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Economic Impact of Adoption of System of Rice Intensification

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ABSTRACT

A socio-economic study was carried out in Nayagarh district of Odisha during 2016-17 to study the impact of System of Rice Intensification (SRI) on quality of life (QOL) of farmers by adopting SRI methodology under multiple constraints using less inputs and maximizing yield resulting in increase in farm based income. The partial budgeting shows that there is a net increase in profit of Rs14790/acre in SRI. Creation of assets and infrastructure, ensuring household level food and nutritional security, increasing health, education and community development and reducing migration, change in agriculture related behavior and knowledge, convergence, risk bearing ability and social networks and inclusion by adopting SRI. There is a 47.05% increase in yield by adopting SRI (SRI: 5.5 t/ha, Non-SRI: 3.74 t/ha) resulting in enhancement of household level gross income (from various sources) by Rs 12061.80/- for SRI farmers compared to non-adopting household. This enhanced income is used towards human capital formation indicating that such farmers experience a forward looking approach, promote entrepreneurial capabilities become less risk averse towards adoption of newer technologies, they are more likely to participate in welfare related programs and in general have higher capacities to project themselves out of vulnerability zone. SRI adopting farmers spend 73.93%, 90% more than non-adopting farmers on education and access private healthcare facilities respectively. SRI households have more access to formal borrowings and have developed greater risk taking abilities than non-SRI households, also they are likely to repay their loans, without having any difference in saving and investment behavior.

Keywords Exploratory study, Human poverty index, Life expectancy, Quality of life (QOL), Vulnerability zone.

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INTRODUCTION

Odisha is one of the fastest growing economy in India with agriculture sector being the largest private enterprise of the state that employs 61.8% of the working population (Census 2011) and contributes 18.9% of Odisha's Gross State Value Added (GSVA) in 2018-19

(https://www.news18.com dt. 28-06-2019). Rice is an important staple food crop in Odisha compensating about 31% of total calorie intake. The higher yields achieved through high use of water and fertilizers during green revolution have started to fade away and environmental problem (like salinization) increased because of over use of synthetic fertilizers and water logging of field have started to occur. As rice cultivation in Odisha is monsoon dependent, it suffers from intermittent soil moisture stress due to erratic rainfall and poor soil quality, flash floods and water logging/ submergence due to poor drainage and low-lying physiography. About 78% of Indian farmers are resource-poor belonging to small and marginal category restricting them for use of optimum quantity of inputs and adopting new technologies which are essential for increasing the crop-productivity. At this juncture, SRI is the best alternative for increasing crop productivity and lowering use of inputs. SRI also provides environmental and economic benefits to the farmers (Varma 2017). Sinha and Talati (2006) showed that adoption of SRI techniques improves the rice yields, as well as increase returns and save labor, it also boost rice productivity per unit of seed, fertilizers and manday. A study of 109 farmers in Madagascar found that average output on SRI plots were 89% higher than on their plots cultivated using conventional method (Uphoff 1999). Many programs launched in Odisha to address the issue of food security at the household level for small and marginal farmers in world along with a number of on-station and on-farm trails promoted by NABARD, Govt. line Departments, different NGOs, different Research institutes, SAUs, CAUs. The objective of the study is to identify a set of indicators that represent the changes in QOL- the direct (on crop yields, income, and crop diversification) and indirect (such as gross household level income, health decisions, schooling of children, food and non-food consumption, nutrition, asset creation) effect of SRI households through partial budgeting and exploratory study. There are different sets of indicators when one accounts for quality of life at the national and international levels. The study first outlines the descriptive indicators related to program outcomes, economic agents, followed by estimation of the impact by using matching methods, especially the propensity score matching (PSM).

Fig. 1. Study area.

Study area

The study area was 5 blocks in Nayagarh district of Odisha (India) with 19° 54' to 20° 32' N latitude and 84° 29' to 85° 27' E longitude and based at an altitude of 90m above mean sea level (Fig.1). It comes under East and South Eastern Coastal Plains (OR-4) and East Coast Plain agro-ecological zone. It has Mixed Red and Black soil. The area is experiencing a hot, moist and sub humid climate with average annual rainfall of 1354.3 mm.

MATERIALS AND METHODS

Data relating to socio-economic status was collected from 60 (34 SRI adopters, 21 drop outs and 5 non-adopters) farmers in Nayagarh district of Odisha during 2016-17 through focused group discussion and semi-structured interviews.

Partial budget was calculated per acre by tabular method from the per acre expenditure pattern. The exploration indicators are based on engagement with beneficiaries in which the participants were exposed to most significant changes that they see in their lives in general and through SRI, in particular. These changes were explored using the CMO (context-mechanisms-outcomes) approach (Linsley *et al*. 2015) exploring dynamic relationship between the context (of the program, organizational settings, program inputs), Mechanism (enabling processes, institutional, formal, informal and social setups to bring about intended change) and Outcome (intended

and unintended consequences). The CMO approach is useful in those contexts where many policy/social interventions intersect with the intervention under study and result in several unintended effects that cannot easily be attributed to a particular intervention. It enabled hypothesizing before undertaking an evaluation and collection of data for the testing. Therefore, this approach as being used here to contextualize impact of SRI on various aspects of QOL (Westhorp *et al.* 2014), which enabled to reject a list of possible indicators that have been tested in second part of this study for determining the impact of SRI on QOL.

SRI participation model and propensity scores

The first step is to estimate the propensity scores (that is, probability for participation and non-participation): Prob [SRI=1|x] where x is a vector of factors that have identified to influence program participation as well as program outcomes. Probit regression was used for specifying the selection model. The representative model has been presented below:

$$F(Y) = \Phi^{-1}(Y) = \beta_0 + \beta_1 age\_head_i + \beta_2 age\_square_i + \beta_3 primary\_education_i + \beta_4 gender\_head_i + \beta_5 education\_head_i + \beta_6 house\_type_i + \beta_7 agri\_land_i + \beta_8 distance\_bank_i + \beta_9 vill\_population_i + \beta_{10} distance\_HQ_i + \beta_{11} distance\_agrimkt_i + u_i$$

The selection model attempts to identify some key factors influencing the adoption of SRI by farmers. The potential determinants have been identified at the farmer and village level. All results are tested for significance using Fischer's t-test between SRI (x) and conventional method (y) by using the formula:

$$t = \frac{\bar{x} - \bar{y}}{\frac{s_1}{n_1} + \frac{s_2}{n_2}} \text{ at } (n_1+n_2-2) \text{ d.f.}$$

Where, s_1= standard deviation of SRI, s_2= standard deviation of conventional method.

$$s = \text{combined SD of 2 samples} = \frac{\sum(x_i-\bar{x})^2 + \sum(y_i-\bar{y})^2}{n_1+n_2-2}$$

RESULTS AND DISCUSSION

Partial budgeting in paddy farms

The analysis of additional costs and returns incurred in the paddy farms per acre (Table 1) reveals that, there is an increment in the profit of Rs 14790/ac realized in paddy cultivated through SRI method. From the components of partial budgeting, the added returns in paddy were attributed mainly through the increased grain productivity obtained in the SRI methodology. The reduction in cost incurred in SRI method was due to the less cost of seeds, nursery management, weed management, manures and plant protection chemicals. However, the cost on cultivation increases due to high cost of ploughing, irrigation, harvesting, threshing and transportation in SRI technology. Cost of grain production was Rs 896/q, Rs 426/q in case of conventional and SRI method respectively.

However, from the partial budget analysis shows that the adoption of SRI technique provide an additional profit to the farmers.

On an average, the SRI household earned Rs 12,061.80/- more than non-SRI household. When income was broken down by source that included income from self-employment, agricultural labor,

Table 1. Partial budget in adoption SRI method over conventional method per acre.

Debit	Amount (Rs)
A. Increase in cost	
(i) Ploughing	250
(ii) Irrigation	150
(iii) Harvesting, threshing and transportation	800
Total	1200
B. Decrease in returns	-
Total debit	1200
Profit	14790
Credit	**Amount (Rs)**
A. Decrease in cost	
(i) Seed cost	350
(ii) Nursery preparation	100
(iii) Weeding	1400
(iv) Fertilizer and plant protection chemicals	865
Total	2715
B. Increase in returns	13275
Total credit	15990

Table 2. Difference between SRI and non-SRI households (n=60). *Significant at 5%, ** significant at 1%.

Variable	SRI	Non-SRI	Difference	t-test
Household incame (INR)				
Annual Gross Income	70480.68	58418.87	12061.8	1.78
Income from self-employment	22751.18	16856.73	5462.8	1.08
Income from agricultural labor	6929.65	5462.61	1466.93	1.8
Income from non-agricultural activities	14782.14	11856.61	2925.53	1.74
Income from livestock	3361.65	3234.7	126.95	0.16
MGNREGS income	1006.38	1477.2	-470.81	-1.49
Pension	2365.64	1191.04	1174.6	1.67
Education outcomes				
Share of children attending private schools	0.066	0.043	0.023*	2.06
Share of children attending public schools	0.37	0.36	0.003	0.12
Share of children attending other schools	0.007	0.008	-0.001	-0.39
Count of children taking private tuitions	0.107	0.107	0	0
Annual expenditure on children's education	1261.91	375.51	-886.4	1.78
Health outcomes				
Frequency of use of private health services	1.89	1	0.89**	8.36
Frequency of use of public health services	0.98	1.19	-0.21*	-3.11
Frequency of use of other health services	0.08	0.34	0.25**	-6.03
Access to health insurance	0.01	0.01	0	0
Investments/loans/debts				
Have invested in at least one of the saving options	0.28	0.3	-0.02	-0.93
Formal loan source	0.86	0.77	0.09	1.16
Full credit access	0.78	0.7	0.08	0.91
Interest rates	4.82	3.96	0.86	0.79
Collateral pledged	0.27	0.56	-0.29**	-3.21
Loan not approved	0.078	0.017	0.061	1.52
Consumption expenditure				
Share of food expenditure	0.9	0.9	0	0
Share of nutritious food expenditure	0.46	0.51	-0.05**	-3.7
Rice yield	23620.47	19432.99	4187.47*	2.01

non-agricultural income and livestock income, the positive gap between the SRI and Non-SRI group is consistently present except for income from MGNREGS (Table 2). The education related variables indicated that households which adopted SRI method of agriculture spent a larger proportion of their income towards sending their children to private schools and spent almost three times on schooling as compared to their counterparts in the non-SRI group. In case of accessing health services, the gap in availing private health facilities between SRI and non-SRI households was 33%, however this difference is not visible when it comes to accessing health insurance. The percentage of SRI households who have accessed loan through formal sources is 86% which is 9 percentage points higher than non-SRI households. However they do not differ when it comes to investing in one of the several savings options. The differences on the household characteristics between SRI and Non-SRI households are statistically similar in case of many variables.

SRI participation model and propensity scores

It is important to note that the program has been able to reach out to households with different socio-economic pre-conditions (Table 2). In case of male or female headed households are equally likely to adopt SRI. Similarly, the age of the head of the household, size of agricultural land and educational attainment did not vary significantly across the SRI and non-SRI households. The results from the participation model (Table 3) (examined the impacts of SRI on household income and child schooling) follow the findings from Takahashi and Barrett (2014).

However in order to understand the distribution of the covariates (i.e. determinants in the participation model) across the SRI and non-SRI households, it is important to analyze that how well the baseline

Table 3. SRI participation model. * Significant at 5%, ** significant at 1%.

Selection factors	Coefficient	Standard error (SE)
Age of the farmer	0.021	0.029
Square of age of the farmer	-0.0001	0.0002
Number of household members who have received above primary education	0.083	0.066
For female farmer=1, 0 otherwise	0.13	0.26
Number of years of schooling attained by the farmer	0.009	0.03
Type of house, where the farmer is residing	0.36***	0.14
Size of the agricultural land	0.038	0.051
Distance of village from the nearest bank	0.074	0.105
Village population	-0.00001	0.00006
Distance of village from the district head quarter	0.007	0.012
Distance of village from the nearest agricultural market	-0.004	0.022

covariates have been balanced by the specification of the SRI participation model using the parameters obtained by the probit estimation, propensity score (the probability that a given farmer household in the sample will adopt SRI practices condition on the specification of the participation model) for all households were computed. After estimating the coefficients of the probit model the propensity scores were estimated and conducted a balancing test that precisely examines the distribution of covariates were treated and comparison households (Table 4).

The above table presents the results from the balance test. It is evident that several household level characteristics were distributed unequally across the two groups in the unmatched sample (for instance, household type, size of agricultural land). Subsequent to the matching procedure, all the covariates were balanced across the two groups of households. This is evident from the insignificant t-value for the matched households.

CONCLUSION

The partial budgeting shows, there is a net benefit of Rs 14,790/ac by adopting SRI method of rice cultivation resulting in a yield enhancement of 47.05% over conventional method of rice cultivation by minimising use of inputs, water and labor resulting in income enhancement of the adopting farmer. Through the SRI adopting households have earned more as

Table 4. Test of balance. * Significant at 5%, ** significant at 1%.

Variable	Unmatched (U) Matched (M)	Average SRI	Average Non-SRI	t-test
House type	U	0.32	0.25	3.04**
	M	0.32	0.29	1.40
Size of agricultural land	U	2.16	1.73	2.75**
	M	1.85	1.79	0.80
Age of the head of the household	U	47.67	46.10	2.32*
	M	47.69	47.31	0.59
Primary education	U	1.80	1.64	2.28*
	M	1.80	1.74	0.91
Male head of the household	U	0.956	0.954	0.21
	M	0.954	0.94	0.12
Education of the head of the household	U	7.15	7.01	0.55
	M	7.14	7.06	0.32
Village population	U	1402.2	1394.4	0.13
	M	1395.3	1404.7	-0.16
Distance from bank	U	5.64	5.56	0.1
	M	5.65	5.73	-0.33

compared to non-SRI households (due to increase in production), still their consumption expenditure, savings and investment habit remain more or less same. SRI households spend 73.96% and 90% more than non-SRI households on education and access to private health facilities respectively. SRI households are sending their kids to private schools more than non-SRI households. The literature on human capital formation due to increase in household income indicates that such households experience a forward looking approach, develop entrepreneurial capabilities, become less risk averse towards adoption of newer technologies, more involvement in welfare related programs and in general have higher capacities to catapult themselves out of vulnerability zone. The sustainability of the system may be studied further w.r.t. inputs used and income generated thereof. Also, economy efficiency and technical efficiency of the methodology may be studied further for large scale dissemination.

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