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RESEARCH PAPER

Adoption Dynamics of the System of Rice Intensification (SRI) Among Farmers in Odisha

Soumya Ranjan Behera[1*], Souvik Ghosh[2], Esakkimuthu M.[3], Sabyasachi Patnaik[4] and Pankaj Kumar[5]

[1]Ph.D. Scholar, Department of Agricultural Extension Education, College of Agriculture Vellayani, Kerala Agricultural University, Thiruvananthapuram, India
[2]Professor, Department of Agricultural Extension, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati (A Central University), Sriniketan, West Bengal, India
[3]Assistant Professor, Department of Agricultural Extension Education, College of Agriculture Vellayani, Kerala Agricultural University, Thiruvananthapuram, India
[4]Ph.D. Scholar, Department of Agriculture Extension Education, MSSSOA, Centurian University of Technology and Management, Paralakhemudi, Odisha, India
[5]Ph.D. Scholar, School of Social Science, College of Post Graduate studies in Agricultural Sciences, CAU (Imphal), Umiam, Meghalaya, India

Corresponding author: soumyaranjan2296@gmail.com (**ORCID ID:** 0009-0007-4737-8632)

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ABSTRACT

This study examines the adoption of System of Rice Intensification (SRI) practices among smallholder rice farmers in Odisha's Ganjam district, where rice is a predominant crop. SRI, a resource-efficient cultivation method, has demonstrated increased yields with lower input costs, making it particularly suitable for resource-poor farmers. Despite SRI's benefits, its adoption remains limited due to socio-economic challenges, particularly for small and marginal farmers. The study utilized an ex-post facto research design, involving a sample of 80 farmers across four villages in Digapahandi and Sanakhemundi blocks. Data were collected through personal interviews and analysed using statistical tools like correlation and multiple regression. Results reveal that SRI adoption is highest in land preparation and irrigation practices, yet lower in areas like weed management and the use of traditional bio-fertilizers, largely due to labour and resource constraints. Regression analysis indicates that factors such as annual income, total irrigated land, and social participation significantly influence SRI adoption, while farming experience negatively correlates with adoption, suggesting reluctance among experienced farmers to adopt new practices. The findings highlight a need for targeted extension services and resource support to encourage broader SRI adoption. Enhancing access to resources and improving knowledge dissemination are crucial for advancing sustainable rice cultivation in the region, ultimately benefiting smallholder farmers and improving regional food security.

HIGHLIGHTS

- Odisha, a leading rice producer explores SRI in Ganjam district to boost yields.
- Socio-economic factors-income, experience, irrigation, and social participation significantly influence adoption.

Keywords: System of Rice Intensification, Smallholder Farmers, Adoption Constraints, Socio-economic Factors, Sustainable Rice Cultivation

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India is one of the leading rice production-hub in the world, accounting for the largest area under rice cultivation globally and ranking second in rice production next to China. The recent trend revealed that, as per 2022 data, 60% of the total rice production area under irrigated system and contributing to approximately 80% of the Indian national rice production systems (Ministry of Agriculture and Farmers' Welfare, 2022). Indian agriculture continues to be dominated by small and marginal farmers, with over 85% of the farming population owning less than 2 hectares of land. These farmers face constraints related to resource availability, affecting their ability to adopt advanced agricultural technologies and improve productivity (Agricultural Statistics at a Glance, 2022). Moreover, farmers often face constraints such as inadequate access to quality inputs, limited exposure to advanced scientific technologies and lack of institutional support, leads to sub-optimal yields (Birthal *et al.* 2021; Sethi & Panigrahi, 2024), But, addressing these research gaps, particularly for resource-poor farmers, is essential for ensuring food security and sustainable agricultural growth.

Currently, in the state of Odisha is a key rice-producing state in Eastern India, cultivates rice on approximately 4.39 million hectares, with an annual production of 9.52 million tonnes and a productivity of 2.17 tonnes per hectare as of 2022 (Pattnaik *et al.* 2022). Besides, rice is being the principal food grain of the state, productivity remains sub-optimal compared to national and international standards. Therefore, total adoption of improved agricultural practices such as the System of Rice Intensification (SRI) offers a potential solution to enhances the grain productivity while optimizing resource uses in the production system (Pradhan *et al.* 2022).

The System of Rice Intensification (SRI) has emerged as a resource-centric and conserving, eco-efficient method offering potential yield increase of 20–30%, while reducing input cost upto 40% (Ravindra *et al.* 2021; Adhikari *et al.* 2023). The SRI practices such as transplanting young seedlings, maintaining wider spacing, using organic inputs, and practicing alternate wetting and drying of fields (Pathak *et al.* 2022). These special features make it particularly attractive to smallholders with limited resources. However, despite its potential, the adoption of SRI remains limited, particularly among resource-poor farmers.

The rate of adoption of SRI in Odisha remains inconsistent and limited despite the fact, multiple promotion efforts, especially in regions like Ganjam district (Singh *et al.* 2022). There are several research studies highlights, socio-economic challenges, labour constraints, limited awareness, and cultural preferences for conventional methods are key deterrents to adoption (Kumar *et al.* 2023; Sethi & Panigrahi, 2024). Moreover, unpredictable rainfall and inadequate irrigation infrastructure further exacerbate these challenges (Adhikari *et al.* 2023). Recent studies have shown that despite the proven advantages of the System of Rice Intensification (SRI) in improving productivity and input-use efficiency, many farmers continue to revert to conventional cultivation practices due to fears of potential crop failure (Pradhan & Mishra, 2022). In Odisha, particularly in the Ganjam district, the State Department of Agriculture has intensified its efforts to promote SRI through awareness drives, capacity-building workshops, and incentive-based schemes. However, farmer adoption remains uneven. While economic benefits of SRI are acknowledged, adoption is hindered by socio-cultural resistance, limited resource accessibility and gaps in extension outreach (Das & Sahu, 2023). Furthermore, environmental uncertainties such as erratic monsoonal behaviour and poor irrigation infrastructure add to the complexity of implementing SRI practices effectively in the region (Pattnaik *et al.* 2021).

The previously proven record of research studies has established the agronomic and economic advantages of SRI and remains limited evidence on the specific factors influences its rate of adoption among resource-poor farmers in Odisha, particularly at district level. This study addresses the gap by assess total extent of adoption of SRI practices among farmers in Ganjam district. The research objective is to identify the key socio-economic, institutional and environmental factors affecting SRI adoption and to recommend strategies to enhance technology diffusion among smallholders. The findings are expected to contribute to more effective extension interventions and policy support for sustainable rice intensification in north-eastern part of India.

MATERIALS AND METHODS

The present study conducted purposively in Ganjam district of Odisha, since it's one of the major rice-producing districts in the state of Odisha with a substantial number of farmers practices the System of Rice Intensification (SRI). This made it a suitable area to generate relevant data on SRI cultivation practices and adoption behaviour with respect to scientific interventions. Totally, two blocks from the Ganjam district viz., Digapahandi and Sanakhemundi, were selected using simple random sampling without replacement technique. Further, within each block, two village were randomly selected *viz*., *Bhismagiri* and *Phasibanda* from Digapahandi, and *Pudamari* and *Pattapur* from Sanakhemundi, constitutes in a total of four study villages. From each selected village, a complete list of farm households who's regularly practicing SRI was prepared with the help of local agriculture extension officials and community informants, adopting probability proportional to size (PPS) sampling for 80 SRI farmers were randomly selected across the four villages. The final sample size was distributed proportionally across the villages based on the total number of adopting SRI farmers per village, as outlined below in the sampling framework as follows.

Block	Village	No. of SRI Practicing Farmers	Sampled Farmers (PPS)
Digapahandi	Bhismagiri	65	20
	Phasibanda	50	15
Sanakhemundi	Pudamari	70	25
	Pattapur	40	20
Total	4 Villages	225	80

The sample size of 80 respondents though modestly determined based on operational feasibility, budget constraints and focused nature of the study. This sample size is acceptable for analytical studies using multivariate methods in social science research, particularly when supported by proportionate sampling and exploratory objectives. However, it is acknowledged the research findings may not be statistically generalize to the entire district but rather serve as indicative approach of the selected regions. An ex-post facto research design employed, as independent variables under investigation (e.g., socio-economic characteristics, previous season adoption decisions) had already occurred and could not be manipulated by the researcher. To assess the rate of adoption, a five-point continuum scale was used to record the farmers' responses regarding each SRI intervention, ranges from *Very highly effective (5)* to *Very low effective (1)*. The data were collected through a pre-tested structured interview schedule developed specifically for this study and administered through personal interview with all 80 selected rice farmers.

The most appropriate statistical tools used for data analysis includes frequency and percentage analysis, mean, standard deviation, range, coefficient of variation, Pearson's correlation coefficient, and multiple linear regression. These tools identify the key attributes and influencing rate of adoption levels of SRI growers, both the enter and backward elimination methods of multiple regression were applied in this research study. Therefore, prior to performing the regression analysis, key assumptions were tested to ensure the appropriateness of the statistical model. The normality of residuals was assessed using the Shapiro-Wilk test and visually examined through Q-Q plots, which confirmed the distribution of residuals did not significantly deviate from normality score. The Homoscedasticity, the constant variance of residuals across levels of predicted values, was verified using residual versus fitted value in the plots, which did not indicate any systematic pattern. Hence, multicollinearity among independent variables was examined using the Variance Inflation Factor (VIF), with all variables showing VIF values well below the threshold of 5, indicating an acceptable level of multicollinearity values. This multicollinearity presides over the Linearity between the predictors and dependent variable confirmed through scatterplots and residual diagnostics. These assumption checks the validated range of reliability and robustness of the regression analysis applied in this research study.

RESULTS AND DISCUSSION

Adoption Level of SRI Practices

Adoption referred to as an "individual matter or phenomenon or behavioural, socio-economical phenomenon or mental process". Adoption behaviour of farmers was measured with the help of interview schedule with respect to different practices under nine aspects of SRI. Extent of adoption of the farmers was measured based on three-point continuum scale and score assigned *viz.,* Full Adoption- 2, Partial Adoption- 1, Non- Adoption- 0, respectively. The collected data were analysed, and results are presented in following Table 1.

Table 1: Distribution of respondents based on their overall Adoption level regarding different practices of SRI

Sl. No.	SRI Practices	Mean score (SD) Adoption
1	**Selection of land**	
	Medium upland/ medium lowland/ lowlands, where water doesn't stand, are suitable	2.00 (0.00)
	Irrigation facility is needed for medium uplands	1.98 (0.16)
Overall (%)		**100 (0.00)**
2	**Land preparation**	
	4-5 ploughing is required for preparing land	1.91 (0.28)
	6-inch depth of ploughing is to be ensured in the last ploughing	1.90 (0.30)
	Preparing well levelled fields with good drainage	1.85 (0.36)
	Require Good puddling and levelling	1.88 (0.33)
	Making channels after 2 m distance	1.84 (0.37)
	Marking at 25×25 cm Distance	1.64 (0.48)
	Not keeping standing water during transplanting	1.68 (0.47)
Overall (%)		**90.62 (12.53)**
3	**Selection of seed**	
	Improved variety of seed	1.81 (0.39)
	Medium lowlands and lowlands require varieties of 150 days duration	1.18 (0.82)
	Medium uplands require varieties of 120 days duration	1.29 (0.62)
Overall (%)		**71.25 (24.3)**
4	**Preparation of nursery bed**	
	Selecting 40 sq m area for one acre crop	1.71 (0.46)
	Bed size 1×10 meter	1.56 (0.52)
	Preparing raised bed of 8-10 cm height	1.61 (0.49)
	Putting well mixed soil and FYM of equal amount on the bed	1.61 (0.49)
	Provide drainage channels on all sides	1.64 (0.51)
Overall (%)		**81.38 (19.14)**
5	**Raising nursery**	
	Using 2 kg seeds per acre	1.78 (0.42)
	Selecting good quality seed with salt solution	1.61 (0.56)
	Sowing only sprouting seeds	1.74 (0.47)
	Broadcasting the sprouted seeds on the seed bed	1.69 (0.52)
	Covering seeds with well decomposed FYM	1.65 (0.55)
Overall (%)		**84.63 (18.96)**
6	**Transplanting**	
	Transplanting 8-12 days old seedlings	1.31 (0.52)
	Putting seedlings with a thin metal sheet of 30×30 cm	1.35 (0.55)
	Transplanting one seedling per hill	1.55 (0.53)
	Transplanting immediately after uprooting from nursery	1.63 (0.54)
	Not removing seeds from the plant while transplanting	1.61 (0.54)
	Not washing the seedlings after uprooting	1.53 (0.59)
Overall (%)		**74.79 (20.67)**
7	**Fertilizer management**	
	Applying 4-5 tonnes FYM/compost per acre	1.56 (0.57)
	Applying before ploughing and incorporating	1.61 (0.54)
	Applying green manuring/brown manuring, vermi-compost	1.51 (0.64)
	Applying 60:30:20 kg NPK	1.61 (0.58)
	Applying nitrogen in three doses	1.63 (0.51)
	Applying potash in two doses	1.63 (0.51)
	Applying panchagavya	0.55 (0.86)
Overall (%)		**72.14 (22.43)**
8	**Water management**	
	Maintaining water at soil saturation	1.66 (0.48)
	Provide drainage channel to avoid submergence	1.61 (0.56)
	Alternate drying and wetting	1.64 (0.51)
	Light irrigation during hairline cracks	1.46 (0.62)
	Keeping 2-3 cm standing water during flowering to maturity	1.45 (0.61)
	Draining water 20 days after flowering	1.46 (0.57)
Overall (%)		**77.4 (20.8)**
9	**Weed management**	
	Irrigating field before one day of weeding	1.38 (0.60)
	Using cono/mandwa weeder for weeding	0.58 (0.85)
	Incorporating weeds into the soil	1.35 (0.48)
	Four weeding at 10 days interval	1.39 (0.56)
	Uprooting weeds manually near to the plants	1.35 (0.53)
Overall (%)		60.37 (24.62)
Overall, SRI practices (%)		78.19 (14.22)

Parenthesis indicates per cent

The study findings reported that, overall farmers in the study area showed a high average level of adoption (78.19%) of SRI practices, though rate of adoption varies substantially across components (Table 1). The land selection universally adopted (100%), reflects widespread understands of site suitability and irrigation needs for SRI. Besides, land preparation (90.62%) also showcased high uptake, particularly in ploughing and field levelling, though practices like marking at 25x25 cm (mean: 1.64) and avoiding standing water during transplanting (mean: 1.68) were less rigorously followed, indicates potential gaps in technical know-how and labour availability. In general, seed selection and nursery preparation had moderate adoption (71.25% and 81.38%, respectively). Notably, selection of duration-specific varieties suitable for specific land types shows low adoption (mean: 1.18 for 150-day varieties and 1.29 for 120-day varieties), pointing to possible constraints in varietal availability or knowledge gaps among farmers.

In the early stage, raising nursery (84.63%) well adopted, with strong adherence to low seed rates and seed selection through salt solution treatment. While transplanting, a critical component in SRI, had moderate level of adoption (74.79%). While most farmers transplanted one seedling per hill and avoided washing seedlings, adoption of the use of a metal sheet (30x30 cm) for accurate spacing was low (mean: 1.35), due to lack of access to or awareness of such tools. The recommended fertilizer management showed moderate level of adoption (72.14%). Also, traditional practices such as application of *Panchagavya* had very low rate of adoption (mean: 0.55), suggests barriers in availability or trust in indigenous formulations. The water management practices (77.4%) were generally well adopted, but strategic water control techniques like alternate drying and wetting (mean: 1.64) and draining after flowering (mean: 1.46) need more emphasis in training programme. Weed management had the lowest adoption rate (60.37%) among all practices. Adoption of Cono-weeders (mean: 0.58) and manual up-rooting of weeds (mean: 1.35) were particularly low, suggesting constraints in labour availability, equipment access and time investment.

These research findings point towards a relatively strong awareness and adoption of foundational SRI practices, while technically complex or labour-intensive practices, particularly weed and water management lag.

Table 2: Correlation between the Socio-economic attributes of farmers and their Adoption on SRI practices

Sl. No.	Farmers Attributes	Correlation coefficient (r)
		Adoption
1	Age (year)	-0.119
2	Years of education	.298**
3	Size of family	-0.041
4	Earning members	-0.025
5	Land holding (ha)	.383**
6	Annual income	.438**
7	Economic status	.308**
8	Farming experience (years)	-0.156
9	Domestic asset	.323**
10	Livestock	0.146
11	Farm implement & machinery	.286*
12	Total irrigated land	.390**
13	Personal localite information sources use	.323**
14	Personal cosmopolite information sources use	.290**
15	Mass media exposure	.374**
16	Social participation	.388**

***Significant at the 0.01 level; *Significant at the 0.05 level.*

The Pearson correlation analysis (Table 2) revealed several statistically significant positive relationships between SRI adoption and socio-economic variables. The notable finding is landholding (r = 0.383), annual income (r = 0.438), and total irrigated land (r = 0.390) had strong positive correlations, emphasised over, better-resourceful farmers are more likely to adopt SRI practices. Also, mass media exposure (r = 0.374) and social participation (r = 0.388) were also significant, underscoring the role of information and community engagement in influencing technology upgradation leads to higher rate of adoption. The selected variables like age (r = -0.119) and farming experience (r = -0.156) showed negative correlations, indicates that younger and less traditionally experienced farmers are more open to innovation, a pattern consistent with literature on technology adoption.

Table 3: Multiple regression (enter method) between the attributes of farmers and their adoption level of SRI practices

Sl. No.	Farmers Attributes	Std. Error	Beta	*t*	Sig.
Constant (30.226)		16.293		1.855	.068
1	Age(year)	.320	.162	.583	.562
2	Years of education	.421	.000	.002	.998
3	Size of family	.742	.113	.881	.382
4	Earning members	2.806	-.190	-1.486	.143
5	Land holding (ha)	2.951	-.086	-.259	.797
6	Annual income	.000	.160	1.033	.306
7	Economic status	5.805	.032	.275	.784
8	Farming experience (years)	.336	-.326	-1.161	.250
9	Domestic asset	1.065	.074	.549	.585
10	Livestock	.831	.026	.227	.821
11	Farm implement & Machinery	1.150	-.059	-.399	.692
12	Total irrigated land	1.212	.355	1.130	.263
13	Personal localite information sources use	.135	.123	1.008	.317
14	Personal cosmopolite information sources use	.128	.147	1.219	.228
15	Mass media exposure	.135	.075	.523	.603
16	Social participation	.218	.256	2.248	.028
R = 0.667, R square = 0.455, F = 3.008**					

Table 4: Multiple regression (backward method) between the attributes of farmers and their adoption level of SRI practices

Sl. No.	Framers Attributes	Std. Error	Beta	*t*	Sig.
Constant (48.80)		8.343		5.850	.000
1	Annual income	.000	.241	2.166	.034
2	Farming experience (years)	.112	-.216	-2.310	.024
3	Total irrigated land	.388	.245	2.429	.018
4	Personal cosmopolite information sources use	.103	.175	1.804	.076
5	Social participation	.185	.276	2.864	.005
R = 0.633, R square = 0.400, F value = 9.481					

The multiple regression analysis using the Regression Enter method (Table 3) revealed that all 16 socio-economic variables collectively explained 45.50% of the variance in SRI adoption ($R^2 = 0.455$, $F = 3.008$, $p < 0.01$). Among these, only social participation ($\beta = 0.256$, $p < 0.05$) emerged as a significant individual predictor, highlights the role of farmer-to-farmer learns and collective action in driving adoption. A more parsimonious model using Backward Elimination method (Table 4) identified five significant predictors, Annual income ($\beta = 0.241$, $p < 0.05$) and total irrigated land ($\beta = 0.245$, $p < 0.05$) were positively associated with adoption, reaffirming that financial and infrastructural resources are key enablers. The social participation ($\beta = 0.276$, $p < 0.01$) and cosmopolite information sources ($\beta = 0.175$, $p = 0.076$) further emphasize the importance of social capital and access to external information channels. The farming experience ($\beta = -0.216$, $p < 0.05$) was negatively associated with adoption, which reflect the resistance of older, experienced farmers to alter entrenched practices. This model explained 40% of the variance in adoption ($R^2 = 0.400$, $F = 9.481$), and the effect sizes (Beta values) suggest that social participation and irrigation access had the largest practical influence among predictors.

Critical Insights and Implications

While the results shows that overall, SRI adoption is promising, low adoption of weed and organic fertilizer management practices remains a significant bottleneck. Labor constraints, lack of weeding tools, and limited trust in indigenous bio-inputs may explain these trends. Similar findings have been reported by Das and Sahoo (2022), who noted that despite high awareness, adoption of labour-intensive SRI components remained constrained due to lack of input access and support services. Also, study that supports these findings is by Mishra and Behera (2021), who observed that although SRI adoption had a positive impact on yield and water use efficiency in Odisha, the adoption of components such as mechanical weeding and organic inputs remained low. The authors attributed this to inadequate training, limited availability of appropriate tools, and farmers' preference for conventional practices due to perceived risk and labour intensity. The study underscores the critical role of social structures, including peer networks, exposure to media, and active group participation, in facilitating adoption. Targeted interventions such as community-level demonstrations, farmer field schools, and access to shared implements like weeders can address these gaps.

Furthermore, the finding that younger and less experienced farmers adopt more readily suggests that extension strategies should be tailored-made by age and experience cohorts. The segmenting farmers by landholding size, education, media use could uncover deeper behavioural trends and adoption barriers, a limitation of this study that future research should address.

CONCLUSION

The rice cultivation occupies approximately 69% of the cultivated area and is a major crop, covering 63% of the total area under food grains, with a rich diversity of rice varieties in the state. This SRI method has gained significant attention for its innovative approach to rice cultivation. The adoption levels of SRI practices among farmers reveal that socio-economic attributes such as education, landholding, and information source usage are positively associated with adoption. However, multiple regression analysis indicates that factors such as annual income, farming experience, irrigated land, use of cosmopolite information, and social participation are key determinants of adoption. The younger farmers tend to exhibit lower adoption rates. To address this, targeted technological guidance and support from extension services are essential to enhance adoption of SRI practices. This particular study provides a foundation for future research and major food policy formulation efforts aimed at improving paddy cultivation through SRI in Ganjam district in particular.

Limitations and Future Studies: This study's sample size was limited to 80 farmers, which may not fully represent the diverse practices across Ganjam District of Odisha. Further research with larger samples and longitudinal studies could explore interventions to overcome socio-economic barriers and examine long-term SRI impacts on yield and resource efficiency.

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