e-planet **17** (2): 89-97 (December 2019)

Evolution of system of rice intensification (SRI) and economic security in Tripura state of North East hill region of India

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Date of receipt: 23.08.2019 Date of acceptance: 17.11.2019

ABSTRACT

India has developed a lot and production has taken momentum but parallel to this, the hunger index of India has not declined. Small-holder families constitute more than half of the national population. Many emerging site specific technologies have been initiated to enhance the production and nutritional status of the country. Among the technology, system of rice intensification (SRI) is one of them which has accelerated the livelihood of the farmers and also suitable for small operational holdings. A study to assess the impact of SRI on livelihood and nutritional food security in the state of Tripura, India has been conducted by collecting the primary data from 200 (100 SRI and 100 Non-SRI) smallholders household. Different indices were constructed to assess livelihood and food security. The SRI found highly economic beneficial method in production of rice in the state of Tripura with higher returns of 11.88 per cent difference between SRI and Non SRI farms. The method has impacted positively to enhance the food, nutrition, health and habitat. Moreover, adopted SRI households had 76 per cent better economic security than Non SRI household. Therefore, study recommend to realize its novelty through extension machinery of the state and also advocate developing a suitable package and practices with its economic benefits so that the SRI can get momentum to enhance area and production of the rice.

Key words: Economic security, evolution, food, SRI, Tripura

INTRODUCTION

Agriculture employs about 60 per cent of the total workforce (FAO, 2013) of the world. The importance of this sector however, increases with diminishing resources for the ever-increasing global population (Brennan, 2012). The potential of agriculture for producing nutritious food is not appropriately tapped for reducing the malnourishment, but by adopting a multi-spectral approach (Das et al., 2014). Although the relationship between agriculture and human nutrition is intuitively direct, i.e. an increase in food production should lead to better availability, accessed and improved food intakes, the relationship however it is quite complex (World Bank, 2007). Hence the notion that malnutrition can be solved entirely by the supply of food grains or agricultural production is vain.

Like many other developing countries, agriculture plays a key role in the socio-economic development of India. The agricultural system in the country is a risk prone activity and a large number of farmers continue to operate under uncertain risk conditions (Akcaoz and Ozkan, 2005). Out of 119 countries, India ranks 103rd on the Global Hunger Index, 2018 with a score of 31.1,

designating a "*serious*" status of hunger (Grebmer et al., 2018). The gross production of food grains in the year 2017 was 2,71,980 metric tonnes while the per capita net availability of food grains in this specific year was 189.1 kg per year (GoI, 2018). The per capita availability depends on production while production is influenced by the profitability and producers share in consumers' rupee.

India still accounts for a quarter of the world's hungry people and home to over 190 million undernourished people (FAO, 2018). Small-holder farmers - defined as those marginal and sub-marginal farm households that own or/and cultivate less than 2.0 hectare of land - constitute 86.08% of the total holdings in 2015-16 against 85.01% in 2010-11 (Anon. 2019). In North East India, small size of operational holdings, ranging from 0.60 ha in Tripura to 1.33 ha in Meghalaya as compared to 1.42 ha at all-India level (Barah, 2006). Tripura state is the second highest densely state among the north-eastern region after Assam. Shortage of cultivable land is the main obstacle in the agriculture sector of the State with two-third of the total geographical area being hilly and a major part of it comprises of Reserved Forests (Anon. 2018). Only 24 per cent of the total area is cultivable, whereas the national average is 43. About 77.68 per cent of the agriculturists are small and marginal farmers in the state of Tripura, which is the highest in the north-eastern region (Anon. 2019).

Food security among the rural poor in India is tightly linked to poverty and production sustainability. Several studies, in the past have focused on leveraging or modifying agriculture to enhance the nutrition level (World Bank, 2007; Fanzo, 2015; Pandey et al., 2016; Halawar, 2019). Food grains mainly rice and wheat continues to be the main pillars of India's food security (Kumar et al., 2007). In India, rice is cultivated on about approximately 42.75 m. ha. area with production of 154.5 MT paddy and productivity of 2.41 t ha^{-1} (USDA, 2016). It is estimated by 2025 that 15-20 million hectares of irrigated rice lowlands, which provide three quarters of the world's rice supply, are expected to suffer some degree of water scarcity (IWMI, 2007). To eliminate hunger and under nourishment for the world's population by 2025, it was estimated that the additional water requirements may be equivalent to all freshwater withdrawal used today for agriculture, industrial and domestic purposes (SIWI, 2005). Therefore, there needs to be a shift from conventional method of rice production to maintain sustainability and from a nutritional perspective. Among the non-conventional methods of farming for rice is the system of rice intensification which aims to improve nutritional outcomes through both the own-consumption, income pathways and environmentally friendly.

MATERIALS AND METHODS

Locale of the study

The study was conducted in north-eastern region of India, in Tripura state. Two districts of the state-South Tripura district and West Tripura district were selected which contributed more than 42.89 per cent and 36.04 per cent of the total area under SRI of the state, respectively. Agricultural situation of the West Tripura district differs to some extent from the other districts in regard to topography soil, extent of rainfall, variation in temperature and humidity which has resulted in difference in cropping pattern. The availability of cultivable land is limited in the district. Another constraint for better agriculture practice is the minimum size of the operational holdings. The paucity of plain land available for cultivation of cereal crops is also an imperative reason for attaching more stress on exploring possibility of horticultural development on hill land and introduction of plantation crops of economic value like black pepper, cocoa, coffee, cinnamon, high yielding early maturing varieties of cashew nut, dwarf varieties like rabi, wheat, groundnut, moong, maximum utilization of land by growing multiple crops in the district. The South Tripura district has been characterized by a humid *summer* and a dry cool *winter* with plenty of rains during July to October. Rain is brought by the South West monsoon, which normally comes in the month of May with maximum intensity of rainfall during June-July. *Autumn* and *Spring* are of very short duration. About 70 per cent of the catchments lie in hills and as such bed slopes are very steep and

the velocity of flood discharges is also high. South Tripura is known as the granary of the state because of its rich agricultural productivity manifested in cultivation and harvesting of high quality rice, potato, varied vegetables and fruits like mango, jackfruit, litchi, pineapple, black berry, etc.

Sampling

From each selected district, two blocks were selected on the basis of highest area under the SRI method at second stage of sampling. In South Tripura, Jolaibari block and Bokafa block were selected while in West Tripura district Lefunga and Bishalgarh blocks were selected. Two villages were further selected from each of the selected blocks. A total of 200 respondents were selected for the study, out of which 100 respondents practised Non-SRI method of rice cultivation. The detailed sampling plan is presented in Table 1.

Data and analysis

Primary household data of 200 rice growers (100 SRI and 100 Non-SRI) have been collected (Table 1) on evolution of SRI in the state since 2003 onwards. The data on cost of cultivation of rice under SRI and Non-SRI for both the seasons of *kharif* and *boro*, annual household income from different sources, expenditures, data on producer's surplus of rice were collected. The state has mono-cropping pattern of rice in three seasons *viz, aush, kharif* and *boro*. To work out the economic returns in SRI and Non-SRI following formulae were use:

Gross returns = Value of the main product + by product

Farm business income = Gross income – Cost A_2

Family labour income = Gross income – Cost B_2

Net income = Gross income – Cost C_2

Farm investment income = Farm business income – Wages of family labour.

To work out the livelihood security, the indicators used by CARE (1996) were used (Table 2).

Apart from above, indices health, habitat and economic security were worked out as follow:

$$\text{Economic Security Index} = \frac{(\%\text{ difference in possesion of economic goods by SRI and Non SRI farmers})}{(\text{Total number of items})}$$

Table 1. Selection of districts, block, village and respondents

District	Block	Village	No. of households			Selection of respondents (No.)		
			SRI	Non-SRI	Total	SRI	Non-SRI	Total
South Tripura	Jolaibari	North Jolaibari	390	90	480	15	12	27
		Kalshi	325	65	390	13	9	22
	Bokafa	Betaga	425	75	500	16	10	26
		Charakbai	370	50	420	14	7	21
West Tripura	Lefunga	Lembucherra	252	108	360	10	14	24
		Kamalghat	352	88	440	14	12	26
	Bishalgarh	Tebaria	225	145	370	9	19	28
		Noapara	245	135	380	9	17	26
Total			2584	756	3340	100	100	200

Table 2. Selected indicators for livelihood security indices

Livelihood security outcomes	Indicators	Measurement
Food Security	Calories Adequacy Ratio (CAR)	24 hours recall method
	Diet diversity	24 hours recall method
Economic Security	Women's income	₹/annum
	Women's saving	₹/annum
	Extent of land	ha
	Levels of productive assets	Per capita value of livestock
	Levels of unproductive assets	Availability of unproductive assets

RESULTS AND DISCUSSION

Evolution of SRI method in India

System of Rice Intensification (SRI) is a package of practices developed by Father Henri de Loulanie at Madagascar during 1980's to overcome the problem of rice cultivation in acidic soil (Patel et al., 2008). SRI method is focus on improving the growing environment of rice plants, above and below ground, by improving the management of plants, soil, water and nutrients, to stimulate the growth of bigger and better root systems and the number and activity of beneficial soil organisms (Hidayati et al., 2016). The method is based on four components - quick and healthy plant establishment, improved soil conditions, weed control and water management. It has several benefits over traditional/conventional method of rice cultivation. The advantages of application of SRI method compared to the conventional method are less seed requirement, water savings up to 50%, reduction in the use of inorganic fertilizers by 50% if coupled with 50% organic fertilizer, or some combination of organic fertilizer and biological fertilizer, production costs reduced by 20%, and increasing yield (Hutabarat, 2011).

SRI was first experimented by the organic farmers of Pondicherry of India in the year 2000 (Prasad, 2007). The water saving potential of SRI was an important trigger that attracted farmers from many southern states to this new method (Basu and Leeuwis, 2012). In India, the adoption of SRI method was slow which started with about 1 million hectares of area under SRI cultivation, making it 2.42% of total area under rice cultivation in the country (Gujja and Thiyagarajan, 2009). This method is regarded as a key means of boosting national rice production under the Government of India's National Food Security Mission (NFSM).

SRI also gained popularity in North-eastern region of India due to its potential for high yields (Pathak et al., 2013). The first trial of SRI in North East was done in the Bokafa sub-division of South district of Tripura in the year 2001 (Anonymous, 2011). After two years of experiment conducted by state agricultural research station, Tripura, it was introduced at farmers' field. In Tripura on an average about 20 per cent higher yield was obtained from SRI as compared to conventional practice. Tripura state produces 176.13 thousand MT rice in 59.47 thousand ha of area with 2.81 t ha^{-1} of yield under SRI method. As whole the state is producing 713.22 thousand MT rice in the area of 254.74 thousand ha, in which SRI contributing 23.35 per cent and 24.69 per cent of area and production in the state (Anon. 2013), respectively. Later on keeping in view its performance success at farmers' field SRI method came into momentum from the year 2003 onwards and it keeps on to increase its coverage in huge area of the state. Year wise adoption of SRI at micro level at the farmers' field termed as evolution of (Table 3) has been estimated. In the year 2003 the area under the method was accounted of 0.32 ha and it increased 52.88 ha during 2014 (Fig. 1). Similarly, the production of rice was estimated to be 7.2 quintal during the first year (2003) and it increased of 22.78 MT during 2014-15 (Fig. 2). Despite of the increasing trend in area and production of rice under the SRI in study area, the yield of rice was found to be in fluctuation trends.

Initially, the yield was estimated of 2.25 t ha^{-1} which has been increased to 4.31 t ha^{-1} (Fig. 3). Perhaps, the yield was the main reason behind attraction of SRI to extend it in the larger area of the state. The method has still potentiality to increase the level of yield as estimated and reported the yield to be 7-8 t ha^{-1} (Anon. 2013). Rice is major crop in this region as well as in the state of Tripura. Therefore, SRI has played a vital role in enhancement of productivity and production of rice to fulfil the requirement of food as well as nutrition of human being in the state. The question of how SRI method can more effectively contribute to improved nutrition outcomes therefore requires an answer that encompasses factors other than food supply, and that takes into account other sectors in addition to agriculture that contribute to nutrition. Hence, the present study is an effort to provide an overview of system of rice intensification and its impact on the food, calories consumption and health security of the rice farmers in the state.

Table 3. Evolution of SRI in Tripura during 2003 to 2014

Year	Area (ha)	Productivity (q ha^{-1})
2003	0.32	22.50
2004	0.96	22.60
2005	2.72	24.15
2006	5.68	18.66
2007	7.44	34.02
2008	13.24	34.75
2009	19.08	32.20
2010	28.92	34.23
2011	34.62	38.75
2012	43.02	40.05
2013	51.02	42.19
2014	52.88	43.08

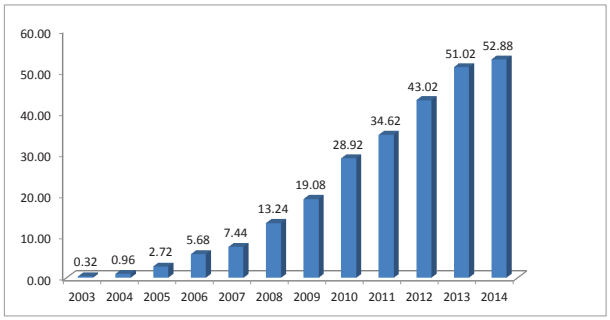

Fig. 1. Evolution of SRI area

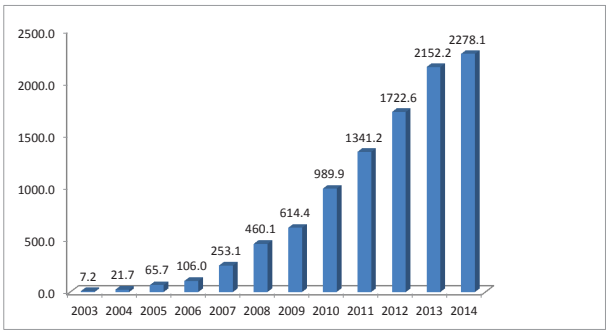

Fig. 2. Rice production under SRI since inception

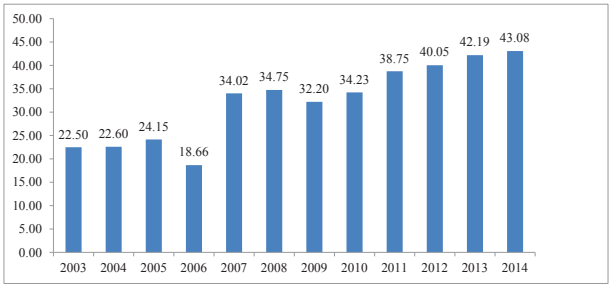

Fig. 3. Progress in yield of rice under SRI

Growth trends in area and production of rice under SRI method

The compound average growth rate in area under SRI for last ten year (2003-2012) was estimated to be of 21.03 per cent with 0.47 per cent in production of rice under SRI. The method has been adopted very fast with increasing trends (Table 4). Consequently, the production of rice has increased from 7.20 q to 2278.10 q considering the increase in production area (Table 4), but the rate of

growth in production was not found an enthusiastic and has been estimated to be merely 0.47 per cent for last ten years. The probable reason may be due to fluctuations in yield (Fig. 4). Fewer yields may be due to climatic and technological factors as SRI is known have method of certain principles.

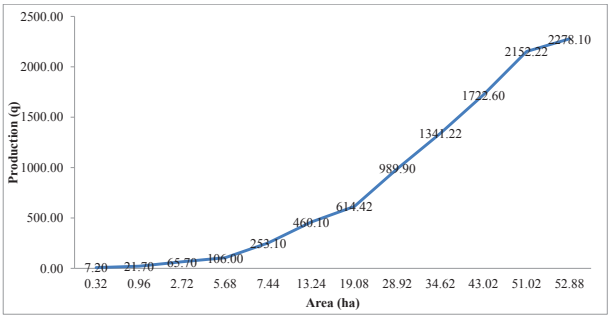

Fig. 4. Trends in area, production of rice in SRI method during the year 2003-14

Table 4. Growth rate of area and production in rice under SRI method of rice cultivation

Year	Area (ha)	CAGR (%)	Production (q)	CAGR (%)
2003	0.32		7.20	
2004	0.96		21.70	
2005	2.72		65.70	
2006	5.68		106.00	
2007	7.44		253.10	
2008	13.24	21.03	460.10	0.47
2009	19.08		614.42	
2010	28.92		989.90	
2011	34.616		1341.22	
2012	43.016		1722.60	
2013	51.016		2152.22	
2014	52.882		2278.10	

Annual income and expenditure

The income and expenditure directly affect the living standard of a household. The annual income of SRI household (₹136309 per annum) was higher than the Non-SRI farmers (₹120338 per annum) with the difference of ₹15970 per annum (11.72%). Similarly, the annual expenditure of SRI (₹ 90246 per annum) was more than Non-SRI (₹ 83135 per annum) with the difference of 7.88 per cent. Hence, SRI method has potential to enhance the income of the farmers (Table 5).

Table 5. Annual income and expenditure of rice grower

	SRI	Non-SRI	Diff.	Diff. (%)
Income (₹/annum)	136309	120338	15970	+11.72
Expenditure (₹/annum)	90246	83139	13647	+7.88

Returns from rice crop

It was apparent from the analysis of returns in rice production under SRI and Non-SRI that the SRI method has realised more economic benefits than Non-SRI in both the seasons of *kharif* and *boro* (Table 6 and 7).

Table 6. Returns from rice cultivation under SRI and Non-SRI during *kharif* season

Particulars	SRI Farm	Non-SRI Farm	Diff (%)
Total Gross return (₹ ha^{-1})	70209.37	61865.67	+11.88
Return Including Family labour (₹ ha^{-1})	13519.51	9735.38	+27.99
Return Excluding Family labour (₹ ha^{-1})	26881.48	20609.38	+23.33
Farm business income (GFI-Cost A2) (₹ ha^{-1})	36237.73	29028.13	+19.90
Farm investment income (Farm business income-wages of family labour) (₹ ha^{-1})	22875.76	18154.13	+20.64

Table 7. Returns from rice cultivation under SRI and Non-SRI during *boro* season (₹ ha^{-1})

Particular	SRI Farm	Non-SRI Farm	Difference (%)
Total Gross return	62680.33	61076.90	+2.56
Return Including Family labour (₹ ha^{-1})	9560.13	4177.83	+56.30
Return excluding Family labour (₹ ha^{-1})	22794.30	17750.52	+22.13
Farm business income (GFI-Cost A2) (₹ ha^{-1})	32150.55	26169.27	+18.60
Farm investment income (Farm business income-wages of family labour) (₹ ha^{-1})	18916.38	12596.58	+33.41

Producer surplus of rice at SRI and non-SRI household

The study of producer surplus is always helpful to know the food security which directly linked to economic prosperity of a farmer. The more marketable surplus farmer is more is resourceful. The marketable surplus was estimated and found to be higher on SRI (63.64%) than Non-SRI (48.23%) even it is higher than the marketed surplus within SRI household. Hence, producer's surplus analysis shown SRI household has more retention power than the non-SRI farmer (Table 8).

Food Security

Per capita food consumption in SRI and non-SRI household

The consumption of food very much depends on the quantum of food production at household. Again the quantum of the food depends on the way of production of food. The diversified food consumed by the SRI and Non-SRI household was estimated on the basis of individual consumption. The quantity of rice consumption was found to be higher on SRI (0.51 kg per capita per day) than Non-SRI (0.45 kg per capita per day) household. The consumption of meat, fruit, milk, eggs, and nuts was found to be consumed more by the SRI than the Non-SRI household except vegetable intake. However, SRI households were observed to take more quantity of different food items than Non-SRI households. Therefore, SRI method has played its role to enhance income of the household and it made them to consume sufficient food item than the Non-SRI (Table 9).

Table 8. Producer surplus of rice in SRI and Non-SRI method (kg)

Particulars	SRI	Non-SRI
Production (kg)	2546.00	1938.43
a) Home Consumption	794.70	827.54
b) Seed	36.40	41.08
c) Feeds	79.39	73.56
d) Wages in kind	15.35	61.29
Sub-total (a to d)	925.84	1003.48
Marketable surplus	1620.16 (63.64)	934.95 (48.23)
e) Losses during storage	15.28	17.45
Marketed Surplus	1604.88 (63.00)	917.50 (47.33)

Note : figures in parentheses are to the total production

Table 9. Per capita food intake in SRI and Non-SRI farmers in kg per day per person

Items	SRI	Non SRI	% change
Rice	0.51	0.45	13.49
Pulse (Dal)	0.05	0.03	49.76
Meat	0.06	0.04	37.78
Vegetable	0.31	0.37	-15.74
Fruits	0.14	0.11	25.51
Milk	0.09	0.07	24.93
Eggs	0.32	0.21	47.83
Fish	0.07	0.06	1.26
Nuts	0.03	0.02	63.85

CONCLUSION

The study has revealed that SRI method has been accepted by the farmers of the Tripura state and area and number of farmers under SRI method have been increased over the year. Thus, SRI has left highly positive effect on every aspects of livelihood security. The method has enhanced the income of the SRI household. It has made capable and more secure to the household of Tripura state in nutritional food security. Producer's surplus, food, economic security all were found in better side than Non-SRI. Therefore, study advocate to prepare and initiate a comprehensive package of practices on SRI for its more adoption. Hence, it is suggested that SRI farming should be taken up as the alternative method of yield enhancement. The interface between agriculture and human development provides a far more complete picture of nutrition that relates supply to demand and production to consumption.

ACKNOWLEDGEMENT

Authors are very grateful to the funding agency of Indian Council of Social Science Research, New Delhi for giving the grant for extra-mural research project from which this paper has been prepared. The authors are also thankful to esteemed Central Agricultural University for implementing this research project.

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