33,200	30,000 - 31,500	28,000 - 30,000
3	Attitude	*	**	***
4	Subjective norms	***	**	*
5	Behavioural control	*	**	***

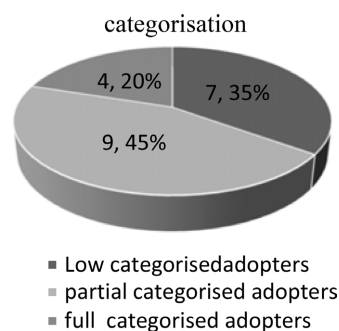


Figure 5. Piechart shows categorisation of adopters for SRI implementation.

fall into this category used SRI only once during the cropping season in an area of 2.5 - 5 cents and then returned to conventional farming. As a result, low adopters experienced poor savings (Rs. 5000 to 6000), heavy investment (Rs. 32,000 to 33,200), and poor belief (attitude), susceptible mindset (Subjective norms: follow what others are doing), and low level of confidence (behavioural control) (**Table 6**). Nine farmer groups were classified as partial adopters, with average savings (Rs. 15,000 - 20,000) and investment (Rs. 30,000 - 31,500) that ameliorated overall behavioural change (**Table 6**). In contrast, four groups of full adopters have been documented to practice SRI cultivation every season without fail, resulting in good savings, low investment costs, and assertive decision making (**Table 6**). Furthermore, it was discovered that farmer groups classified as full adopters were responsible for transferring knowledge about SRI through sharing their experiences and motivating other adjacent farmers in their own groups to engage in SRI cultivation. The proportion of adaptation has increased to a greater extent among these groups. These observations were made based on farmer group interviews, and their perceptions were later converted into reasoned action using a theory of planned behaviour [2].

4. Conclusion and Policy Implications

This study assessed the significance of SRI in terms of water savings, input costs, plant growth, and social impacts, and discovered that the sampled number of SRI farmers has a significant reduction in number of pumping hours (322), as well as number of irrigation days (22), when compared to conventional paddy farmers. This approximation serves as a complementary base for cumulative water saving *i.e.* 8586 m³·ha⁻¹ under tubewell irrigation. Although the certainty of water application at various stages of crop development is irrational in the farmer's field, irrigation has been provided at regular intervals with an open sluice system to reach the tail end fields. Thus, sluice leakage with various land characteristics is causing concern and wasting water, which, when combined with the pressure on sinking groundwater tables, makes water conservation less important in tubewell irrigation.

The approximation of water savings in this study is in line with the findings of [6], while input cost and plant growth parameters can be attributed to the ob-

servations of [8] [10]. The grain value was calculated using the government price (MSP), which was Rs. 19,200/t-ha⁻¹ in the evaluation year of 2020-2021, whereas the studies that quoted their observations in the years 2011-2016 were at prices ranging from Rs. 9150 to 12,500/t-ha⁻¹. So a two-fold increase in the value of the minimum support price could pave the way for irrigation system improvement, which would only be possible if the SRI system switched to alternate wetting and drying (AWD) method. Appropriate drainage, irrigation scheduling, water control at open sluice, and block irrigation are some of the areas that must be modified to the best of the farmer's ability in order to benefit the most from both types of paddy cultivation. The amount of electricity that could be saved for water savings estimates was not calculated, but assumptions can be made based on an approximation of the number of pumping hours and irrigations calculated for SRI and conventional paddy.

Reduced cultivation costs for seed and labour have resulted in maximum net returns of 69 percent over conventional paddy, as well as a significant increase in SRI grain yield of 22 percent and a decrease in straw yield of -39 percent, indicating an improved grain to plant biomass index (HI). The net returns calculated do not include family labour expenses, as some studies shows no significant difference in net returns when family labour is included [12]. If this study had included family labour at constant outside labour rates, the cost of SRI cultivation would have changed significantly, but the beneficial comparison between SRI and conventional practise would have remained constant. The common established belief about SRI is a labour-intensive method and associated with drudgery, but this analysis shows 60% reduction in labour cost which is the second highest contributor to total returns. Adjustments in the labour market for paddy cultivation have always resulted in two-way reflections at the village level, as deploying labour improves local employment while reducing labour intensity benefits smallholders [10]. Thus, policy and procedure compilations of the government, NGOs, SAUS, and other farmer cooperative societies should reform non-farm mechanisation towards farm mechanisation by facilitating custom hiring centres (CHCs) that support rural livelihoods through employment promotion.

The recuperation of self sufficiency in paddy cultivation is a policy debate for further maximization of the production [13]. Therefore, the findings of this study urge policymakers, FPOs, and other members of the farming community to comprehend the modified perceptions of SRI implementation and its consequences. Correlate them with the Farmer group (FGs) management-based strategy for collective decision making, which increases the chances of implementing crop diversification and, as a result, land productivity.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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