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SYSTEM OF RICE INTENSIFICATION (SRI) METHODS IN BIHAR: A DISTRICT LEVEL STUDY

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ABSTRACT

This study is based on primary data collected from 840 farm households of 14 districts of Bihar following stratified random sampling procedure. This study examines socio-economic conditions of SRI farmers and their views on SRI and its effects on paddy and wheat in Bihar. Analysis shows that preference for SRI technique in paddy and wheat is higher among male farmers than those of female. Literate farmers have more preference for SRI. Increase in literacy among farmers can improve agriculture productivity in Bihar. The analysis finds significant increase in productivity of paddy and wheat after using SRI technique. However, limitations reported by the farmers include labour intensive nature of SRI, shortage of skilled labour and lack of machine diversifications useful for different nature of soil which are responsible for the low preference of SRI among farmers. Thus, the study suggests that training of farmers at panchayat or village level, effective Kisan call centre facility, proper display of SRI at village or panchayat level and regular studies are essential to promote the use of SRI in Bihar.

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Introduction

Being mainly an agrarian economy largely dependent on vagaries of monsoon, policy supports to the farmers are essential for supporting food security and livelihood in Bihar. Under given limitations, policies dedicated to agriculture development have supported a lot to improve agriculture production in Bihar. However, there is still huge untapped potential in agriculture in Bihar, in terms of productivity and its diversification. The average yield of rice and wheat are 1.45 and 2.19 t/ha, respectively, as against the production potential (experimental yield at research farm as well as realised in frontline demonstration) of 4.5-5.0 t/ha. Even though the State is rich in soil and water resources, its average yield of rice and wheat are only about 32 and 44 per cent of the potential yield, respectively. Gap between the State average productivity and potential is very high owing to technology adoption and inputs. Considering improvement in agriculture productivity at priority, a series of programmes have been implemented by the government of Bihar starting from first agriculture road map. The focus of these programmes is improving agriculture productivity and farm income. One such programme regarding productivity improvement is SRI, which covers both aspects of technology and inputs. Debate on the impact of SRI on productivity and its limitations in Bihar prompted to communicate this study for extenuating implications of SRI in the improvement of productivity and further improvements needed to increase uses of SRI in Bihar. Based on primary survey of farm households, this study presents socio-economic dynamics of SRI farmers, impact of SRI on productivity of paddy and wheat. Since this method has been used universally in Bihar, it suffers from limitations as well. Thus, this study will underline the limitations of SRI in Bihar and policy suggestions.

The study is largely based on farmers' views on SRI programme. This work also tries to identify problems related to use of SRI in Bihar and effective interventions that can support effectively in promoting use of SRI in Bihar.

Agriculture in Bihar

Besides severe drought and flood, agricultural sector is the largest employer in Bihar but contributing a declining share of its state domestic product (SDP). Thus, the major chunk of the population is dependent on agriculture for their livelihood while producing less and also getting less. Untapped potential in agriculture in Bihar is reflected in low net sown area (around less than 60 per cent comparatively lower than Punjab and Haryana), low irrigation (only 57 per cent of the cultivated area is irrigated), and low cropping intensity (only around 50 per cent of the cultivated area is sown more than once). Untapped potential is also reflected in production and productivity dynamics of agriculture.

In terms of production, Bihar is the seventh largest producer of rice, sixth largest producer of wheat, eighth largest producer of coarse cereals, eleventh largest producer of pulses, eighth largest producer of foodgrain,

fifteenth largest producer of oilseeds, sixth largest producer of sugarcane in India (Table 1). Except sugarcane, performance of Bihar in foodgrains and non-foodgrains production is less satisfactory. In terms of per capita availability of foodgrain and non-foodgrain crops, Bihar stands at lower position (Table 2) (except sugarcane and wheat).

Volatility in production of summer moong, gram, lentil, pea, other rabi pulses, arhar, urad, bhadai moong, linseed, sunflower, jowar, bazra, ragi, and small millets is a result of change in area rather than change in the yield. For other foodgrains and non-foodgrains, yield volatility explains volatility in production. Productivity seems to be a major factor responsible for the increase in production of wheat, maize, gram, rape seed/mustard between 1999 and 2010. Decrease in acreage is responsible for decrease in production of summer moong and lentil, linseed, arhar, urad, sesamum, sunflower and ragi. Both the factors, decrease in land acreage and productivity, are responsible for decline in production of other rabi pulses as well.

The overall picture points out that considering the availability of resources, potential of agriculture in Bihar is still untapped. Analysis shows that productivity has not increased significantly in Bihar. Growth in land acreage resulted in growth in agriculture in Bihar. To increase the overall production, policies related to increasing production by utilising fewer resources are essential.

Table 1 : State-wise Production of Foodgrain and Major Non-Foodgrain Crops in 2013-14 (Thousand Tonnes)

State / Union Territory	Paddy	Wheat	Coarse Cereals	Pulses	Total Food-grains	Oilseeds	Sugarcane
Andaman and Nicobar Islands	16.2	-	0.3	0.3	16.8	#	-
Andhra Pradesh	12724.7	4	5385.4	1551	19665.1	1822	15360
Arunachal Pradesh	276.2	4.5	92.8	540.8	914.3	0	-
Assam	4327.1	40.4	25	104.3	5096.8	166.7	969
Bihar	5505.8	4738	2139.9	522	12905.8	121.3	13477
Chhattisgarh	6716.4	134	263.1	482.1	7595.6	200.5	-
Dadra and Nagar Haveli	25.5	0.3	1.7	5.2	32.7	0	-

(Contd...)

Table 1 *(Contd...)*

State / Union Territory	Paddy	Wheat	Coarse Cereals	Pulses	Total Food-grains	Oilseeds	Sugarcane
Daman and Diu	3.6	-	0.4	0	4	-	-
Delhi	29.6	84.7	7.8	0.1	122.1	0	-
Goa	126.5	-	0	8.9	135.5	#	-
Gujarat	1636	4694	2020.6	729	9179.6	6912	12550
Haryana	3998	11800	1051	125.1	16974.1	992.5	7446
Himachal Pradesh	120.8	670.7	685.9	51	1528.4	8	-
Jammu and Kashmir	610.9	601.9	551.3	13.9	1777.9	50.8	-
Jharkhand	2810.6	370.4	526.1	578.6	4285.7	188.9	-
Karnataka	3572.6	210	6825.8	1600.5	12208.9	1152	35910
Kerala	509.2	-	0.3	4	513.5	0.9	210
Madhya Pradesh	2844.8	12937	2551.8	4644.3	22978	6655	3310
Maharashtra	3120	1602	5955.2	3169	13846.2	6164	76555
Manipur	398.5	5.6	58.6	27.9	490.6	0	-
Meghalaya	273.9	0.8	42.1	3.2	320	0	-
Mizoram	59		8.2	5.7	72.8	-	-
Nagaland	429.6	5.5	147	42.5	624.6	0	-
Odisha	7613.4	1.1	325.7	419.3	8359.4	166.7	936
Puducherry	49.8	-	0.1	0.5	-	0	-
Punjab	11267	17620	553.8	39.6	50.4	75.8	6312
Rajasthan	312.6	8663.2	6432.9	2490.9	29480.4	5903	363

(Contd...)

Table 1 *(Contd...)*

State / Union Territory	Paddy	Wheat	Coarse Cereals	Pulses	Total Food-grains	Oilseeds	Sugarcane
Sikkim	20.3	0.4	75.9	5.8	17899.5	0	-
Tamil Nadu	5349.8	-	2819.7	613.8	102.4	789.8	31760
Tripura	711.8	0.3	5.9	8.7	8783.2	0	-
Uttar Pradesh	14636	29890.9	3803.2	1697.4	726.7	913.2	135162
Uttarakhand	578.6	842.4	298.9	56.5	50027.5	37	6432
West Bengal	15370.7	927.8	538.6	241.7	1776.5	926.9	1705
Others	-	-	-	-	17078.9	167.5	1565
India	106645.5	95849.8	43294.9	19783.7	265574	32414.3	350022

Source: Indiastat.com

Table 2 : List of States According to Per Capita Availability of Foodgrain and Major Non-Foodgrain Crops

Paddy	Wheat	Coarse Cereals	Pulses	Total Foodgrain	Oilseeds	Sugarcane
Punjab	Punjab	Sikkim	Arunachal Pradesh	Sikkim	Gujarat	Maharashtra
Chhattisgarh	Haryana	Karnataka	Madhya Pradesh	Uttarakhand	Madhya Pradesh	Uttar Pradesh
Nagaland	Madhya Pradesh	Himachal Pradesh	Rajasthan	Tripura	Rajasthan	Uttarakhand
Arunachal Pradesh	Uttar Pradesh	Rajasthan	Maharashtra	Haryana	Maharashtra	Karnataka
Tripura	Rajasthan	Nagaland	Karnataka	Arunachal Pradesh	Haryana	Tamil Nadu
Odisha	Himachal Pradesh	Arunachal Pradesh	Nagaland	Rajasthan	India	Haryana
West Bengal	Uttarakhand	Andhra Pradesh	Chhattisgarh	Madhya Pradesh	Andhra Pradesh	India
Haryana	India	Maharashtra	Andhra Pradesh	Nagaland	Karnataka	Punjab
Manipur	Gujarat	Jammu and Kashmir	Jharkhand	Chhattisgarh	Tamil Nadu	Gujarat
Andhra Pradesh	Jammu and Kashmir	Haryana	India	Andhra Pradesh	West Bengal	Andhra Pradesh
Assam	Bihar	Tamil Nadu	Dadra and Nagar Haveli	Himachal Pradesh	Chhattisgarh	Bihar
Meghalaya	Maharashtra	India	Gujarat	India	Jharkhand	Madhya Pradesh
India	Jharkhand	Madhya Pradesh	Manipur	Karnataka	Assam	Assam
Goa	West Bengal	Gujarat	Odisha	Odisha	Uttar Pradesh	Odisha
Jharkhand	Chhattisgarh	Uttarakhand	Sikkim	Manipur	Jammu and Kashmir	West Bengal

(Contd...)

Table 2 *(Contd...)*

Paddy	Wheat	Coarse Cereals	Pulses	Total Foodgrain	Oilseeds	Sugarcane
Dadra and Nagar Haveli	Delhi	Manipur	Tamil Nadu	Assam	Odisha	Kerala
Tamil Nadu	Karnataka	Bihar	Uttar Pradesh	Gujarat	Uttarakhand	Rajasthan
Uttar Pradesh	Arunachal Pradesh	Punjab	Himachal Pradesh	Jammu and Kashmir	Punjab	
Karnataka	Nagaland	Uttar Pradesh	Goa	Jharkhand	Himachal Pradesh	
Uttarakhand	Manipur	Jharkhand	Uttarakhand	Bihar	Bihar	
Mizoram	Assam	Meghalaya	Mizoram	Maharashtra	Kerala	
Bihar	Dadra and Nagar Haveli	Chhattisgarh	Bihar	Meghalaya		
Jammu and Kashmir	Sikkim	Odisha	Haryana	Dadra and Nagar Haveli		
Andaman and Nicobar Islands	Meghalaya	Mizoram	Assam	Goa		
Puducherry	Tripura	West Bengal	West Bengal	Mizoram		
Madhya Pradesh	Andhra Pradesh	Dadra and Nagar Haveli	Tripura	Andaman and Nicobar Islands		
Sikkim	Odisha	Daman and Diu	Punjab	West Bengal		
Maharashtra		Tripura	Jammu and Kashmir	Daman and Diu		

(Contd...)

Table 2 *(Contd...)*

Paddy	Wheat	Coarse Cereals	Pulses	Total Foodgrain	Oilseeds	Sugarcane
Gujarat		Assam	Meghalaya	Kerala		
Himachal Pradesh		Andaman and Nicobar Islands	Andaman and	Delhi Nicobar Islands		
Kerala		Delhi	Puducherry	Uttar Pradesh		
Daman and Diu		Puducherry	Kerala	Punjab		
Rajasthan		Kerala	Delhi	Tamil Nadu		
Delhi						

Source: Author's Calculation using Table 1 and census 2011.

Table 3 : Area, Production and Yield of Foodgrain and Major Non-Foodgrain Crops During 1999-2000 and 2009-10 in Bihar

Year	Area	Production	Yield
	(ha.)	(M.T.)	(kg/ha)
Wheat	0.037	0.21	0.13
Maize	0.029	0.103	0.09
Summer Moong	0.53	0.27	0.25
Gram	0.36	0.31	0.14
Lentil	0.97	0.96	0.067
Pea	0.56	0.56	0.14
Khesari	0.63	0.68	0.23
Other Rabi Pulses	1.50	1.50	0.14
Arhar	0.29	0.33	0.19
Urad	0.15	0.08	0.093
Bhadai Moong	0.12	0.16	0.109
Rapeseed/Mustard	0.057	0.133	0.115
Linseed	0.27	0.13	0.13
Sesamum	0.076	0.19	0.15
Sunflower	0.27	0.16	0.18
Jowar	0.29	0.44	0.19
Small Millets	0.18	0.16	0.09

Source: Diwakar et al, 2014.

SRI and Programme Initiated by the Government to Promote SRI

The System of Rice Intensification, known as SRI, is a climate-smart, agro-ecological methodology for increasing the productivity of rice and more recently other crops by changing the management of plants, soil, water and nutrients. SRI methodology is based on four main principles that interact with each other: early,

quick and healthy plant establishment, reduced plant density, improved soil conditions through enrichment with organic matter, reduced and controlled water application. Based on these principles, farmers can adapt to recommended SRI practices to respond to their agro-ecological and socio-economic conditions. Adaptations are often undertaken to accommodate changing weather patterns, soil conditions, labour availability, water control, access to organic inputs, and the decision whether to practise fully organic agriculture or not.

The principles of SRI, which are fundamental to achieving the expected benefits, are the following: 1. Very young seedlings should be used to preserve the plant's inherent growth potential for rooting and tillering 2. Transplanting single seedling per hill should be done quickly, carefully, shallow and skillfully, in order to avoid any trauma to the roots, which are the key to plants' success 3. Reducing the plant population radically by spacing hills widely and squarely, so that both the roots and canopy have room to grow and can have greater access to nutrients, sunlight, etc. 4. Providing growing plants with sufficient water to meet the needs of roots, shoots and soil biota, but never in excess, so that the roots do not suffocate and degenerate 5. Active soil aeration improves rice crop growth by benefiting both roots and beneficial aerobic soil organisms 6. Augmenting organic matter in soils, as much as possible, improves performance of the rice crop, by improving soil structure and functioning and supporting beneficial soil organisms. Each of the six principles of SRI has an important bearing on the performance of the crop. Detailed benefits of SRI method are discussed in Table 4. The overall effect of adopting SRI practices is an increased grain yield which can be obtained irrespective of the variety planted.

Table 4 : Significance of SRI Principles

Principle	Significance
1. Young seedlings	• Much greater potential for tillering and root growth • Earlier arrival within a better growing environment in the main field extends the time for tillering • No transplanting shock if transplanting is done carefully.

(Contd...)

Table 4 *(Contd...)*

Principle		Significance
2.	Single seedling per hill	No competition for nutrients, water and space within a hill
		• Seed requirements are reduced
		• This practice combined with wider spacing enables all leaves to be photosynthetically active; whereas with crowding, lower leaves do not get enough exposure to sunlight for photosynthesis. This deprives the plant - and especially the roots – of possible supply of photosynthates.
3.	Wider spacing	• Promote more profuse growth of roots and tillers
		• More space (below and above ground) per hill for access to nutrients, water and light
		• Inter-cultivation with mechanical weeder is made possible
4.	Moist and unflooded water management regime	Non-hypoxic condition of soil favours root health and functioning, and also supports more abundant and diverse communities of beneficial aerobic soil organisms
		• No degeneration of roots, which otherwise will be as much as 75 per cent degraded by panicle initiation under flooding
		• Exposing the soil to sunlight is favourable for warmth
		• Water savings of up to 40 per cent

(Contd...)

Table 4 *(Contd...)*

Principle	Significance
	• Energy saving where water is pumped.
5. Inter-cultivation	Churning up of the soil activates the microbial, physical and chemical dynamics
	• Triggers greater root growth and tillering
	• Weed biomass is incorporated into the soil as green manure
	• Weeding costs can be reduced.
6. Liberal use of organic manures	Gives better plant growth response than inorganic fertilisers
	• More sustained supply of nutrients
	• Favourable growth of soil biota
	• Enrichment of soil health.

Source: Thiyagarajan and Gujja (2013).

To increase the productivity of agriculture by utilising less resource, Government of Bihar has introduced supports to promote SRI in the State. Government of Bihar is providing seeds, micro-nutrients, bio-fertilisers, conoweeder, etc., after a display at panchayat, block or district level to farmers in Bihar to promote them to use SRI practices. Government claims that it increases yield and increases income. In selection of farmers, priority is given to SC & ST (17 per cent of total beneficiary farmers) and women (33 per cent of total beneficiary farmers). This study seeks to examine the claim.

Concern and Sampling

SRI is already raising factor productivity and incomes for more than one million smallholders around the world on more than one million hectares (Meyer, 2009). In the present day, it is applied in various agro-ecosystems in Africa and Asia: from tropical and coastal to semi-arid and mountainous regions. Experiences suggest that crop yields under SRI can be doubled, and even in some cases, quadrupled (Anthofer, 2004; Sato & Uphoff, 2007). Furthermore, several studies found a

significant reduction in the total amount of water needed (Ceesay et al 2006; Uphoff, 2001). Low external input use (water, fertiliser, etc) marks SRI as an environmentally friendly technology for small scale farmers in developing countries. However, Alagesan & Budhar (2009) found that farmers faced difficulties in the large-scale adoption of SRI in Tamil Nadu', India, due to knowledge deficits and labour shortages. Non-adoption and dis-adoption was examined by Moser and Barrett (2002) in Madagascar; they also cited problems relating to the higher labour needs of SRI. A study by Barrett et al. (2004) found that half of the gains from SRI adoption are based on farm and farmer characteristics rather than the technology itself. Besides, SRI is a beneficial solution for a State like Bihar, there is no such study available for a State like Bihar. This study tries to fill this gap.

This study is based on primary data collected from 14 districts (Begusarai, Dharbangha, East Champaran, Gopalganj, Khagaria, Madhubani, Muzaffarpur, Sheohar, Smastipur, Saran, Sitamarhi, Siwan, Vaishali and West Champaran) (assigned by Department of Agriculture, Government of Bihar) of Bihar provided by A N Sinha Institute of Social Studies (ANSISS), Patna, Bihar following given methodology: From each district, two blocks having highest number of beneficiaries are selected. In selected blocks, panchayats rather than villages are selected on the basis of number of beneficiaries. From each panchayat, 15 beneficiaries are selected on the basis of stratified random sampling method. Total 840 farm households are surveyed. Focus group discussions of 20 members including different stakeholders are done in all fourteen districts of Bihar.

Macro Level Findings

Land plays a significant role in agriculture dynamics of Bihar. Small, medium and large farmers are getting larger benefit of Flagship Programmes of Agricultural Development, Government of Bihar (Table 5). Gender-wise distribution presented in Table 6 shows that access to the benefit of Flagship Programmes of Agricultural Development, Government of Bihar is higher among male farmers. Benefits were mostly distributed at block or district level and it was very difficult for female farmers to collect those benefits from outside their villages (Diwakar et al, 2014). However, it negates the objective with the programme stated (to benefit women, SC & ST).

Table 5 : Landholding Size-wise Distribution of Sample Beneficiaries of Flagship Programme of Agricultural Development, Government of Bihar (in percentage)

Beneficiary Categories According to Landholding	All Fourteen Districts
Less than 2.5 acres	18.67
2.5 to 5 acres	39.48
More than 5 and less than 10 acres	20.69
More than 10 acres	21.17

Source: ANSISS Data.

Table 6 : Gender-wise Distribution of Sample Beneficiaries of Flagship Programme of Agricultural Development, Government of Bihar (in percentage)

Gender	All Fourteen Districts
Male	96.07
Female	3.93

Source: ANSISS Data.

Use of modern techniques like SRI is important for improvement in income of farmers and eradication of poverty among farmers' households. The analysis of data presented in Table 7 shows that 52 per cent of selected sample farm households were using SRI in paddy cultivation. About 35 per cent of selected sample farm households were using SRI in wheat cultivation. It indicates higher preference for SRI in paddy cultivation than in wheat cultivation in Bihar. Landholdings-wise distribution of SRI practitioners gives a more significant picture. At all, preferences for SRI in paddy and wheat cultivation among small and large farmers were higher than others (Table 8).

Table 7 : Distribution of Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Access	SRI Paddy	SRI Wheat
Yes	52.5	35.83
No	47.5	64.16

Source: ANSISS Data.

Table 8 : Landholding-wise Distribution of Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Beneficairies' Categories According to Landholding	SRI Paddy	SRI Wheat
Less than 2.5 acres	16.10	16.28
2.5 to 5 acres	37.87	39.53
More than 5 and less than 10 acres	22.90	19.93
More than 10 acres	23.13	24.25

Source: ANSISS Data.

Table 9 : Literacy-wise Distribution of Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Level of Education	SRI Paddy	SRI Wheat	Level of Education	SRI Paddy	SRI Wheat
Illiterate	4.76	5.98	Graduation	20.63	21.93
Primary	7.03	7.64	Master Degree	3.63	3.32
Middle	10.43	11.63	ITI	0.45	0.66
Secondary	34.01	31.23	B.Ed.	0	0
High secondary	19.05	17.61			

Source: ANSISS Data.

Table 10 : Social Category-wise Distribution of Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Social Category	SRI Paddy	SRI Wheat	Social Category	SRI Paddy	SRI Wheat
General	44.22	48.84	Minority	1.81	1.99
OBC	45.35	42.52	Mahadalit	3.17	1.66
SC	3.17	2.66	Other	0.23	0.33
ST	2.04	1.99			

Source: ANSISS Data.

Overall trend confirms that enthusiasm for increasing productivity is higher among small farmers. Literacy played a significant role in promoting use of SRI programme in Bihar. Table 9 shows that literate farm households have more preference for SRI. In order to improve the use of high-yielding techniques of production, improvement in level of education can have significant and positive contribution. Social category-wise distribution shows (given in Table 10) that preference for SRI is higher among general and OBCs (Other Backward Castes) farm households than others.

District Level Overall Findings

In this section, analysis has been done to distinguish the use of SRI in different districts. Table 11 shows that use of SRI practices is not as high like hybrid seeds demand in Samastipur, Gopalganj, Siwan and Saran. About 88 per cent of total beneficiaries have access to hybrid seeds in Samastipur, which is highest among all districts but the percentage of farm households using SRI practices is low, and thus indicates absence of linkages among production enhancing programmes in Bihar.

Table 11 : Distribution of Sample Beneficiaries of SRI Programme in Districts of Bihar (in percentage)

SRI	Sitamarhi	Samastipur	Begusarai	Sheohar	Madhubani	Darbhanga	Khagaria
SRI Paddy	70	20	66.67	75	70	68.33	48.33
SRI Wheat	55	20	61.67	46.67	38.33	43.33	40
SRI	Vaishali	Muzaffarpur	East Champaran	West Champaran	Gopalganj	Siwan	Saran
SRI Paddy	46.67	65	45	65	16.67	38.33	41.67
SRI Wheat	11.67	38.33	28.33	36.67	23.33	11.67	46.67

Source: ANSISS Data.

Landholding and Access to Benefits

Table 12 shows landholding-wise distribution of farm households using SRI. It shows that usage is not similar in all districts. Share of marginal landholding farmers in total SRI farmers is high in Madhubani, Muzaffarpur, Siwan, Khagaria, Darbhanga and Saran. The share of large landholding farmers is very high in West Champaran and Gopalganj. Overall trend suggests that interest for SRI among marginal, small and medium landholding farmers is comparatively high. One significant difference between SRI Paddy and SRI Wheat programme is that percentage of marginal and small farmers using SRI method for wheat production is higher than rice production.

Table 12 : Landholding-wise Distribution of Sample Beneficiaries of SRI Programme in Districts of Bihar (in percentage)

SRI	Rice						
Beneficiaries' Categories According to Landholding	Vaishali	Muzaffarpur	East Champaran	West Champaran	Gopalganj	Siwan	Saran
Less than 2.5 acres	30	26	4	6	10	13	21
2.5 to 5 acres	37	44	11	20	0	43	38
More than 5 and less than 10 acres	26	21	48	26	30	30	29
More than 10 acres	7	10	37	49	60	13	13
Beneficiaries' Categories According to Landholding	Sitamadhi	Samastipur	Begusarai	Sheohar	Madhuvani	Darbhanga	Khagaria
Less than 2.5 acres	17	45	14	20	19	5	10
2.5 to 5 acres	17	27	33	16	45	39	41
More than 5 and less than 10 acres	40	27	22	45	33	44	24
More than 10 acres	26	0	31	18	2	12	24

Table 12 ***(Contd...)***

SRI	Rice						
Beneficiaries' Categories According to Landholding	Vaishali	Muzaffarpur	East Champaran	West Champaran	Gopalganj	Siwan	Saran
Less than 2.5 acres	43	30	12	5	14	20	22
2.5 to 5 acres	14	52	12	19	7	40	30
More than 5 and less than 10 acres	29	13	47	33	14	20	30
More than 10 acres	14	4	29	43	64	20	19
Beneficiaries' Categories According to Landholding	Sitamadhi	Samastipur	Begusarai	Sheohar	Madhuvani	Darbhanga	Khagaria
Less than 2.5 acres	15	42	19	32	13	4	25
2.5 to 5 acres	21	33	25	11	52	50	42
More than 5 and less than 10 acres	39	25	25	39	17	31	25
More than 10 acres	24	0	31	18	17	15	8

Source: ANSISS Data.

Access to Irrigation to SRI Farm Households

There is hardly any disagreement that the effect of irrigation on agriculture production is very positive and significant. Table 13 shows situation of irrigation of sample households. Table also shows that percentage of irrigated land of total land available (landholding) to beneficiaries is low in Khagaria, Muzaffarpur, Samastipur and Vaishali. Except these districts, access to irrigation to SRI Farm Households is satisfactory. The data show that higher irrigation landholdings have higher probability of using SRI practices.

Table 13 : Access to Irrigation among Sample Beneficiaries of SRI Programme in Districts of Bihar (in percentage)

Districts	Vaishali	Muzaffarpur	East Champaran	West Champaran	Gopalganj	Siwan	Saran
SRI Paddy	61	68	90	90	97	81	75
SRI Wheat	73	68	82	90	97	78	76
Districts	Sitamadhi	Samastipur	Begusarai	Sheohar	Madhuvani	Darbhanga	Khagaria
SRI Paddy	73	63	81	83	73	82	70
SRI Wheat	72	68	77	86	69	87	65

Source: ANSISS Data

Link Between SRI Programme and Other Flagship Programmes of Government of Bihar

Correlation matrix presented in Table 14 shows positive correlation between percentage distribution of beneficiaries of Zero Tiller and Thresher and Sprinkler and Thresher and Drip Irrigation and Thresher. Table shows negative correlation between percentage distribution of conoweeder and Power Tiller and negates coordination between SRI and other programmes.

In this section, a district level analysis of socio-economic situation of beneficiary farmers of SRI programme has been discussed. District level analysis also shows that share of experienced and little older farmers is higher than the younger farmers. This reflects that SRI is famous among little older and experienced farmers and having greater access to irrigation.

Table 14 : Correlation Matrix of Distribution of Beneficiaries of Machines and Equipments under Flagship Programme of Agricultural Development, Government of Bihar

Item	Conoweeder	Thresher	Combine Harvester	Zero tiller	Tractor	Power tiller	Drip Irrigation	Sprinkler	Pumpset
Conoweeder	1.00								
Thresher	-0.29	1.00							
Combine Harvester	-0.12	0.01	1.00						
Zero tiller	-0.06	0.6596*	-0.09	1.00					
Tractor	0.16	0.29	-0.09	0.20	1.00				
Power Tiller	-0.21	0.33	0.30	0.30	0.05	1.00			
Drip Irrigation	-0.13	0.5873*	0.12	0.49	-0.24	0.04	1.00		
Sprinkler	0.24	0.6011*	0.06	0.28	0.43	0.34	0.19	1.00	
Pumpset	0.13	0.44	-0.41	0.31	0.32	0.21	0.18	0.49	1.00

Source: Author's Calculation using ANSISS Data. Note: * denote 10 per cent level of significance.

Impact of SRI on Agriculture

This section highlights effects of SRI on productivity, sale and income of paddy and wheat producer farm households.

Effect on Use of Land

Table 15 highlights the effect of SRI on use of land used for paddy and wheat. The Table shows that use of land used for paddy cultivation has increased. Similar trend can be seen for wheat. Overall, it is found that area under cultivation of paddy and wheat has increased after government support under Flagship Programme of Agricultural Development of Government of Bihar.

Table 15 : Pattern of Land Distribution of Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Beneficairies' Categories According to Landholding	Land used in Paddy Cultivation		Land used in Wheat Cultivation	
	Before Plan	After Plan	Before Plan	After Plan
0 acre to one acre	28.01	16.14	21.62	12.48
1.1-3 acres	41.02	45.00	53.51	54.86
3.1-5 acres	17.82	23.14	13.69	17.61
5.1-10 acres	10.18	12.00	8.83	11.19
10.1-20 acres	2.55	2.86	2.16	3.30
20.1-40 acres	0.42	0.86	0.18	0.37

Source: ANSISS Data.

Effect on Productivity and Sale of Paddy and Wheat

Table 16 shows the changes in yield of paddy and wheat production of SRI farmers. Table shows that productivity of paddy and wheat has increased significantly. Analysis also shows that small farmers have also experienced growth in productivity, which is a positive sign for policy makers.

Table 16 : Yield of Paddy, Wheat of Sample Beneficiaries of SRI Programme in Bihar (in Quintal)

Beneficairies Categories According to Landholding	Paddy Cultivation		Wheat Cultivation	
	Before Plan	After Plan	Before Plan	After Plan
Less than 2.5 acre	10.54	17.448.58	13.15	
2.5 to 5 Acre	10.89	17.579.09	13.52	
More than 5 and less than 10 acre	11.31	18.048.97	12.85	
More than 10 acre	11.43	17.949.97	14.31	

Source: ANSISS Data.

Table 17 shows the effect of SRI on sale of wheat and paddy. Table shows that sale of wheat and paddy has increased after using SRI. However, effect of SRI in terms of marketable surplus on the production of wheat cultivation is less satisfactory.

Table 17 : Sale Reported by Sample Beneficiaries of SRI Programme in Bihar (in percentage)

Reply	Paddy Cultivation			Wheat Cultivation	
	Before Plan		After Plan	Before Plan	After Plan
Yes	92.97	95.20	89.96	91.03	
No	7.03	4.80	10.04	8.97	

Source: ANSISS Data.

In this section, detailed analysis is presented about the outcomes of SRI practices. Area under cultivation of paddy and wheat has increased due to SRI practices. Productivity of paddy and wheat cultivation has increased significantly. Analysis shows that percentage of farmers who reported increase in sale has increased.

Problems Related to SRI in Bihar

Interactions with beneficiary farmers and other farmers reflected major concerns regarding SRI practices in Bihar. Debates about the adoption of SRI practices are focused on SRI's being more-labour intensive than conventional methods. During

interactions, it was reported by a large number of farmers, especially large farmers that SRI practice is labour intensive. It was noticed during interactions that concern regarding SRI was misinterpreted by some farmers while it has been found that labour costs are relatively lower than those of conventional practices.

A major concern was reported by the farmers that SRI is a more rigorous and exact regime that needs precision-timed operations and constant supervision. non-availability of trained labour is reported as a serious problem because government concentration on agriculture labour to use SRI practices was missing in the flagship programme of Government of Bihar. Lack of specifications regarding the designs of weeders and conoweeders appropriate to different soil types appeared as a serious problem. It was found during household interaction that they were not using weeders and conoweeders because they were not suitable for their land. The SRI principles are applicable in rainfed rice & wheat, and to other crops, such as sugarcane, finger millet, pulses, showing increased productivity over current conventional planting practices. While our study found that SRI principles are applied only to rice & wheat in Bihar it was found in many studies that role of civil society in information dissemination has been important. Unfortunately, involvement of civil society to promote use of SRI is not clear in Bihar. It is known that proper marketing facility also affects agriculture production. Proper marketing facility will encourage farmers to produce more and use better techniques of production. Unfortunately, lack of proper marketing facility was reported by sample farm households in Bihar in the study.

Conclusion and Policy Analysis

This study examines farmer's views on SRI regarding its effects on paddy and wheat production in Bihar. SRI programme has been discussed. Analysis also shows that share of experienced and little older farmers is higher than the younger among farmers in using SRI practices by farm households. This reflects that SRI is famous among little older farmers and experienced farmers and having greater access to irrigation. Analysis also confirms the role of literacy in improving agriculture productivity in Bihar. Productivity of paddy and wheat increased significantly after using SRI practices. Analysis also shows that small farmers also experienced growth in productivity, which is a positive sign for policy makers. However, limitations reported by the farmers include labour intensive nature of SRI, shortage of skilled labour and absence of proper machines useful for different nature of soil which are responsible for the low preference of SRI among farmers. One of the important objectives of present study is to throw up policy recommendation to increase SRI practices in Bihar. Policy recommendations are largely drawn upon the field experiences.

Level of awareness about SRI practices is low in Bihar. Effective Kisan Call Centre facility, printed newsletters, printed leaflets in local languages and street demonstrations like street play can promote farmers to use SRI in Bihar. Special focus is needed on training of agricultural labourers especially about SRI techniques, use of green fertilisers, etc. Village teachers or educated people can be trained as local resource persons to promote farmers to use SRI practices. Involvement of civil society with incentives can promote SRI practices in the State. Recognitions to successful farmers at block district and State level can promote farmers to use SRI method. An alternative technology to conoweeder and weeder for hard soil needs to be developed. Extensive research is needed on the improvement of marketing chain in Bihar.

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