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Economic Impact Analysis of SRI Technology in Improving Agricultural Productivity of Tribal Households in Nayagram Block in *Jungle Mahal* in West Bengal

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Abstract: There is a compelling need to increase rice productivity in India due to less availability and low productivity of land. The system of Rice Intensification (SRI) has been proved to be successful method of rice cultivation in many areas around the globe. In this backdrop there is an urgent need to explore the possibilities of adopting new innovative production technique like SRI in the dry zones where the yield is low. Here an attempt has been made to understand the justification of the SRI cultivation in terms of productivity and profitability in the dry zone like Nayagram block in West Bengal in India. The results suggest that in terms of both cost savings and productivity gain, SRI performs better compared to conventional methods of cultivation. The probability of adoption of SRI by farmer households increases with the adult family members, livestock, membership of farmers' organization and access to irrigation.

Keywords: SRI, *Jungle Mahal*, Agricultural productivity, Tribal

INTRODUCTION

India at present faces a daunting challenge to provide food security to the burgeoning population. It is well documented in the literature that production technique play vital role in improving the yield or productivity in the agricultural sector with its striking impact on reducing poverty [1, 2]. Agriculture accounts for 80 percent of the total water consumption in India and about 60 per cent is consumed by paddy alone. Traditionally flooding method of irrigation is used for growing paddy with 2-3 centimeters of water on the field throughout the growing period. Though paddy is not a desirable crop in the water scarce dry zones, it remains to be the most preferred crop to maintain the subsistence need. Number of new methods of paddy cultivation are being invented and promoted for improving water use efficiency and improving productivity in paddy cultivation [3]. The system of Rice Intensification (SRI) has been proved to be successful method of rice cultivation in many areas around the world.

The traditional paddy cultivation was oldest method of rice cultivation. It has undergone changes due to changing times in many areas. SRI paddy was introduced in Madagascar for the benefit all the farmers. The traditional method needs extra labour and a lot of fertilizers. Farming with modern methods is also expensive using outside inputs. It was noticed that, farmers adopting conventional methods could increase their production only by using expensive inputs such as chemical fertilizers, pesticides and hybrid seed. It is becoming increasingly difficult for the community to afford these things. It is also known that using chemicals is harmful to the environment. The system of rice intensification (SRI) consists of a set of management practices that were mainly developed through participatory on farm experiments in the central highland of Madagascar in the 1980s. The main elements of SRI include early transplanting of young seedlings, transplanting single seedlings with wide spacing, mechanical weeding with a rotary push weeder, no need for continuously standing water during the vegetative growth phase, and reliance on compost as far as possible, with supplemental or no chemical fertilizer [4]. There are some differences between the SRI paddy and traditional paddy in nursery management. While the SRI paddy cultivation needed about 2 kgs of seed per acre for nursery management, the traditional cultivation needed about 30 kgs of seed per acre for nursery management. There are also major differences between the SRI and traditional paddy cultivation in the method of transplanting. The wider spacing was followed between the plants and rows in SRI paddy (25x25cms) as compared to traditional paddy (20x15cms).

Several studies have shown that SRI practices have numerous benefits such as increasing productivity; curbing water requirement; reducing the cost of cultivation; offering the crop resistance to biotic and abiotic stresses; improving soil condition; and lowering greenhouse gas emission. However, the practice has some limitations and criticisms, hindering its wider adoptability. Therefore, extensive research and extension programs should be launched to promote SRI among the rice farmers. In addition, government should formulate appropriate policies and regulations to widely establish this system in India. A "Slightly Modified System of Rice Intensification" (SMSRI) is being adopted by farmers to cope with the local conditions and needs. In this backdrop we have undertaken the present study to explore the possibilities of innovative agricultural production technique like SRI/SMSRI in the dry zones of India. The present study was undertaken in Nayagram Block in Paschim Medinipur district of West Bengal to note the impact of SRI method of rice cultivation on the farmers.

LITERATURE REVIEW

According to Joypalreddy and Shenoy [5], SRI paddy was introduced to offset the heavy cost of traditional paddy cultivation by reducing water use and pesticide use to attain higher profit. According to them while large amount of water was required for traditional paddy cultivation, a much low level of water is maintained throughout in SRI paddy cultivation and because of this reason, SRI paddy was called as poor farmers' crop. According to Kumar *et al* [6], the water saving alone should be a strong justification for adopting SRI method wherever water is not abundant. Styger et al [7] found that in 2007, in Goundam circle, SRI yields of 7.7 t/ha (n = 130 farmers) compared to 4.5 t/ha in farmers' fields. Debbarma and Singh [8] studied on economic analysis of system of rice intensification (SRI) in Tripura state and found that SRI required lesser amount of critical inputs, which constitutes more than 25 per cent of the total cost. The study of Rao [9] has shown that Benefit Cost Ratio (BCR) is higher for SRI (1.76) than traditional (1.25) methods in North Coastal Zone of Andhra Pradesh for the period 2008-09. Ghosh and Chakma [10] based on their study in West Bengal found that under SRI, B: C (Benefit – Cost) ratio varies from 5.06: 1 to 3: 1, but in the conventional method it varies from 2.18: 1 to 1.78: 1 and SRI farmers are experiencing multiple benefits in terms of both economics and ecology. Field experiments conducted by Hameed *et al* [11]during the summer season of 2008 in Al-Muthanna province in southern Iraq showed significant differences in the yield components of grain number. According to Chapagain *et al* [12], net returns increased approximately 1.5 times for SRI-organic management regardless of the added labor requirements for weed control. The study by Dhananchezhiyan *et al* [13] was aimed to develop the spaced mat nursery to suit the available transplanter for System of Rice Intensification (SRI) method of cultivation. Dahal [14] attempts to succinctly review the present situation of SRI in Nepal and its benefits, along with its limitations and criticisms. Arayaphong [15] quantifies and compares costs and benefits of SRI and the conventional system of rice cultivation in Thailand to find the best system for a farmer, the environment and a society. Pathak [16] examines farm level performance of System of Rice Intensification method of paddy cultivation as against the traditional method of paddy cultivation, in the state of Gujarat.

Based on the study in Southern Africa, according to Rappocciolo [17] challenges for disseminating SRI includes: resistance by farmers who hold on to their traditional ways; geographical and infrastructure constraints (such as frequent droughts and poor irrigation systems or unreliable supply of irrigation water); inadequate access to inputs such as seeds, organic fertilizers, and mechanical tools; and a need for extra labour (and which may be in conflict with other labour requirements arising at the same time; this is often critical as SRI requires a lot of precision in terms of the timing and type of labour at different stages of production). According to Mahender Kumar et al [18] SRI method, using less water for rice production can help in overcoming water shortage in future and it can also make water available for growing other crops thus promoting crop diversification. Ibrahim [19] finds that SRI practices in Malaysia in paddy cultivation has resulted in the increase in yield as well as superior quality paddy because of its shorter crop cycle, less need for seeds and fertilizer. Peruri [20] evaluates the system of rice intensification (SRI) method of paddy cultivation was introduced by the Government of Andhra Pradesh in the year 2003.

The variations in the yields as well as cost across plots of the SRI make it a risky proposition when to the traditional paddy. On the flip side the water requirement for the SRI is almost half that of the traditional paddy. While water use efficiency is one of the factors influencing high adopting rates, the ultimate indicators is the profitability and risk factors and the tradeoff between the two [3]. Therefore, the economics of the SRI needs to be examined.

MATERIALS AND METHODS

Study area

The Nayagram block in *Jungle Mahal* is the most backward region in Pascim Medinipur district as well as in West Bengal. In terms of Human

Development Index (HDI), Naygram is the lowest one in Paschim Medinipur district. One of the reasons for poor economic development is low agricultural development. The cropping intensity is the lowest one Paschim Medinipur district. Also agricultural productivity is poor compared to many other blocks in West Bengal. The area has ST and SC population of 58%. The main source of income of community is agriculture. The area mainly depends upon mono-cropping, i.e. *Kharif* paddy is the only crop grown. The production from the agricultural land is uncertain due to erratic rainfall and occasional late onset of monsoon. Farmers cannot do timely intercultural practices and thereby production gets reduced drastically. In addition to this lack of knowledge on improved agriculture technology and unavailability of timely and adequate credit also play a significant role for the poor yield. Families could somehow manage a food sufficiency of 6-8 months from their own farm production. People also migrate to nearby agriculturally developed area of Purba Medinipur to work as an agriculture labour. Dependency of people on *babui* rope making and *sal* plate making as a secondary source of livelihood is evident from the area. It generally acts as a source of cash income for these families. Farmers are generally dependent on chemical fertiliser and pesticides. It is very difficult for the community to purchase required amount of fertiliser. We have selected four villages nalmely Panchami, Dudhiasole, Balimundi Baksha in Nayagram block in Paschim Medinipur district of West Bengal.

Methodology

We have used different methodologies according to our objectives. We have used ANOVA technique to test the statistical difference of averages for different parameters of cost and production of paddy cultivation for SRI and traditional cultivation. We have also used graphs, charts and tables for our analysis.

We have used the following logit model to find the determinants of adoption of SRI technique by the households.

$$Y_i = \frac{1}{1+e^{-[\alpha+\sum_{j=1}^{7}\beta_j x_i+u_i]}} \qquad \text{(Eq. 1)}$$

For all j = 1, 2… 6 (Number of variables) and i = 1… 160 (Number of households)

Where,

Y_i (Dummy variable) = 1, if the household has adopted SRI

=0, otherwise

α = coefficient of the constant term

β_j = coefficient of the independent variables

x_i = independent variables

u_i = Error term

Sampling Design

This study is mainly based on the primary data collected from 160 farmers selected randomly from 4 villages' in one G.P. called Arra of Nayagram Block of Paschim Medinipur District. Out of the 160 sample households, 60 are purposively selected from farmers who have adopted traditional method (TM) of paddy cultivation and the other 100 are selected from farmers who have adopted SMSRI method of paddy cultivation. All the households surveyed were of ST category. Survey was conducted based on a structured questionnaire in the year 2015 and valuable information was collected by way of observation and interviews.

The farmers who have started to practice the SRI methodology for rice cultivation were categorized into 'SRI farmers' and the farmers who have still been practicing the flooded rice cultivation were categorized into 'non-SRI farmers'. We have first interviewed some SRI farmers and traditional farmers with the information from PRADAN and block office. Then, the interviewed farmers were asked to nominate other farmers who were conducting similar practices of rice cultivation. Those new farmers were interviewed and the same process was continued. Altogether, 160 farmers were interviewed of which 100 were SRI farmers (Improved paddy) and 60 were traditional. During the sample survey it is observed that most of the farmers were not exactly following the SRI method practiced elsewhere, but they followed a slightly modified version of SRI called SMSRI method (improved paddy). In Table 1, we have given the names of the villages and the number of households selected for survey from each under SRI and traditional techniques of paddy cultivation.

Table 1: Sample households for survey

		No. of Households		
Sl.No.	Name of the Village	Improved Paddy (SRI)	Traditional	Total
1	Panchami	42	15	57
2	Dudhiasole	21	5	26
3	Balimundi	19	36	55
4	Baksha	18	4	22
	Total	100	60	160

Source: Primary Survey

RESULTS AND DISCUSSION

We have already stated that we have selected 160 households of whom 60 households have adopted traditional methods of cultivation and 100 households have adopted SRI method of cultivation. Some characteristics of the surveyed households like caste, household size, type of house, source of drinking water, poverty status and source of irrigation have been presented in the Table 2.

Table 2: Household characteristics (% of households)

Item		Traditional (N=60)	SRI(N=100)	Total (N=160)
Caste (Type)	*Munda*	48.3	68	60.6
	Santal	51.7	32	39.4
Household Size	Up to 2	6.6	6	6.25
	3 to 5	70	54	60
	6 to 8	23.3	32	28.75
	Above8	0	8	5
Type of House	Kancha	85	91	88.75
	Pakka	10	5	6.87
	Mixed	5	4	4.375
Source of Drinking Water	Tube well	41.7	71	60
	Kuno	58.3	29	40
Poverty Status	BPL	100	100	100
	APL	0	0	0
Source of Irrigation	River	18.3	8	11.9
	Tank	0	1	0.6
	Shallow	1.7	12	8.1
	Canal	35	43	40
	Happa	0	20	12.5

Source: Primary Survey

Different kinds of assets and livestock possessed by the households have been presented in Table 3. Many households are observed without possession of agricultural assets like power tiller, spray machine and shallow tube well. Though most of the households possess cycle and mobile, many households do not possess assets like TV and radio.

Table 3: Assets of the households (% of households surveyed)

Item		Traditional (N=60)	SRI(N=100)	Total (N=160)
Agricultural Assets	Bullock Cart	16.7	33	26.9
	Irrigation Pipe	18.3	33	27.5
	Motor Pump	16.7	25	21.9
	Power Tiller	0	3	1.9
	Spray Machine	0	6	3.8
	Shallow	0	1	0.6
Non Agricultural Assets	T V	26.7	32	30
	Radio	28.3	41	36.3
	Cycle	93.3	95	94.4
	Motor Cycle	13.3	15	14.4
	Mobile	61.7	95	82.5
Livestock	Cattle	96.7	96	96.3
	Buffalo	38.3	71	58.7
	Goats	66.7	89	80.6
	Pigs	23.3	17	19.4
	Sheep	1.67	19	12.5
	Hen	93.33	99	96.9

Source: Primary Survey

In Table 4, we have presented membership of associations by the households, Government beneficiary schemes enjoyed by the households and participation in participation of *Gram Samshad* Meeting.

Table 4: Membership of Associations by the households (% of households surveyed)

Item		Traditional (N=60)	SRI (N=100)	Total (N=160)
Membership of Associations	Self-help Group	36.7	68	56.25
	Farmer's Association	0	4	2.5
	Lamps Group	3.3	7	5.62
Beneficiary Scheme of Households	Rationing	100	100	100
	Indira Abas	20	11	14.4
	Lodha House	0.63	0	0.63
	Older Allowance	13.3	14	13.8
Participation of Gram Samshad Meeting		48.3	58	54.375

Source: Primary Survey

Different paddy varieties adopted by farmer households have been given in Table 5. We have found four types of paddy namely *Kali Champa*, *Lalat*, *Mini Swarna*, *Swarna*. Most of the traditional paddy growers depend upon *Swarna* variety

Table 5: Paddy varieties adopted by the farmer households (% of households surveyed)

Crop Name	SRI (N=100)	Traditional (N=60)
Kali Champa	24.0	26.7
Lalat	32.0	11.7
Mini Swarna	12.0	0.0
Swarna	32.0	61.7

Source: Primary Survey

Economics of SRI

SRI paddy cultivation was introduced in Nayagram block during the kharif seasons in 2008-09. It was promoted by Government and facilitated by an NGO named PRADAN. Besides, some progressive farmers came to know about it from the NGO and fellow farmers have started adopting the SRI since 2008-09 itself. The SRI is presently slowly spreading in this block. Farm management aspect of the SRI in Nayagram block reveal that farmers are not following the method as specified in a number of studies. All the sample farmers use the high yielding paddy variety seeds for the SRI as well as traditional paddy plots. In Table 6, we have presented the comparison of SRI and traditional paddy in terms of yield and value of product per acre. The average yield of paddy is 1.09 Tons/acre for traditional and 1.398 tons/acre for SRI paddy.

Table 6: Comparison of traditional and SRI in productivity for sample households

	Mean				
	Traditional (N=60)	SRI (N=100)	Total (N=160)	F Value	Level of Sig
Yield (Tons/Acre)	1.090	1.398	1.283	497.5	0.000
Total Value Main Production (Rs.) per acre	10870.3	14703.9	13266.3	227.1	0.000
Total Value By Product (Rs.) per acre	385.9	246.4	298.7	338.3	0.000
Total Production(Rs.)/Acre	11256.2	14941.8	13559.7	209.4	0.000

Source: Primary Survey

We have given the different cost components of traditional and SRI paddy in Table 7. It was observed from the literature survey on SRI, across the countries that the SRI not only uses less seeds and water but also little or no fertilizers and pesticides. In Nayagram block the SRI is transplanted in single seeding spaced at 20-25 cms. And less number of waterings is used when compared to the traditional paddy. In the case of all other inputs, the methods of application for the SRI are akin to that of traditional paddy plots. In facts, farmers are applying more chemical fertilizer, organic fertilizers as well as machine hour value on the SRI plots when compared to traditional plots. However, the pesticide value, seed and labor requirement of the SRI plots are less in SRI than traditional plots in the Nayagram block. As a result, total labour cost tend to be lower for the SRI cultivation (Table 7).

Table 7: Descriptive statistics of various farm management indicators

	Mean				
	Traditional (N=60)	SRI (N=100)	Total (N=160)	F Value	Level of Sig
Family Labour Cost (Rs./Acre)	3362.8	2336.7	2721.5	53.9	0.000
Hired Labour Cost (Rs./Acre)	2262.2	2008.0	2103.3	4.0	0.048
Machine Hour Cost (Rs./Acre)	701.8	763.6	740.4	19.5	0.000
Irrigation Charges (Rs./Acre)	621.5	258.8	394.8	45.9	0.000
Seed cost (Rs./Acre)	736.7	159.6	376.0	3026.0	0.000
Pesticide cost (Rs./Acre)	125.2	85.7	100.5	170.6	0.000
Chemical Fertilizers cost (Rs./Acre)	519.1	1330.9	1026.5	831.9	0.000
Organic Fertilizers cost (Rs./Acre)	484.6	495.7	491.5	0.5	0.499
Total Cost (Rs./Acre)	8813.9	7439.1	7954.6	185.8	0.000
Profit (Rs./Acre)	2442.3	7502.8	5605.1	379.2	0.000

Source: Primary Survey

The results reveal that the SRI is better yielding compared to traditional methods of paddy. However, to test whether the difference in averages of the parameters are statistically significant, ANOVA tests were carried on all the important indicators. As per the tests, differences in yields, seed, irrigation cost, labor use, cost and profit are statistically significant (Table 7). Actually all the cost averages are statistically significant for the two techniques of production. The results indicate that yield gain and less cost of the SRI are translated into profits. This is solely, as observed in the earlier studies, due to low labour inputs in the SRI method. It is clear that farmers in Nayagram block are less labour. From the farmers perspective the SRI is more profitable than traditional paddy. As the SRI require less number of irrigations , irrigation charge is lower for this technique.

A comparison between SRI and traditional paddy in terms of productivity , cost and profit per acre have been given in Fig. 1

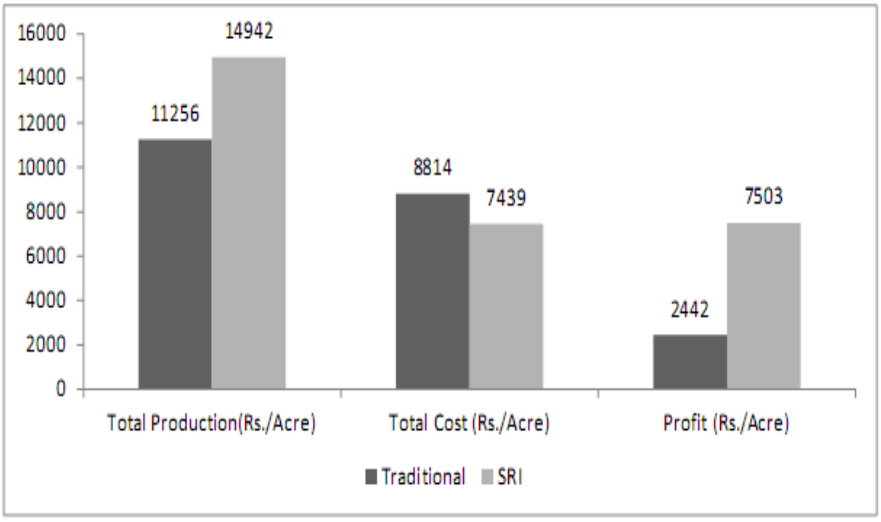

Fig-1: Comparison of SRI and traditional Paddy: value of Production, cost and profit (Rs./Acre)

Determinants of adoption of SRI

Six independent variables were considered as given in the Table 8 to find the determinants of SRI. We have used the model given in methodology (Eq. 1) for that purpose. The independent variables include Actual age (ACTAGE) of the household head, family size in adult equivalent (FAMSIZE), live stock standard unit (LSU), membership of any farm organization (MEMBER), existence of drinking water source from tube well (DWS) and source of irrigation (IRR). Livestock Standard Unit of the household of the household is calculated taking 0.50 for cattle & buffalo, 0.10 for sheep and goat, 0.20 for pig, 0.01 for poultry. The summary statistics of the variables and the expected relation of the variable with the adoption of SRI have been given in Table 8.

Table 8:Summary statistics of the determinant variables

Variables		Average value	Range (Minimum to Maximum)	Expected sign
Actual age of the household (Yrs.)	ACTAGE	37.66	16 -66	+
Family size in adult equivalent (Nos.)	FAMSIZE	4.64	0-15	+
Live stock (Unit)	LSU	4.63	0.88 – 14.53	+
Membership of organization (Y=1,N=0)	MEMBER	0.57	0-1	+
Existence of drinking water source(Y=1,N=0)	DWS	0.60	0-1	+
Source of irrigation(Y=1,N=0)	IRR	0.57	0-1	+

Source: Primary Survey

The logit regression results (using SPSS software) are shown in Table 9. The results suggest that the statistically significant factors affecting the likelihood of adoption of SRI technology are actual age (ACTAGE) of the household head, family size in adult equivalent (FAMSIZE), live stock (LSU), membership of any farm organization (MEMBER), existence of drinking water source (DWS) and source of irrigation from sources like tube well, tank, river and *happa* (IRR). The estimated results also revealed that the Nagelkerke R^2 = 0.642 and the overall percentage of correct prediction is 86.2%. The irrigation plays a very crucial role in adopting SRI by households.

Table 9: Logit Regression Results

	B	Sig.	Exp(B)
ACTAGE	0.08	0.003	1.083
FAMSIZE	0.483	0	1.621
LSU	0.564	0	1.757
MEMBER	0.95	0.053	2.585
DWS	1.393	0.008	4.025
IRR	1.374	0.008	3.951
Constant	-8.935	0	0

Source: Own Estimation

CONCLUSION

The paper highlights the economics of SRI cultivation for the tribal households in Nayagram Block in *Jungle Mahal* in West Bengal. SRI has been proved to be economic for the farmer households in the dry zones of West Bengal. The results suggest that with a higher adult family members and access to irrigation are able to derive more benefits from the SRI cultivation. The analysis supports the yield advantages and cost savings of the SRI technique of paddy cultivation. There is urgent need of proper extension services, particularly on the part of the government regarding the economic and ecological advantages of SRI. The extension support system should work towards awareness building in terms of water use efficiency and improving allocative efficiency of other inputs.

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