Resilient farm technologies in achieving sustainable development: Performance and Adoption of SRI under multiple constraints in Odisha, India

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Abstract:

Rice yield underperformance coupled with production instability in Odisha is primarily due to low irrigation potential, the spatiotemporal disparity in rainfall pattern and relentless confrontation with biotic and abiotic stresses. System of rice intensification (SRI) was introduced in the state during early 2000 with the promises of higher production horizon. However, the present scenario of patchy adoption pattern has necessitated comprehensive study on dynamics and determinants of adoption of SRI. Increased SRI area allocation is observed at the expense of reduced number of adopting farmers. Economic scarcity of skilled labour, difficulties in transplantation and mechanical weeding, low irrigation potential and poor on-farm water management were major constraints as experienced by SRI adopters as well as dropouts. Farmers' compliance in following different resilient SRI components that also varied spatiotemporally has resulted in realized incremental yield. Irrespective of severe drought during 2015-16, SRI yielded significantly higher than conventional one with a considerable decline in hazardous and environment polluting chemicals usage. Probit analysis indicated that active social involvements of NGOs, on-farm training and demonstrations, and realized incremental rice income influenced SRI adoption. Further SRI area expansion hindered mainly because of infeasible land topography, area saturation and lack of farmers' interest.

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1. Introduction

Despite significant improvements in terms of farm technology and its expansion over the last several years, food security remains a crucial global problem. Rice is the staple food for more than half of the global population, while in Asia, it accounts for 91 percentage (Varma, 2017). Facing mounting pressure on land and water resources, enhancing rice yield is crucial for improving food security and lessening poverty amid masses in rural India. With largest area under rice (43.39 million ha), India produced 156.54 million tons during 2015-16 and stood next to China in the world (FAOSTAT, 2017). But, the yield levels in India were low at 3.62 tons per ha compared to other major rice producing countries such as, China (6.75 tons/ha), Japan (6.70 tons/ha), and Indonesia (5.13 tons/ha). Rice consumption is growing due to high-income elasticity of demand. To meet the growing demand, strategic increase in rice production is indispensable. While there exists meagre scope in area expansion, production enhancement is conceivable only by heightening productivity with an improvement in production efficiency through technological breakthrough to meet the goal of SDGs sub objective of ensuring sustainable food production systems and implementation of resilient agricultural practices by 2030 (UN, 2015).

India's food security has greatly sustained through the green revolution of 1960's but is characterized with high input usage particularly fertilizers, irrigation and plant protection chemicals that has enhanced the cost of production significantly in later stage. The impressive surge in rice output has been limited to irrigated belts of the country. The skewed distribution of green revolution and increased costs of cultivation have given alarming signal to future needs of food security, while water scarcity has posed a major threat.

With looming climate change conditions, reliability of farming on monsoon is going to be a very tough proposition. Increasing need of water from diverse sectors have necessitated innovations in farm techniques to harness additional farm output from per drop of water (UNESCO, 2016). Rice is grown with high water consumption. It has been estimated that irrigated rice uses 34-43 percent of the global irrigated area while 1900 to 5000 litters of water is used to produce one kg of rice(Jagannath, Pullobhatla, & Uphoff, 2013). Therefore, it is pertinent to introduce innovations in rice production system.

In the context of rice production enhancement to meet the global food demand and ensuring food security to masses, it is relevant to have a technique which not only ensures high productivity but also sustainability in terms of resource conservation and efficient use of the scarce factors of production.

System of Rice Intensification (SRI) is an innovative method of rice farming which ensures high productivity by manipulating the agronomic aspects of plants, soil, nutrient and water which thereby enhances land, labour and water productivity. The main advantage of SRI as envisaged is the resource conservation in shape of less seed and lower water utilization than that of the conventional transplanting. This technique has raised the hope, aspiration and new possibilities of higher yields. Large number of studies indicates considerable higher productivity and enhanced returns linked with SRI (Varma, 2017). Takahashi and Barrett (2014) illustrated that SRI generated average yield gains of around 64% relative to conventional methods in a study in Indonesia. Sinha and Talati (2007) found average yield increase of 32% among farmers who partially adopted SRI in West Bengal. Styger et al. (2011) demonstrated 66% enhanced yields in SRI compared to experimentally controlled plots using farming practices similar to local rice growers in Mali and 87% higher productivity against the surrounding farmer rice fields.

SRI has also faced extensive cynicism within the conventional rice breeding community (Sheehy, et al., 2004; McDonald, Hobbs, & Riha, 2006). Disagreement among the scientific community on metrics of the benefits of SRI in terms of rice productivity has been a matter of concern (Glover, 2011). Takahashi and Barrett (2014) and Sinha and Talati (2007) demonstrated that increased productivity was related to varying degrees of adherence to SRI principles.

Taking into consideration of beneficial impact on the rice yield and overall income, it would naturally anticipate that SRI would be widely spread and accepted. But the adoption is patchy and scale advantage is not achieved in India. Diffusion of SRI has been sluggish and uptake rates have been low in many areas where it has been introduced as a potential catalyst for improving productivity, integration and food security (Moser & Barrett, 2003). Given its asserted yield and earning prospective, low adoption is a dilemma even in places with excess labour.

The primary impediments for embracing SRI seems to revolve around learning the principles and practices involved in this knowledge-intensive method and possible social constraints to adopting visibly different rice production and water management methods within ostensibly homogenous production communities(Moser & Barrett, 2003), or, what we now term ‘homophily’(Banerjee, Chandrasekhar, Duflo, & Jackson, 2013). SRI is a knowledge-intensive farming practice that requires significant local adaptation and managerial skills but requires time and aptitude. There is evidence that farmers are constrained by information and skills necessary for local adaptation.

While the area under SRI has been increasing, comprehensive studies using farm level data covering various socio-economic aspects of SRI adoption at the farm level is still lacking for Odisha, a predominantly rainfed rice farming state in Eastern India. In this background, an attempt has been made in this study with the following objectives:

1. To study the dynamics and determinants of adoption of SRI and constraints faced by farmers in adoption of the methodology

2. To estimate the yield, income, cost advantage and resource conservation of SRI adopter over non-adopters

3. To evaluate the level of adoption of different components of SRI by different categories of farmers

2. Characteristics of rice production in Odisha

Rice covers about 46% of the GCA and is the major crop, covering about 62% of the total area under food grains in the state. Being the staple food the state economy is directly linked with improvements in production and productivity of rice. Odisha is the 5^{th} largest rice-producing state in India accounting for roughly 6% of the national rice output. The area under rice was 3.94 million ha, with average rice yield being 2.26 tons/ha and production of 8.91 million tons during 2015-16.

Majority of the rice area is rainfed, while only 35 % is irrigated. The state is prone to drought as well as submergence that results in a low and highly unstable yield (Figure 1). As per the official statistics, Modern variety acreage increased from 4% in 1970 to about 86% in 2013 at the rate of 6.4% annually (Figure 2) (various issues of Odisha Agriculture Statistics). Although rice yield in Odisha is positively correlated with MV coverage, rice yield increased only by 155kg/ha, on an average, for every 10%-point increase in the share of area under MVs (Figure 3). Thus MVs expansion alone will not result in a substantial yield improvement which necessitates technological breakthrough. Here the innovative SRI technology may play significant role in swinging the productivity at a higher plateau.

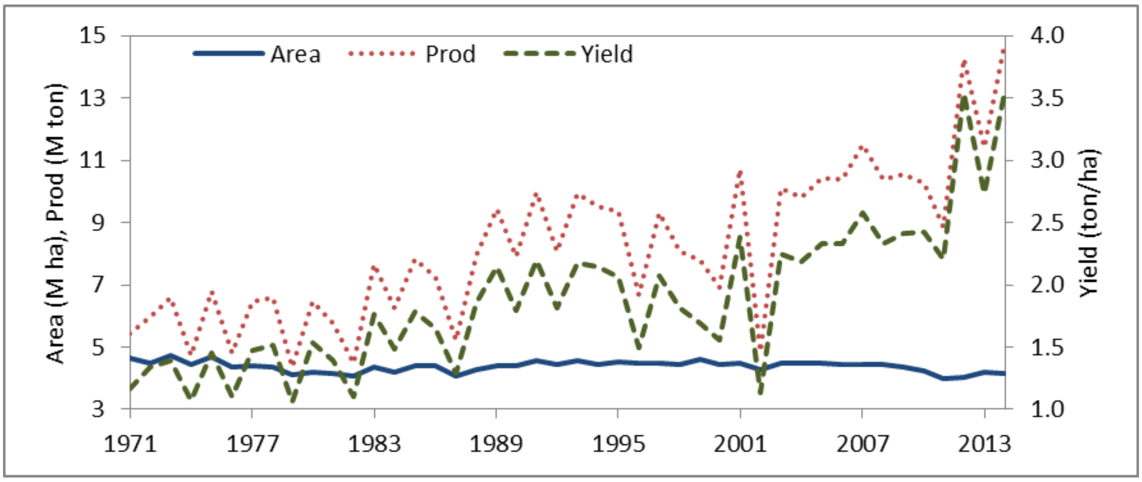

Figure1. Rice area, production and yield in Odisha

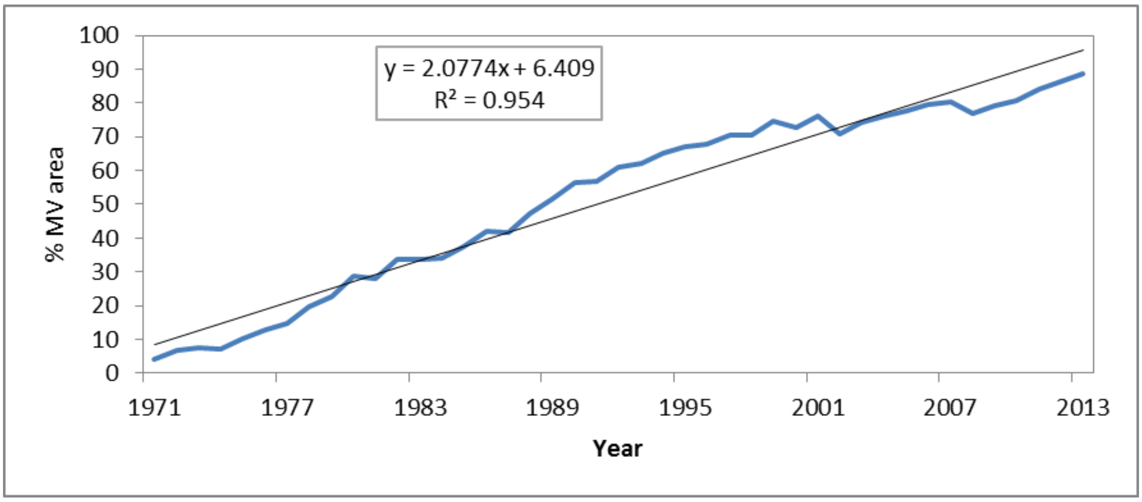

Figure2. Trend in adoption of MVs in Odisha

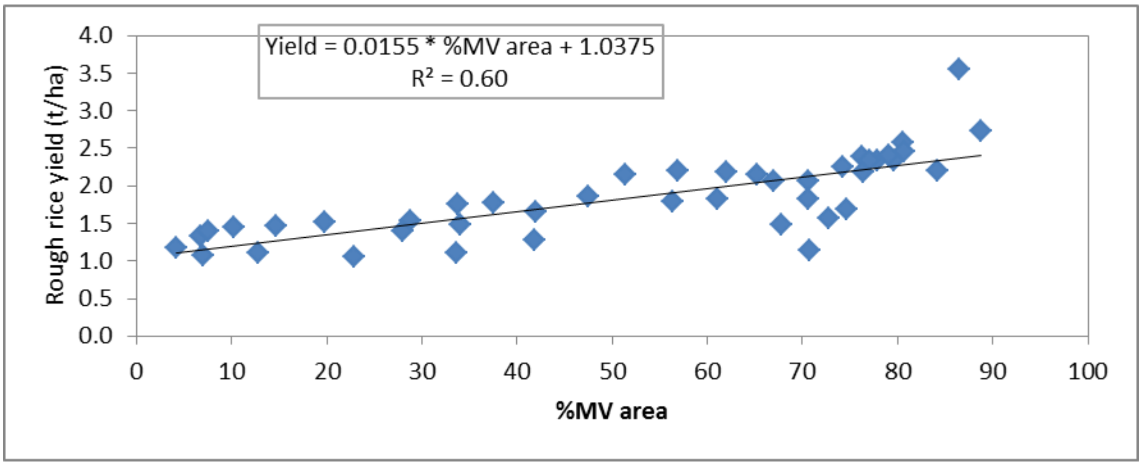

Figure3. Relationship between rice yield and percentage area grown to modern varieties in Odisha during1971-2013

3. Materials and methods

Data for this study has been obtained from field level household surveys across 13 districts of Odisha. A sample of 522 farmers, covering 297 SRI adopters, 148 drop outs and rest 77 farmers practicing conventional rice farming were chosen for the study (Table -1). Purposive sampling method was followed for selecting villages and then the farmers as it was still believed that the spread of adoption of SRI was limited. Farmers practicing conventional method of rice nearby SRI farms were considered as non-adopters. SRI drop out farmers had been selected from among the farmers who had discontinued practicing or who had not practiced SRI during the *kharif*, 2015 though some practices of SRI recommendation were partially followed during earlier rice growing seasons.

Table 1: Sampling framework

Sl. No	**District**	**Adopters**	**Drop outs**	**Non adopters**	**Total**
1.	Angul	21 (7)	17 (11)	10 (13)	48 (9)
2.	Cuttack		7 (5)		7 (1)
3.	Deogarh	31 (10)	7 (5)	6 (8)	44 (8)
4.	Kalahandi	27 (9)	12 (8)	10 (13)	49 (9)
5.	Kandhamal	34 (11)	10 (7)	5 (6)	49 (9)
6.	Kendrapara		6 (4)		6 (1)
7.	Keonjhar	32 (11)	21 (14)	7 (9)	60 (11)
8.	Khurda	11 (4)	7 (5)	(0)	18 (3)
9.	Koraput	43 (14)	5 (3)	9 (12)	57 (11)
10.	Malkangiri	12 (4)	12 (8)	6 (8)	30 (6)
11.	Nayagarh	34 (11)	21 (14)	5 (6)	60 (11)
12.	Rayagada	25 (8)	10 (7)	8 (10)	43 (8)
13.	Sambalpur	27 (9)	13 (9)	11 (14)	51 (10)
	Grand Total	297 (100)	148 (100)	77 (100)	522 (100)

Note: Figures in parentheses are percentage to column total

3.1. Analytical techniques employed

3.1.1. Garrett' ranking technique

Analysis of constraints faced by the farmers have been carried out by using Garrett' ranking technique. A 10 point scale was prepared according to their responses regarding their constraints which range from Scale: Lowest=1 and highest=10. Garrett's ranking technique is in the following manner:

Percentage position = 100 $(R_{ij}-0.50)/N_j$

Where, R_{ij}= Rank given for the i^{th} item by the j^{th} individual and

N_j-= Number of items ranked by the j^{th} individual

The percentage position of each rank was converted into scores using Garrett table. For each constraint, scores of individual respondents were added together and were divided by total numbers of respondents. Thus, mean score for each constraint was ranked by arranging them in the descending order.

3.1.2. Probit model

Further, to analyse the probability of adoption of SRI method of rice cultivation by the household subject to different factors that influence the participation in that particular activity, probit model has been used. The participation equation is estimated with a dummy variable equal to 1, if the household participated in the activity, and 0 otherwise is regressed on the independent variables: years of education, experience in years of farming, affiliation with any type of organization in the village equal to 1 or otherwise 0, total operational area in acres, total income in rupees, total land under rice cultivation in acres, rice yield on non SRI farms in qt/acre, NGO support in facilitating SRI equal to 1 or otherwise 0, training received on SRI, canal as source of irrigation, percentage of non-farm income to total income, percentage net agricultural income, percentage of medium land to total land and percentage area irrigated. It is understood that, SRI is more adopted by those who have got higher proportionate of medium land. Thus, a probit is fitted separately for each case to reveal the intensity of participation in SRI as compared to non-adopters.

Z_I is a vector of independent variables of the participation equation.

$$P_i^* = \alpha Z_i + \varepsilon_i \quad P_i = 1 \Leftrightarrow P_i^* > 0; P_i = 0 \Leftrightarrow P_i^* \leq 0$$

where, P_i^* is a non-observed continuous latent variable and P_i is an observed binary variable, with a value of 1 if the household participates in the SRI and 0 as non-adopter.

3.1.3. Tabular analysis

The cross tabulation technique was used to assess the economics of crop production in the studied area. The percentage and average were computed and compared to draw meaningful inferences.

4. Results and discussion

4.1. Socio-economic profile of the sample households:

Among the adopters, 49% belonged to scheduled tribes (STs) followed by other backward castes (OBC) (44%) and scheduled caste (SC) (5 %) as depicted in Table 2. OBCs constituted 49% of the drop outs. STs comprised 56% of the non-adopters and OBCs' share was 40 percent. Only three percent of the adopters were female headed. Considering the age of the respondents (average 46 years), more than 60% of the adopters and dropouts were in the age group of 40 -60 years. Educational status of the adopting farmers indicated that 38 and 21% of them had attended the secondary and higher secondary classes respectively. A significant 31% of farmers had no formal educational attainment, mainly because of the fact that the SRI promotion has been mainly targeted towards the poor marginalized section of the society.

Table 2: Demographic profile of sample respondents

Sl. No.	Particular	Adopters (297)	Drop outs (148)	Non-adopters (77)	Grand Total (522)
1.	Caste wise classification				
a)	General	4(2)	-	-	4(1)
b)	Other backward caste	131(44)	73(49)	31(40)	235(45)
c)	Scheduled caste	16(5)	15(10)	3(4)	34(6)
d)	Scheduled tribe	146(49)	60(41)	43(56)	249(48)
2.	Gender wise classification				
a)	Male	287 (97)	147 (99)	76 (99)	510 (98)
b)	Female	10 (3)	1 (1)	1 (1)	12 (2)
3.	Age classes				
a)	15-40 years	72 (24)	37 (25)	25 (32)	134 (26)
b)	40-60 years	200 (67)	95 (64)	39 (51)	334 (64)
c)	>60 years	25 (9)	16 (11)	13 (17)	54 (10)
4.	Average age of household head (HH) (years)	45	46	46	46
5.	Educational status(Years)				
a)	No formal education	93 (31)	26 (18)	19 (25)	138 (26)
b)	1-4	19 (6)	10 (7)	10 (13)	39 (8)
c)	4-10	114 (39)	76 (51)	32 (41)	222 (43)
d)	10-12	63 (21)	28 (19)	14 (18)	105 (20)
e)	12-15	8 (3)	8 (5)	2 (3)	18 (3)
6.	Average years of schooling of HH	5	6.3	5	5.5

Note: Figures in parentheses are percentage to column total

Farming was the main profession and livelihood of the majority of the households among the sample respondents (97%) and more than 60% were also found to be engaged in both off-farm and no- farm labour wage earning activities as secondary occupation (Table 3). Average labour availability of the sample households was 498 man days that varied between 485 in case of non-adopters to 502 for adopters. It indicates that SRI adopters had higher family labour to sustain the time bound activities for SRI technique of farming. Female labour availability was about 33% of the total family labour across the study districts.

Table 3: Occupational status and average family labour contribution

Particular	Adopters (297)	Drop outs (148)	Non-adopters (77)	Grand Total (522)
Primary occupations				
Farming	291 (97)	142 (96)	76 (99)	509(97)
Service	5 (2)	4 (2)	-	9 (2)
Others	1(1)	2(1)	1(1)	4(1)
Secondary occupations				
Business	32 (11)	12 (8)	6 (8)	50 (10)
Farming	6 (2)	6 (4)	1 (1)	13 (3)
Labour	172 (58)	85 (57)	58 (75)	314 (60)
Service	6 (2)	4 (3)	2 (3)	12 (2)
Others	15(5)	5(3)	2(3)	22(4)
Average family labour available/ year	502	494	485	498
Average male family labour available/ year	338(67)	336(68)	313(65)	334(67)
Average female family labour available/ year	164(33)	158(32)	172(35)	164(33)

4.2. Classification of farm categories:

Marginal farmers constituted 53% of the total farming households and the percentage varied from 51% in case of drop outs to 64% for non-adopters (Table 4).

Table 4: Distribution of farmers according to farm size

Farm types	Adopters	Drop outs	Non-adopters	Grand Total
Marginal	155(53)	76(51)	49(64)	280(54)
Small	102(34)	62(42)	27(35)	191(36)
Large	40(13)	10(7)	1(1)	51(10)
Total	297(100)	148(100)	77(100)	522(100)

Note: Figures in parentheses are percentage to column total

Average operational holding of the households varied between 2.35 acres in case of non-adopters to 3.25 acres for adopters. On an average, acreage under rice was about 2.48 acres which was found to be highest among the adopters (2.67acres) and lowest in case of non-adopters (1.91 acres). Out of the total rice area, about 61 percent was under medium land. Irrigated area under rice was highest among the adopters. Irrigated rice area was as low as 30% in case of drop outs. Low irrigation potential might have played major role for dis–adoption among the drop outs while, majority of the respondents affirmed SRI could be practiced on medium land (Table 5).

Table 5: Land holding pattern of sample farmers

Particulars	Adopters	Drop outs	Non-adopters	Grand Total
Experience in years of rice farming (years)	21.9 (100)	21.9 (100)	22.1 (100)	21.9 (100)
Own land irrigated area (ac)	1.26	0.60	0.80	1.00
Owned-land dry area (ac)	1.76	1.98	1.46	1.78
Leased in land irrigated area (ac)	0.13	0.22	0.03	0.14
Leased in dry area (ac)	0.11	0.19	0.06	0.13
Leased out land irrigated area (ac)	0	0.02	0	0
Leased out dry area (ac)	0.02	0.04	0	0.02
Total owned land (ac)	3.02	2.58	2.26	2.79
Average total operational area (ac)	3.25	2.92	2.35	3.02
Average operational irrigated area (ac)	1.39(43)	0.80(27)	0.83(35)	1.14(38)
Total land under rice cultivation (ac)	2.67(100)	2.39(100)	1.91(100)	2.48(100)
Upland (ac)	0.06(2)	0.02(1)	0.03(2)	0.05(2)
Medium (ac)	1.55(58)	1.56(65)	1.34(70)	1.52(61)
Low (ac)	1.06(40)	0.81(34)	0.54(28)	0.91(37)
Rice area irrigated(ac)	1.01(38)	0.72(30)	0.67(35)	0.86(35)
Area feasible for SRI(ac)	1.56(58)	1.15(48)	1.03(54)	1.37(55)

Note: Figures in the parentheses indicate percentage to the total

Source wise irrigation status (Table 6) indicates that 64% of the adopters were having some assured irrigation sources whereas the same was only 44 and 40% for drop outs and non-adopters respectively.

Table 6: Source wise irrigation status of the sample farmers

Sources of irrigation	Adopters	Drop outs	Non-adopters	Grand Total
Rainfed	108(36)	82(56)	46(60)	236(45)
Canal	147(50)	39(26)	25(33)	211(40)
Bore well	4(1.5)	7(5)	-	11(2.5)
River lift and stream	18(6)	11(7)	5(6)	34(6)
Tank	4(1.5)	5(3)	1(1)	10(2)
Well	7(2)	4(3)	-	11(2.5)
DBI (Diversion based irrigation)	9(3)	-	-	9(2)
Total	297(100)	148(100)	77(100)	522(100)

Note: Figures in the parentheses indicate percentage to the total

Farming was considered as the major occupation as well as main source of income (Table 7). Total farm income varied from Rs 33516/-(43% of total income) in case of adopters to Rs 17676/- (31 % of total income) for non-adopters. It was observed that share of rice income to total income was highest at 30% for adopters and lowest for drop outs (22%). For adopters, share of non-farm wage income was considerably lower than that of drop outs and non-adopters. On the income front, adopters were having highest income with Rs 78035/- per annum than that of drop outs (Rs 64088/-) and non-adopters (Rs 57290/-) and rice was the major source of income among all. It is also observed that wage labour component both off farm as well as non-farm was higher in case of drop outs and non-adopters than that of adopters.

Table 7: Income profile of the sample farmers from various sources

Sources of income	Adopters	Drop outs	Non-adopters	Overall
Rice	23182(30)	14111(22)	13873(24)	19237(27)
Total farm income(crop)	33516(43)	21121(33)	17676(31)	27665(39)
Business income	13253(17)	8480(13)	7506(13)	11052(16)
Non-farm labour	13506(17)	17626(28)	16948(30)	15182(21)
Off farm labour	4730(6)	4539(7)	4344(7)	4619(6)
Service	7982(10)	7493(12)	7247(13)	7735(11)
Remittances	783(1)	1622(2)	1429(2)	1116(2)
Others	4265(5)	3207(5)	2140(4)	3652(5)
Total	78035(100)	64088(100)	57290(100)	71020(100)

Note: Figures in the parentheses indicate percentage to the total

About 46% of the adopters had some affiliations with service cooperative society or Panchayat Raj institutions or NGOs (Table 8). But majority of the farmers had no affiliation which indicates scope for further social networking to bring dis-adopters and non-adopters under technology adoption purview.

Table 8: Affiliation with society/Panchayat Raj institutions/NGO

Affiliations	Adopters (297)	Drop outs (148)	Non-adopters (77)	Total (522)
Yes	138 (46)	42(28)	8(10)	188(36)

4.3. Adoption patterns of SRI

SRI involves mainly six component practices, such as low seed rate (2 kg/ac,) using single seedling per hill, transplanting young seedling (less than 15 days), transplanting at wider spacing (25 cm X 25 cm), high dose of FYM and weeding at regular interval by mechanical weeder (minimum 2-3 times). Adoption levels of these practices are presented in Table 9 during 2013-14 to 2015-16 *kharif* (wet*)* and *rabi* (post rainy) seasons separately. It is observed that the number of marginal farmers practicing SRI during *kharif* had increased from115 during 2013-14 to 178 in 2014-15 but declined to 156 during 2015-16. However, area allocation to SRI had increased from 1.14 acre in 2013-14 to 1.22 acre during 2015-16. Similar observation was also observed for small farmers. Lower number of farmers opting for SRI during last year might be due to severe drought situation prevailing during 2015-16. So it is evinced that though overall number of farmers practicing SRI declined, area allocation had increased across size class. Thus, the perceived benefit from SRI influences area expansion. But due to bio physical, agro ecological and social constraints, many farmers dropped out of practicing SRI.

Seed rate was found to be more than double than that of the prescribed rate of 2 kg per acre during *kharif* which was due to varied reasons like apprehension of poor germination due to seedbed damage by animals/birds/insects and weather parameters, chances of mortality of seedlings, deficient rainfall, etc. High deviation was observed also in the young seedling transplantation, which varied by seasons, years and farm categories. Lower adoption of transplanting of seedling of prescribed age during 2015-16 was mainly because of late monsoon and early season drought. Other major reasons for transplanting older seedlings were scarce availability of assured irrigation, climatic aberrations, fear of mortality of seedlings due to both biotic as well as abiotic stresses, labour problem etc. Though one seedling per hill was practiced by more than or close to 60% of the farmers irrespective of farm sizes, low adoption was observed during *kharif*, 2015-16 because of transplanting of older seedlings. Barring few exceptions, square planting with 25 cm X 25 cm had been widely practiced among the adopters. Mechanical weeding by weeder was widely followed among the adopters, however, adoption was limited to two numbers of weeding against three. Though FYM was utilized, it was not at par with the recommended dose mainly due to scarcity.

Water management was not found to be truly followed because of uncertainty of rainfall and availability of irrigation water during *kharif* season.

Yield gain of SRI over conventional practices was observed across size class, years and seasons. Still with severe drought, farmers practicing SRI had experienced significantly higher yield advantage than that of non-practicing farmers during *kharif*, 2015-16. More than 80% of farmers reported incremental yield gain under SRI against that of conventional.

Overall it was observed that farmers' compliance towards practicing of different components of SRI varied widely across farm size and years during *kharif*. It was observed that in initial years, farmers' compliance remained low whereas, in subsequent years, the same was observed to be higher. This might be due to farmers' realizing higher yield complying with various SRI principles.

Table 9: Percentage of adopters adopting different practices of SRI during 2013-14 to 2015-16

Yr.	Farm class	Number of farmers	Area (acres)	Seed rate (kg/ac)	Application of organic manures qt/ac	Planting of 8-12 days seedlings	One seedling per hill	Square planting	Mechanical weeding minimum two times	Required water level	Grain yield (kg/acre)	% yield increment over conventional	Farmers realized yield increment	Adopted All SRI practices
Kharif														
2013-14	Marginal	115	1.14	4.75	12.69	36.52%	56.52%	98.26%	74.78%		16.99	16.24	81.58%	24.35%
	Small	76	1.30	3.83	10.34	63.16%	67.11%	93.42%	86.84%	1.32%	16.11	13.42	80.00%	25.00%
	Large	22	1.05	2.91	12.64	68.18%	77.27%	95.45%	90.91%	4.55%	15.86	27.60	100.00%	40.91%
2014-15	Marginal	178	1.12	4.39	12.05	37.08%	57.30%	99.44%	79.21%		16.85	20.76	85.83%	27.53%
	Small	109	1.36	3.53	10.88	48.62%	60.55%	95.41%	88.07%		15.51	18.77	87.18%	43.12%
	Large	34	1.06	3.34	14.13	61.76%	73.53%	97.06%	94.12%		15.50	21.95	96.43%	44.12%
2015-16	Marginal	156	1.22	4.68	12.12	28.21%	44.87%	98.08%	79.49%		15.32	28.09	75.64%	33.97%
	Small	98	1.56	3.42	11.69	44.90%	53.06%	95.92%	85.71%		14.25	26.54	84.69%	51.02%
	Large	31	1.33	3.69	14.50	38.71%	45.16%	96.77%	77.42%		13.92	38.64	93.55%	45.16%
Rabi														
2013-14	Marginal	17	0.95	2.76	4.05	58.82%	76.47%	100.00%	88.24%	11.76%	20.76	11.12	91.67%	17.65%
	Small	23	0.83	2.39	7.69	86.96%	78.26%	100.00%	100.00%		18.28	12.33	94.44%	47.83%
	Large	10	0.92	3.10	12.11	90.00%	90.00%	100.00%	100.00%	10.00%	17.45	10.44	90.00%	50.00%
2014-15	Marginal	35	0.89	2.94	8.71	71.43%	71.43%	100.00%	88.57%		19.70	12.78	93.55%	34.29%
	Small	40	0.93	2.78	10.53	70.00%	75.00%	100.00%	87.50%	7.50%	17.31	8.91	75.68%	45.00%
	Large	15	0.91	3.80	12.79	93.33%	93.33%	100.00%	93.33%	6.67%	17.13	8.77	85.71%	53.33%
2015-16	Marginal	37	1.05	2.78	10.19	86.49%	75.68%	100.00%	100.00%	8.11%	19.73	18.24	89.19%	45.95%
	Small	42	1.12	2.52	10.30	85.71%	78.57%	100.00%	97.62%	11.90%	17.83	14.79	85.71%	52.38%
	Large	14	1.12	3.71	13.51	92.86%	92.86%	100.00%	92.86%	7.14%	17.11	11.52	71.43%	57.14%

4.4. Factors influencing adoption of SRI over dis-adoption and non-adoption

To analyse the probability of participating in SRI method of rice cultivation by the households subject to different factors that influence the participation in a given activity, the probit regression technique was used with the help of statistical package 'gretl'. The results presented in Table 10 suggest that the model has correctly predicted 94.7% considering the independent variables. The Chi-square value with 14 independent variables is highly significant implying the robustness of the model. It indicates that farmers with higher experience in rice farming, the probability of SRI adoption becomes higher. Interestingly, farmers owning higher operational land primarily used for rice cultivation are less likely to adopt the SRI. It has been observed that probability of adoption of SRI is more in case of marginal farmers with typical tiny parcel of land where they have much more holds on field operations. Similarly farmers having large operational area are quite hesitant to adopt a technology which has got to adhere to strict and timely management practices.

The total income of the farming households has very little but positive impact on SRI adoption. Farmers with assured income sources, the probability of SRI adoption is higher. Also, when rice yield of non SRI farms are quite satisfactory, there is little incentive to go for SRI. The factors which had got positive significant impact on adoption of SRI were found to be the involvement of NGOs in providing information on SRI, training received on SRI, percentage net agricultural income to the total income and percentage area under medium land to total rice area. So, it is evident from the study that involvement of civil society actors in promoting SRI has influenced probabilities of adoption of SRI in Odisha. Similarly, imparting training to farmers on different SRI principles has desired impact on adoption of SRI. Medium land provides the most secure environment for SRI and thus large numbers of farmers are following SRI in medium lands.

Table 10: Factor affecting Adoption of SRI over non-adopter

	Coefficient	*Std. Error*	*z*	*p-value*
Constant	−0.1265	0.7311	−0.1730	0.8626
Education (Yrs.)	−0.0432	0.0346	−1.2479	0.2121
Experience in years of farming	0.0311	0.01334	2.3250	0.0201**
Membership with organization	0.3339	0.3104	1.0759	0.2820
Total operational area (acre)	−0.2279	0.1315	−1.7331	0.0831*
Total land under rice cultivation (acre)	0.2539	0.1902	1.3348	0.1820
Total income (Rs)	6.70263e-06	2.91885e-06	2.2963	0.0217**
Non SRI/Conventional farm grain yield (qt/acre)	−0.2201	0.03702	−5.9434	<0.0001***
NGO Support (Y=1, N=0)	2.2365	0.4352	5.1383	<0.0001***
Training received on SRI (Y=1, N=0)	1.0868	0.2993	3.6313	0.0003***
Have access to Canal irrigation (Y=1, N=0)	0.4725	0.3491	1.3535	0.1759
% of non-farm income to total income	−0.4281	0.5937	−0.7212	0.4708
% of net agriculture income to total income	2.1065	0.8521	2.4723	0.0134**
% of medium land to total land	1.3305	0.4419	3.0106	0.0026***
% irrigated area of GCA	0.0025	0.0046	0.5605	0.5751

Note: Dependent variable: SRI adopter and non-adopter, Standard errors based on Hessian, ***, ** and*indicates level of significance at at1, 5 and 10 percent respectively.

Mean dependent var	0.794118	S.D. dependent var	0.404887
McFadden R-squared	0.656328	Adjusted R-squared	0.577447
Log-likelihood	−65.35279	Akaike criterion	160.7056
Schwarz criterion	219.5694	Hannan-Quinn	184.0772

Number of cases 'correctly predicted' = 354 (94.7%)

f(beta'x) at mean of independent vars = 0.405

Likelihood ratio test: Chi-square(14) = 249.615 [0.0000]

Test for normality of residual -

Null hypothesis: error is normally distributed

Test statistic: Chi-square(2) = 3.67044 with p-value = 0.159579

4.5. Factors affecting drop outs in SRI

Though farmers are found to be adopting SRI, there is tendency to drop out in the later years. Many factors are responsible for this behaviour. Though in this study, only constraints have been quantified, focused group discussions with the farmers during field visit reveal some compelling features which are both deliberate as well as many a time uncontrollable. The qualitative information gained from field visits, interactions with the farmers, field functionaries, coordinators of partner organizations, reveals that there are broadly two types of dis-adoption:

1. Wilful dis-adoption: In which, the farmer wilfully decides not to adopt the practice in subsequent years.
2. Forced dis-adoption: In which, some uncontrolled external factors forced the farmer not to adopt SRI. Such type of dis-adoption can either be temporary (if the farmer dis-adopts for a particular season/year) or permanent.

4.5.1. Lack of proper awareness among the farmers

It is observed that in majority of the cases, rather than farmers' own initiatives, SRI has been forced upon by the implementing agencies and due to constrained of limited time and higher target compulsions, proper awareness and capacity building could not be made. Because of affinity and rapport of the extension personnel with the farmers at ground level, many a times though farmers initiate SRI, lack of whole hearted involvement resulted in area allocation to unfeasible land and also improper care and timely operations mostly related to planting and weeding upsets the desired yield. Because of time bound nature of operations, farmers' anxiety and worry to implement the various operations create a sense of insecurity which led to drop outs in subsequent seasons.

4.5.2. High expectations

While promoting SRI, positive aspects of the practice are briefed which creates high expectations among the farmers about incremental yield and income advantages without considering the field and environmental viability as well as practices to be followed. This often leads to loss in confidence when unexpected yield is realized and created a negative sense in following SRI.

4.5.3. Excessive emphasis on practices than principles

It is frequently found that farmers are compelled to follow strict management practices without considering the viability of the bio physical parameters. So it becomes wearisome for the farmers to follow SRI in subsequent seasons. Without considering the rationale behind the principles, farmers follow practices, which hinder achieving the desired results.

4.5.4. Prioritization of SRI principles

It is often found that excessive emphasis is given on transplanting young seedlings in recommended spacing and due diligence is not maintained in making farmers follow timely intercultural activity of mechanical weeding which has also higher bearing on successful SRI crops. Levelled and graded field is another important consideration for successful SRI practice. However, this key aspect is often neglected while selecting fields for SRI adoption which hampers proper water management leading to less than expected yield and thus created indifference towards further adoption.

4.5.5. Channelizing inputs and resources

Promoting SRI by provision of inputs dose create a hype in initial stage but sends wrong signal about subsidies and contributes seriously towards changing the mind-set of the farmers. So instead of concerning towards benefits of SRI, priority is fixed on input and cash incentives. So as soon as the inputs supply is blocked, withdrawal symptom is found to be too common.

4.5.6. Withdrawal of hand holding support

Very often, implementing agencies constrained by withdrawing from area of operation due to various reasons within a stipulated time and this creates a sense of deprivation among the farmers and there remains greater likelihood of drop outs among them though they might have experienced higher yield advantage but confidence still remains low. Marginal risk averse farmers are very often reluctant to take up a new technology in the absence of hand holding support, guidance and continuous backing.

4.6. Constraints faced by the farmers

The study has categorized 50 numbers of constraints under different dimensions such as technological, transplanting, intercultural operations, infrastructure support, general, technical, social, economic and others. Results revealed large number of variations in terms of constraint faced by the farmers in adoption of SRI across adopters, drop outs and non-adopters. Overall, adopters had fifteen major limitations(Table 11a) in maintaining ideal field condition and water level at field situation, scarcity of skilled labour and their reluctance to performing activities confirming to the SRI practices, hardship in mechanical weeding, non-availability of green manure, required FYM/organic manure, labourers reluctance as planting window is short and labourers want to maximize their objective function of higher wage per hour, hydrological problem constraining practice of alternate drying and wetting, non-availability of required bio fertilizer, weeding higher area with mechanical weeder, lack of support price to output, topographical as majority of the rice land are not levelled which results in uneven distribution of water and thus poor plant population and ultimately lower yield, problem to solve technological problems through extension personnel as well as implementing agencies and lack of assured source of irrigation.

Drop outs and non-adopters had different sets of constraints than that of adopters which can be seen by the ranks from tables 11b and 11c respectively.

Table 11a Estimates of Garrett score and ranking for constraint analysis by adopters

Constraints	Constraints Sub Group	Garrett Score	Rank
Technological support	No attempt to solve technological problems	25.33	13
Transplantation	Difficulty in maintaining ideal field condition	63.70	1
	Labourer's reluctance	36.44	7
Intercultural	Not possible to maintain water at field situation level	60.36	2
	No assured source of irrigation	23.94	15
	Difficulty in mechanical weeding	38.45	4
	Not possible to weed more area with weeder	29.69	10
Infrastructural support	Non availability of irrigation infrastructure	24.96	14
General	Economic scarcity of skilled labour	39.64	3
	Non availability of sufficient FYM/organic manure	36.91	6
	Non availability of Green manure	37.01	5
	Non availability of Bio-fertilizer	30.12	9
Economic	No support price in marketing	27.32	11
Others	Topographical	27.15	12
	Hydrological	36.23	8

Table 11b Estimates of Garrett score and ranking for constraint analysis by dropouts

Constraints	Constraints Sub Group	Garrett Score	Rank
Technological support	Inadequate training	29.73	14
	Insufficient guidance and experience	37.53	8
	No attempt to solve technological problems	34.23	11
Transplantation	Difficulty in maintaining ideal field condition	62.63	1
	Labourer's reluctance	40.07	5
Intercultural	Not possible to maintain water at field situation level	60.32	2
	No assured source of irrigation	37.77	7
	Difficulty in mechanical weeding	43.12	4
Infrastructural support	Non availability of irrigation infrastructure	30.08	13
General	Economic scarcity of skilled labour	39.64	6
	Non availability of sufficient FYM/organic manure	33.35	12
Technical	Complex technology for actual implementation	28.91	15
Economic	No support price in marketing	35.56	9
Others	Topographical	47.23	3
	Hydrological	35.54	10

Table 11c Estimates of Garrett score and ranking for constraint analysis by Non adopters

Constraints	Constraints Sub Group	Garrett Score	Rank
Technological support	Inadequate training	60.93	2
	Lack of exposure visit to develop confidence	34.63	15
	Insufficient guidance and experience	49.43	6
	No clarification and understanding of SRI principles	50.99	4
	No attempt to solve technological problems	40.53	10
Transplantation	No skill competency in nursery raising	46.58	7
	Difficulty in uprooting single seedlings from the mat/raised bed	35.67	13
	Difficulty in maintaining ideal field condition	41.03	9
	No skill in transplanting single seedling with proper spacing	50.08	5
	Difficulty in transplanting at shallow depth	38.09	12
Intercultural	Not possible to maintain water at field situation level	41.29	8
General	Non availability of sufficient FYM/organic manure	35.18	14
Technical	Complex technology for actual implementation	61.49	1
	Unsuitability of the technology	38.26	11
Social	Lack of confidence in taking new technique	52.42	3

4.7. Economics of rice cultivation in SRI and conventional method

There was difference in nursery management between conventional and SRI methods. Quantity of seeds used by the SRI practicing farmers was found to be 4.5 and 3.6 kgs/ac for *kharif* and *rab*i season respectively whereas, for conventional practice the seed rate was 28 and 26 kg/ac respectively. It was observed that overall cost advantage including seed cost in nursery management was found to be Rs 655 and Rs 743/- per acre for the respective seasons (Table 12).

Table 12: Per acre economics of nursery management in SRI and Conventional method during 2015-16

Particulars	Adopters				Drop outs		Non adopters	
	Non SRI		SRI		Non SRI		Non SRI	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Male labour (human hrs.)	4.2 (94)	5.5 (156)	3.8 (93)	5 (141)	4 (104)	4.7 (129)	4.6 (108)	5.7 (161)
Female labour (human hrs.)	0.6 (10)	-	0.5 (9)	-	0.7 (13)	-	0.8 (15)	-
Bullock pair (animal labour hrs.)	2 (58)	1.8 (47)	1.1 (41)	0.6 (22)	2.1 (67)	1.8 (93)	2.3 (61)	2.3 (104)
Machine labour (hours)	0.1 (18)	0.3 (57)	0.1 (20)	0.1 (35)	0.1 (36)	0.3 (103)	0 (17)	0.2 (76)
Seed (Kg)	27.6 (402)	25.9 (436)	4.5 (82)	3.6 (96)	28.2 (399)	29.1 (520)	27.6 (436)	31 (485)

Note: Figures in parentheses are expenditures in rupees of respective inputs.

Overall cost and return analysis indicates that, in spite of severe drought experienced during 2015-16, the average yield advantage under SRI practice was found to be 3.23 and 1.4 quintals per acre respectively during *kharif* and *rabi* (Table 13) against conventional for adopters. The return to cost ratio for adopters was found to be 1.59 and 2.06 for SRI plots against 1.23 and 1.76 for conventional plots during *kharif* and *rabi* season respectively.

Table 13: Per acre economics of rice cultivation across the groups.

Particulars	**Adopters**				**Drop outs**		**Non adopters**	
	Non SRI		**SRI**		**Non SRI**		**Non SRI**	
	Kharif	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***	***Kharif***	***Rabi***
Area(ac)	1.91	1.51	1.35	1.10	1.94	1.55	1.88	1.39
Grain yield (Qt/ac)	11.40	18.53	14.63	19.93	13.51	19.48	12.75	18.33
Total value of output (Rs.)	13580	22719	17854	23678	15397	23101	14617	22176
Total cost of cultivation(Rs.)	11069	12889	11212	11486	11677	13625	11211	13707
Net profit(Rs.)	2511	9830	6642	12192	3720	9476	3406	8469
Return to cost ratio	1.23	1.76	1.59	2.06	1.32	1.70	1.30	1.62

4.8. Resource conservation under SRI

It is widely perceived that SRI is an input saving technology. Tables 14a and 14b depict the quantum of reduction in the use of different resources both in terms of quantity and value terms for *kharif* and *rabi* seasons respectively.

Quantum of seed saved was more than 22 kgs during both the seasons. Use of FYM was found to be higher than that of conventional practice and it was obvious as SRI principles manoeuver on organic farming. There was significant decline in application of Urea by around 5 kgs during *kharif* season and that for *rabi* season it varied between 12.84 to 16.46 kgs respectively for all the farmers practicing conventional rice farming and SRI adopters who had also conventional rice plots. The decline in DAP/mixed and MOP fertilizers during *rabi* season varied from 13.73 and 10.47 kgs respectively in case of all non SRI farms to 14.7 and 11.35 kgs respectively for farms following both conventional as well as SRI practice.

Higher male labour hours during *kharif* and *rabi* had been used in SRI against that of conventional practice indicating female labour displacement under SRI against that of conventional practice. Cost advantages were also observed across seasons which were prominent during *rabi*. There was significant decline in plant protection chemicals during *rabi* season over conventional farming.

By and large, the study clearly shows that there was considerable decline in hazardous and environment polluting chemicals under SRI practice. Taking in to consideration that 2015-16 being severe drought year, practicing SRI farms could achieve higher yield establishes the fact that the SRI practice can be followed in rainfed drought prone area.

Table14a: Resource use efficiency in SRI over conventional practice during *kharif* season (2015-16)

Particulars	N			Mean			Mean difference	
	SRI (239)	Non-SRI (All=367)	Non-SRI (adopter only=157)	SRI	Non-SRI (All)	Non-SRI (adopter only)	SRI v/s Non-SRI (All)	SRI v/s Non-SRI (adopter)
Quantity								
Grain yield (qtls/ac)	239	367	157	14.63	12.46	11.40	2.17***	3.24***
Seed (kg /ac)	239	367	157	4.38	27.17	27.96	-22.79***	-23.58***
Manure (qtls/ac)	214	306	129	12.17	10.35	9.66	1.82**	2.51***
Fertilizer Urea (kg /ac)	181	309	123	32.20	37.11	37.34	-4.92**	-5.14**
Fertilizer DAP/ mixed in (kg /ac)	176	305	122	30.01	32.31	33.64	-2.3	-3.63*
Fertilizer MOP in (kg /ac)	131	214	88	20.17	20.82	23.27	-0.65	-3.1*
Other fertilizer in (kg /ac)	24	43	17	7.61	13.20	11.63	-5.59	-4.02
Bullock power in (hours/ac)	239	367	157	32.64	31.63	31.38	1.01	1.27
Machine power in (hours/ac)	239	367	157	4.97	4.67	4.69	0.3	0.28
Total human labour in (hours/ac)	239	367	157	256.22	266.00	270.09	-9.78	-13.87*
Male labour in (hours/ac)	239	367	157	153.36	125.47	128.88	27.89***	24.49***
Female labour in (hours/ac)	239	367	157	102.86	140.53	141.22	-37.67***	-38.36***
Value								
Seed(Rs/ac)	239	367	157	83.45	406.87	403.01	-323.41***	-319.55***
Manure(Rs/ac)	218	320	131	1277.23	949.48	997.78	327.75***	279.45**
Fertilizer Urea(Rs/ac)	181	309	123	259.24	289.33	297.96	-30.09**	-38.72**
Fertilizer DAP/ mixed(Rs/ac)	176	305	122	766.49	836.71	870.52	-70.22*	-104.03**
Fertilizer MOP(Rs/ac)	131	214	88	396.48	399.10	444.21	-2.63	-47.73
Other fertilizer(Rs/ac)	34	43	17	328.18	437.77	515.40	-109.59	-187.22
Total human labour(Rs/ac)	239	367	157	5791.70	5894.71	5837.10	-103.02	-45.4
Male labour(Rs/ac)	239	367	157	3866.92	3195.21	3174.32	671.71***	692.61***
Female labour(Rs/ac)	239	367	157	1924.77	2699.50	2662.78	-774.73***	-738.01***
Plant protection expenses(Rs/ac)	86	122	50	402.23	466.62	445.94	-64.4	-43.71
Total rupees saved in SRI over conventional practice (Rs/ac)							-478.61	-552.31

Note: ***, **, * indicates statistical significance at 1%, 5% and 10% level.

Table14b: Resource use efficiency in SRI over conventional practice during *rabi* season (2015-16)

Particulars	N			Mean			Mean difference	
	SRI (82)	Non-SRI (69)	Non-SRI (adopter only=36)	SRI	Non-SRI (All)	Non-SRI (adopter only)	SRI v/s Non-SRI (All)	SRI v/s Non-SRI (adopter)
Quantity								
Grain yield (qtls/ac)	82	69	36	19.93	18.68	18.53	1.24**	1.4**
Straw yield (qtls/ac)	82	69	36	24.67	23.33	23.23	1.35**	1.45**
Seed (kg /ac)	82	69	36	3.18	28.02	25.47	-24.84***	-22.29***
Manure (qtls/ac)	78	42	28	11.05	9.41	8.22	1.64	2.83*
Fertilizer Urea (kg /ac)	82	59	26	31.66	44.50	48.13	-12.84***	-16.46***
Fertilizer DAP/ mixed in (kg /ac)	82	58	26	31.23	44.96	45.93	-13.73***	-14.7***
Fertilizer MOP in (kg /ac)	81	52	25	19.99	30.45	31.33	-10.47***	-11.35**
Other fertilizer in (kg /ac)	19	32	16	5.07	4.84	4.90	0.23	0.17
Bullock power in (hours/ac)	82	69	36	20.05	24.19	30.75	-4.14	-10.7*
Machine power in (hours/ac)	82	69	36	2.76	2.93	3.14	-0.17	-0.38
Total human labour in (hours/ac)	82	69	36	205.22	189.76	208.18	15.46	-2.96
Male labour in (hours/ac)	82	69	36	108.84	85.39	96.66	23.45**	12.18
Female labour in (hours/ac)	82	69	36	96.38	104.37	111.51	-7.99	-15.14
Value								
Seed(Rs/ac)	82	69	36	89.88	467.63	442.22	-377.75***	-352.34***
Manure(Rs/ac)	79	57	30	913.97	598.86	678.94	315.11**	235.03*
Fertilizer Urea(Rs/ac)	82	59	26	249.45	334.67	364.66	-85.21***	-115.21***
Fertilizer DAP /mixed(Rs/ac)	82	58	26	810.70	1143.40	1167.15	-332.7***	-356.45***
Fertilizer MOP(Rs/ac)	81	52	25	392.37	598.87	626.80	-206.5***	-234.43***
Other fertilizers(Rs/ac)	19	33	16	367.41	407.63	352.60	-40.23	14.8
Total human labour(Rs/ac)	82	69	36	4981.23	4822.87	5408.28	158.37	-427.04
Male labour(Rs/ac)	82	69	36	3106.29	2529.05	2812.52	577.24**	293.77
Female labour(Rs/ac)	82	69	36	1874.95	2293.82	2595.76	-418.87	-720.81**
Plant protection expenses(Rs/ac)	59	45	22	515.73	1023.97	749.55	-508.24***	-233.81**
Total rupees saved in SRI over conventional practice (Rs/ac)							-918.79	-1896.5

Note: ***, **, * indicates statistical significance at 1%, 5% and 10% level.

4.9. Area expansion under SRI

Only 18% of the SRI practicing farmers had expressed their willingness on area expansion under SRI whereas, 76% had expressed their inability to increase the area as 34% of them had already covered their entire rice area under SRI and for 40%, the remaining area under rice was not feasible for SRI. Among the farmers who opted for increasing area, main reasons were increase in yield and cost effectiveness of SRI over conventional practice. About six percent had expressed that they would decrease the area under SRI because of uncertainty in the production front due to drought and production was not commensurate with conventional practice and few had expressed that the SRI practices were too cumbersome and also labourers unwillingness to follow the practices particularly for transplanting and weeding operations.

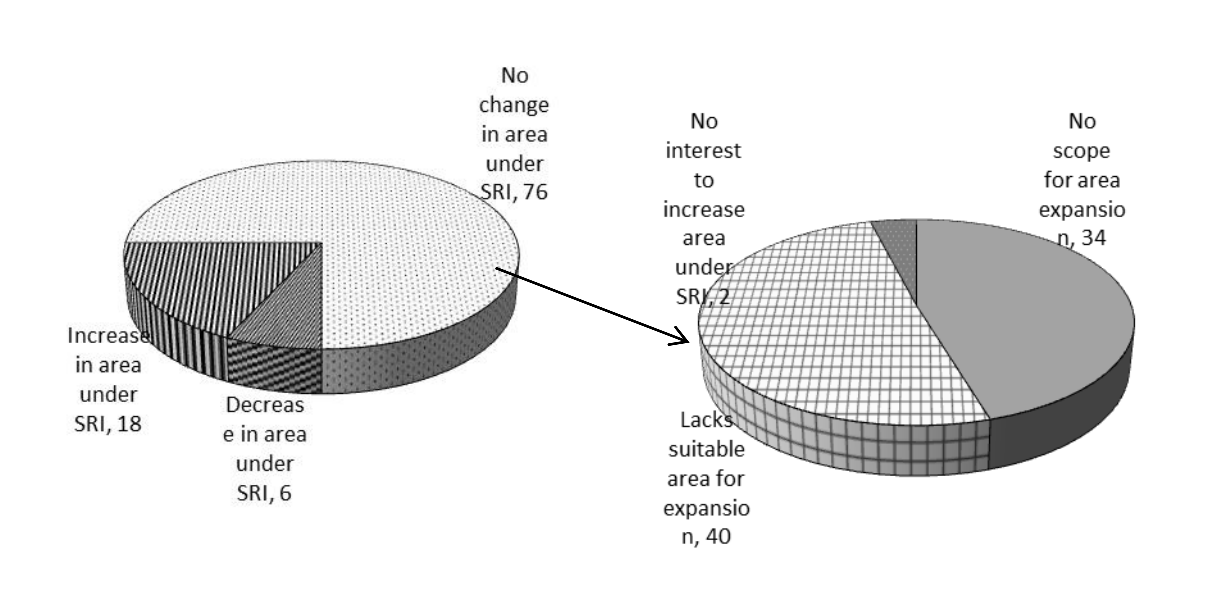

Figure 4 Perception of the practicing farmers about change in area under SRI

4.10. Perceived benefits of SRI over conventional practice

While analysing the positive impact of SRI over conventional practice, cent percent farmers had expressed high saving of seeds over conventional practice (Figure 5). Yield advantage and profitability over conventional practice had been observed by 86 and 88% respectively of the practicing farmers, while only around 52 to 53% had expressed that SRI was compatible to the system, technically feasible and resulted in sustained production. However, 74% maintained that SRI helped in improving the soil health and only 42% had opinion that SRI had increased water use efficiency.

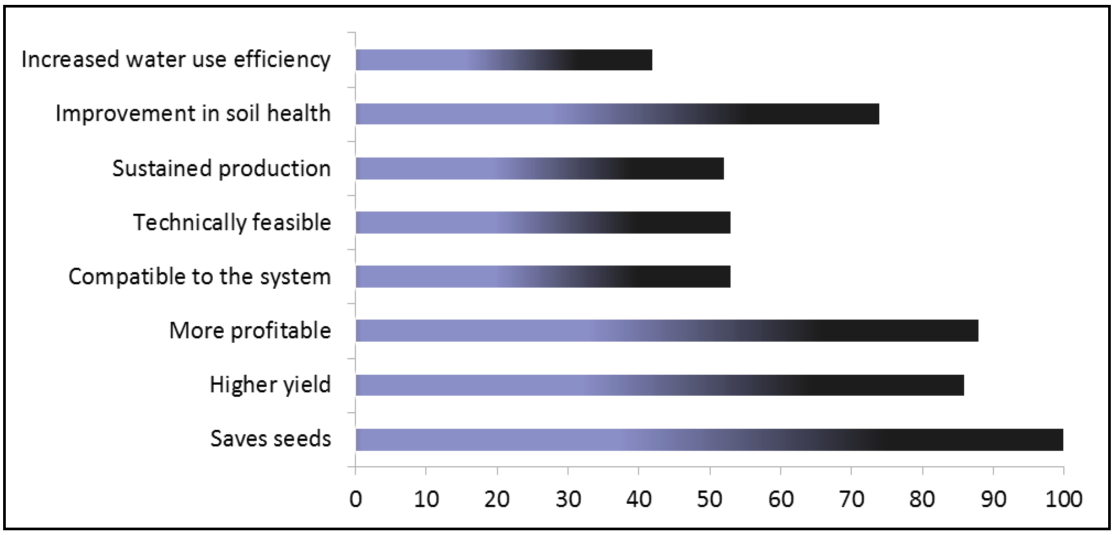

Figure 5 Advantages of SRI relative to Conventional practice

5. Conclusion

Odisha is handicapped with low irrigation infrastructure, frequently subjugated by adverse climatic fluctuations which have resulted in low and wide variability in yield across the years. Also, it has wide variations in rice ecosystem which prohibits farmers to adapt to a particular rice technology. So sustainability of rice production in varied agro system is an issue for the farmers over the years. To bring the productivity to a higher platform, SRI has been regarded as a technology which is proved to be resilient to the problems encountered by the farmers in the state.

Out of the total average rice area of 2.48 acres, irrigated area constituted only 35 percent indicating predominantly rainfed rice farming system across the study area. The rice ecosystem represents quite a risk prone environment particularly during drought years. Canal was found to be major source of irrigating indicating that water management in SRI plots would be very difficult to maintain because of flow irrigation.

Adoption pattern of SRI among practicing farmers indicated that agro ecological factors along with mental obstruction and predicament played significant role in deciding the seed rate and age of the seedling in majority of the farmers. Similarly mechanical weeding was found to be widely followed but timing and number of times were compromised. Irrespective of prevailed drought during 2015-16, SRI farmers experienced an incremental yield gain during the year while, farmers compliance towards following different components of SRI improved over the time.

Though SRI had been advocated since a decade in the state, its adoption had been sluggish and patchy. Major hurdles for practicing farmers were maintaining required water at field situation followed by difficulty in mechanical weeding, lack of assured source of irrigation, covering higher area under mechanical weeder as well as erratic rainfall. Practicing farmers were hugely constrained by lack of availability of skilled labour for practicing various methods of SRI particularly transplanting and weeding, non-availability of sufficient FYM, green manure and bio-fertilizers.

The benefits out of SRI outweighed that of conventional practice both in terms of yield and profits during *kharif* season while considering the severe drought faced by the state during 2015-16. However, more than 75% had expressed their inability for area expansion because of compelling factors.

The study indicates that more than 70% of farmers had positive outlook for SRI in terms of yield, profitability and improved soil status, however, compatibility of the SRI to the existing farming system, technical feasibility, sustained production and increased water use efficiency were reported by only around 42 to 53 percent.

6. Major policy options

The study clearly specified that SRI had positive impact on both rice yield and income even during adverse weather condition. However, there had been wide disparity among the level and intensity of adoption. The different components of SRI had different acceptance level across the state. Thus, redesigning location specific technology pertaining to different SRI components is necessary.

Resource farmers should be identified at the community level and developed who would promote demonstration and dissemination of SRI. Suitable farm level modification of different SRI components should be encouraged in performing different operations as well as improve the rice productivity.

Mechanization should be taken up in large scale particularly related to power weeder, as manual mechanical weeding is strenuous and suitable incentives should be provided for promoting use of power weeder.

Necessary arrangements should be made to provide adequate training to the young labour especially to the young women as they were found to be displaced and disadvantaged due to highly skilled nature of the operations. Labour bank may be created at community level.

Location specific trials should be carried out to find out the factors responsible for yield variability and suggested majors should be followed to overcome the issue.

Efforts should be given to tap irrigation potential under the existing framework like suitability of diversion based irrigation, water harvesting structure etc. A radical institutional set up of extension services need to be reframed to bring back the SRI drop outs for SRI area expansion.

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