CONSTRAINTS TO THE DISPERSAL OF NRC AGRICULTURAL TECHNOLOGY IN INDIA: THE CASE OF SRI (SYSTEM OF RICE INTENSIFICATION) IN TAMIL NADU

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Introduction

Agriculture sector has been acknowledged as engine of economic growth and critical to poverty reduction through improvements in rural incomes in developing countries like India. Since the beginning of development planning, policy making in India has been occupied by problems of low per capita production of food grains and accompanying food insecurity. This was partly addressed by large scale investments in irrigation early years of planning and subsequent advances brought by the green revolution, helped the country to achieve a technological breakthrough in the agricultural sector in 1960s. In the Green Revolution process, the knowledge and technologies generated by investment in R&D has played major role in achieving food security for its growing population (Ramasamy, 2013) and achieving self-sufficiency of food grains. Besides the achievement of green revolution in attaining high productivity during 1970s and 1980s, it was restricted only to irrigated regions and to particular crops like wheat and rice.

India's high rate of economic growth, since 1990s, has been accompanied with high growth of non-agricultural sectors, particularly the service sector. It seems that agriculture and its allied sector have been neglected for long time under neoliberal economic policies since 1990s (Kakarlapudi, K.K. 2010 and 2012). The ignorance of agriculture and its allied sectors had two major consequences in the economy. There is a reduction of the growth rate of food-grain production from 2.93 % during 1986-97 to 0.93 % during 1996-2008 (Dev S.M and Sharma, A.N. 2010). This decline of food grain production associated with increase in the cost of fertilizers, seeds and irrigation facilities etc. became challenges for the small farmers to purchase it (Ahmad, F. and Haseen, S. 2012). On the other hand, there is a decline of employment rate from 2.7 per cent per year in 1983-94 to only 1.07 per cent per year in 1994-2000 for all India. This was the first time the growth rate of employment is less than the growth rate of population. These kinds of employment pattern have had major effects on the incidence of poverty (Ghosh, J. 2010). It is also most important to note that

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the impact of GDP growth originating from agriculture on poverty reduction is twice as compared to that of GDP growth generated from non-agricultural sector (Shankar, V. 2010). It is very clear that this high rate of economic growth has not been inclusive and failed to trickle down to the poorer sections of the society (Ghosh, J. 2010). Failure of trickle down can be witnessed from the fact that India still has one-fourth of the world's poor (William D. Dar, 2011).

Despite the decline of agricultural growth, majority of Indian population continues to associate with agriculture sector either directly or indirectly for their livelihoods. For India, achieving high rate of food production would be the one of the major challenges over the next 2-3 decades (Daniel, R.R. 2000). Therefore, inclusive Growth has been the prime aim in the course of last two five year plans. The country has not witnessed any big technological breakthrough in agriculture (Government of India, 2011) that can challenge high input driven post green revolution agricultural technologies (Bhatt, K.K. 2015) which are viable for marginal and small farmers.

Technological interventions in agricultural sector are seen as critical to sustain economic growth through policy making. Regardless of its advantage, the green revolution has been criticised for many other reasons. Initially it was criticised for its large farmer bias and bias towards farmers with assured irrigation; of late there is a growing recognition of its negative environmental impacts due to over and disproportionate use of chemical fertilizer, pesticides and water, and depletion of ground water (Abrol, D. 2015) and most importantly, the growing limits to its ability to sustain productivity increases. In this context, there has been a shift in state policies towards emphasis on new technologies that can increase yields with less use of water, chemical fertilizer and pesticides and hence reduce negative externalities. There are many natural resource conserving technologies that have been propagated such as conservation tillage, integrated pest management, soil nutrient testing and precision farming. System of Rice Intensification (SRI) is one among such technologies. This technology has been developed outside the formal research establishment in India as well as other parts of the world. This method of cultivation has some advantages as compared to conventional methods of cultivation in terms of nursery preparation, transplantation process, less use of water, chemical fertilizer/pesticides. It is a labour intensive technology. This technology also has potential to be viable for small and marginal farmers in terms of using of less water and with low cost of inputs (seed, organic fertilizer and less labourers in weeding process), contrary to green revolution technologies in 1960s. (Rajeesh S. 2012 and Mukherjee, K. 2012).

This paper proposes to explore the constraints to the diffusion of SRI technology both in resource endowed (e.g. water) and resource scared (dry land) region in Tamil Nadu. Tamil Nadu is a state that has witnessed dramatic decline in agriculture's contribution to state income and is also a region marked by high levels of rural indebtedness.

Paper is divided into four sections. The introduction and background, statement of the problem and objectives of the study are given in section I. Sources of the data, methodology and theoretical framework of the paper is presented in section II. Discussions on the distribution and constraints of SRI technology are carried out in Section III, while the summary and findings are presented in section IV.

Statement of the Problem

The share of area under SRI cultivation in total area under paddy cultivation in Tamil Nadu has increased from 23.5 in 2007-08 to 52.6 per cent in 2012-13 (Table 2). This increasing trend shows that this technology received positive response from farmers at state level. This technology has covered around 50% of area of paddy cultivation in the state within short span of time. Despite the positive response to SRI from farming community, micro level studies however suggest that there is still inadequate adoption/diffusion of SRI technology in Tamil Nadu (Pushba, 2013). It is necessary therefore to analyse the variation in diffusion of SRI technology across different ecological zones and districts and also across different categories of farming households to identify factors accounting for this variation.

The following questions will help us to address the issue of variations and determining factors (determinants) behind diffusion of SRI technology. What are the factors determining the farmers' adoption behaviour? Who are the stakeholders involved in diffusion process? How are they helping framers to adopt technology? Do government policies and programmes help the farmers to adopt technology? Does extension training make any difference in SRI adoption? Do stakeholders work together to help farmers? Do the resource endowments matter? Do land and labour relations matter? With these questions, this study has following objectives in order to explore the constraints to the diffusion of SRI Technology.

Objectives of the study

1. To understand trend and Pattern of diffusion of SRI in Tamil Nadu
2. To understand the constraints to diffusion of SRI technology in different agro-climatic conditions

Data and Methodology of Study

This study uses both primary and secondary data. The primary data have been used to analyse the constraints to diffusion of SRI technology. Given the absence of precise data on SRI, it was decided to undertake a census in selected villages to identify the precise number of SRI adopters, dis-adopters and non- adopters. First the farmer was asked whether he or she is cultivating paddy fully or partially in their field. Then it was ascertained whether she or he is following SRI technology at present. For this study, a farmer was considered to be non-adopters if the household never adopted or had adopted but withdrew from SRI practice. The system of rice intensification was introduced in Tamil Nadu in 2004 by Tamil Nadu State Agriculture University (TNSAU). Tirunelveli (Tamirabarani river basin) is the first district where SRI technology had been implemented in the state along with Cauvery river basin in Thanjavur district. Despite of early intervention, these are the districts have low diffusion as compared with many districts in Tamil Nadu. Tirunelveli is the district has both river basin and rain-fed (more tank and pond irrigation depends on rainfall) method of paddy cultivation as compared to Thanjavur districts.

The main purpose of this study is to understand the constraints to the diffusion of SRI technology across different ecological zones. Therefore, this study proposes Tirunelveli district, accompanied with both river basin and rainfed regions, as a study area. Two blocks have been selected from Tirunelveli district. These are Ambasamudram from Tamirabarani river basin as water abounded region and Nanguneri from rainfed region. Census has been done in Thottakudi panchayat from Nanguneri block and Melaseval Town panchayat from Ambasamudram block in Tirunelveli district. Focus Group Discussion (FGDs) was also carried out to understand other constraints associated with diffusion of SRI technology. The secondary data have been used to fulfil the first objective of understanding the trend of diffusion of SRI in Tamil Nadu. Area under SRI cultivation is the only available data as far as secondary data is concerned. There are discrepancies between data available from primary and secondary.

Limitations of the SRI data

The data which have been provided by directorate of agriculture has its own limitation. The directorate of agriculture has data only on area under SRI cultivation at district level. The data on production and productivity of SRI technology is not available. Even the data on area under SRI cultivation is over estimated at district level. The area under SRI cultivation is higher than area under total paddy cultivation in certain districts. This data covers only those who have registered with agricultural department. The agricultural department provides limited amount of subsidy. Those who come first or early are only entitled to this subsidy. It is observed from the field that many farmers adopted SRI technology but they haven't informed to agricultural department.

Conceptual framework and Methodology of the Study

The national system of innovation (NSI) has been developed in 1980s by Freeman (1987), Lundvall (1992) and Nelson (1993). This three authors' contribution have enriched the scope of national system of innovation. Freeman (1987) attempts to explain the role of policy, corporate R&D in accumulating process, human capital and role of industries through industrial value chain to understand the innovation performance of a country. Lundvall (1992) emphasis the three building blocks such as (i) sources of innovation and actions of agents (ii) types of innovation (both radical and incremental innovation) and (iii) non-market institutions. Finally, Nelson (1993), tried to look into the set?up of actors and how and why they collaborate. He also tries to explain the institutions 'role in the collaboration of different actors.

The National system of innovation approach has been used to understand the interaction of different stakeholders involved in innovation process. It was also being used to understand how these interactions of different stakeholders are shaped by different social, institutional and political factors (Fagerberg and Verspagen, 2009). Its boundary is limited between countries. NSI has been criticized for its assumption of homogeneity of different regions of a particular country. Regional system of innovation (RSI) has used a particular region (particular geographical area) within country as a boundary to study the interaction of different stakeholders involved in innovation process of particular region. Regardless of its common aspects with NSI it differs in internal organization and relationship between firms, role of public sector and policies along with its own institutional setup. These aspects are missing in NSI at national level. Pavitt (1984) criticised, both NSI and RSI are limited with spatial dimension and not capturing the sectoral differences of technological trajectories. Malerba (2002) has developed an innovation approach called sectoral system of innovation to capture the interaction of different stakeholders in a particular sector.

This study uses the Sectoral System of Innovation (SSI) as a theoretical and conceptual framework to understand the determinants and constraints to the diffusion of SRI technology in Tamil Nadu. There are three building blocks in SSI. These are (i) knowledge and technology, (ii) Actors and Network and (iii) Institutions. These three building blocks cover both aspects of supply and demand sides of diffusion process. These indicators have been identified to understand three building blocks of SSI through a) review of literature and b) from primary field visits and primary census collected in study area.

The following indicators are being used to understand the first building block (knowledge and technology) of Sectoral System of innovation. These are awareness, knowledge and nature of SRI technology being received and practised by farmers. The nature of SRI technology dealing with issues related to types of inputs, nursery preparation, transplantation, weeding process, fertilizer, pesticide, and water and pest management.

The second building block deals with actors and networks involved in technological diffusion process. This study considers individual farmers and farming households as actors and considers farmers' clubs, NGOs and extension departments are considered as networks. Individual farmers and farming households are treated as demand side factors. Gender, age and educational status are covered under individual characteristics that may influence adoption of SRI technology. Households' characteristics or indicators include size of the households, composition of household income (agricultural versus non-agricultural) wealth, landholding size and access to irrigation, credit, and fertilizers at the right time. NGOs, farmers' clubs and SHGs are included to understand the role of networks in diffusion process. Institutions' role in the process of diffusion can be captured through the role of PRI, tenure system, local social norms and customs related to agriculture system.

Importance of System of Rice Intensification in Indian Agriculture Sector

Many countries use rice as a one of the main stable food for its population in this world. These countries need to continue to produce rice for their food in order to maintain low cost food which is essential for country's growth rate (Byerlee, D. 2009). More than 90 per cent of world's rice is grown and consumed in Asia and it is staple food for more than half of global population. India ranks first in terms of area under SRI cultivation (45.54 m ha) and second for SRI production (99.18 m t) owing to low productivity (2.18 t ha-1) (Meyyappan et al, 2013). Rice (Oryzasativa) is the most widely grown crop in India. It is cultivated in 45.50 million hectares and has production of 96.43 million tonnes of grain (Sathish et. al, 2012). India occupies the world's largest share of area under rice cultivation under a wide range of agro-ecological conditions (Sathish et. al, 2012). Tamil Nadu is one of the main rice producing /growing states in India with 1.93 m ha of area under cultivation, 5.18 million tonnes of production and 2.68 tonnes per hectare of productivity which has lower rate than world average of 4.25 tonnes per hectare (Meyyappan et al, 2013). Rice production has to be increased in India to meet the increasing demand and particularly in Tamil Nadu state with the problems of drought, poor quality irrigation water, non-availability and high cost of labour during peak season, shrinking resources and frequent and prolonged power cuts. Now rice cultivation has become a less remunerative due to increased cost of cultivation. System of Rice intensification (SRI) is emerging as a new technology to increase the rice production besides it saves land, water, labour and other resources (Gujja, B. and Thiyagarajan T.M. 2009; Reddy, D.N. and Venkatanarayana, M. 2013).

System of Rice Intensification (SRI) is an improved method of rice cultivation which was developed in 1983 in Madagascar by Fr. De Laulanie, a French priest and agriculturist through working with farmers (Uphoff et.al, 2002). SRI is being conceptualized as system rather than as a technology. It is not fixed package of technical specifications but it is a system of production process based on certain core principles (Namara, R. E., et al 2003). It has been spread to many parts of the world. This is not new variety/hybrid but it is an improved method of cultivation of paddy. Any type of paddy can be cultivated under this method. This method is following six principles/components such as young aged seedlings, careful single seedling transplanting, wider spacing, water management, weeding and compost/organic manuring (Sathish et. al, 2012). There are possibilities in variation of these principles according its local conditions (Namara, R. E., et al 2003). The main advantages of this method of cultivation are less water, less seed (2 kg/ac), fewer plants per unit area (25 cm x 25 cm), less chemical fertilizers, more organic manures and less pesticide (Sathish et. al, 2012). SRI method of paddy cultivation differs from traditional methods of cultivation in terms of higher yields of both grain and straw, reduced duration of crop cycle (by 10-15 days), less chemical inputs, less water requirement, increased grain weight without change in grain size, higher head rice recovery rate, withstands cyclonic gales and soil health improves through biological activity. Nirmala and Vasantha (2013) argue that the places where depleted water resources, stagnated rice productivity, the growing importance of organic agriculture, increased production costs and the need for better utilization of family labour among small and marginal farmers, calls for a shift in cultivation practice. They further argued that the practice of SRI requires not only less demand for water but also of simultaneously increasing rice production (Nirmala and Vasantha, 2013).

Diffusion of System of Rice Intensification in Tamil Nadu

The system of rice intensification was introduced in Tamilnadu in 2004 by Tamil Nadu State Agriculture University (TNSAU). At first SRI technology was experimented among 200 farmers in Cauvery and Tamiraparani river basins of Tamil Nadu. The main aim behind this experiment was to compare the performance of SRI technology with conventional rice cultivation. The comparative result has shown that the SRI cultivation had higher rice yields with less input and 8 per cent of labourer reduction per hectare (Africare, Oxfam America, WWF-ICRISAT Project, 2010). This experimentation result, in Tamirabarani river basin, showed that the yield under SRI technology was ranged from 4214 to 10655 kg/ha as compared to conventional method of cultivation, which ranged between 3887 to 8730 kg/ ha. The additional yield advantage under SRI method of cultivation was an average 1570 kg/ha (Thiyagarajan, T.M. 2006). It is also observed from the field that the method of Square planting was the only constraint faced by workers. SRI technology related data available at directorate of Agriculture of Tamil Nadu starts only from 2007-08 onwards. District level data will help us to understand the diffusion rate of SRI technology. The diffusion rate can be defined as share of area under SRI out of total area under total paddy cultivation. Despite the good performance of SRI technology at macro level, there is variation among different agro ecological zones and districts within the state. It is necessary to analyse the performance of SRI at ecological zones and districts levels to understand the variation in diffusion of SRI technology.

Table 1: Zones wise Area under System of Rice Intensification (share in State SRI cultivation).

Table 1a. Zones wise Area under System of Rice Intensification						
Zones	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**
Cauvery Delta zone	40.39	39.95	33.79	34.57	37.54	32.61
North-Eastern zone	36.16	36.40	36.48	35.74	33.09	44.67
North-Western zone	4.56	5.78	6.36	6.58	5.14	4.80
South Zone	7.05	6.83	11.04	12.42	12.66	11.33
Southern zone	6.27	7.22	7.50	6.41	7.18	4.30
Western Zone	4.68	1.82	3.36	2.88	2.99	0.77
Table 1b. Zone wise share of area under SRI in Total paddy cultivation – (Diffusion Rate)						
Zones	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**
Cauvery Delta Zone	30.1	33.3	36.3	48.0	56.9	41.7
North Eastern Zone	26.4	34.3	41.4	48.9	58.5	59.1
North Western Zone	28.5	39.8	57.5	63.8	61.5	67.4
South Zone	7.8	9.1	18.4	25.9	35.9	29.4
Southern Zone	18.8	27.6	39.1	51.9	45.2	35.6
Western Zone	44.2	19.2	41.2	47.3	63.2	57.8
State	23.5	27.9	35.2	44.6	52.6	45.9

Source: Directorate of Agriculture Tamil Nadu

Almost 77 per cent of area under SRI technology is being occupied by North Eastern and Cauvery Delta zones in Tamil Nadu. Despite of high and increasing trend in diffusion rate, the area under SRI technology has shown a deceleration trend in Cauvery Delta. On the other hand, North Eastern zone has shown an increasing trend both in diffusion rate and area under SRI technology from 2007-08 to 2012-13. The ensured and viable irrigation facility in these regions could be the reason for its better performance. As far as diffusion rate is concerned both Western and North Western zones are doing better than Cauvery

Delta region. Both the South and Southern zones are lacking behind in the as far as diffusion of SRI technology is concerned. Diffusion of SRI technology in southern zone follows state's average diffusion rate of SRI technology. Despite increasing trend of diffusion rate, South zone still has lowest diffusion rate in the state as compared to other zones in Tamil Nadu. Sothern and Western zones contribute the lowest share in state's area of SRI cultivation. Southern zone consists of two main rice producing district namely Tirunelveli and Thoothukkudi districts. In sum, diffusion of SRI technology in south zone is lower than all other zones in Tamil Nadu. Apart from agro-climate zone level analysis, it is also necessary to have district level analysis to understand micro level variations of diffusion across districts level.

Table 2: District wise the share of area under SRI in area under paddy cultivation from 2007-08 to 2012-13 in Tamil Nadu

District wise Diffusion of SRI Technology in Tamil Nadu						
	2007-08	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**
Cauvery Delta Zone						
Ariyalur	0.00	0.00	48.50	49.58	79.58	92.60
Karur	31.37	14.08	39.97	52.67	59.55	90.42
Nagapattinam	35.90	31.43	32.88	48.19	56.75	22.92
Perambalur	17.31	84.68	42.19	44.23	28.63	21.12
Thanjavur	23.63	41.79	35.04	50.78	55.02	57.70
Thiruvarur	34.29	30.95	35.91	42.44	58.29	31.47
Tiruchirapalli	28.55	29.51	42.15	53.45	62.87	72.73
North Eastern Zone						
Cuddalore	33.46	37.19	41.79	42.40	49.35	43.14
Kancheepuram	38.31	55.79	54.82	64.76	71.45	97.58
Thiruvallur	27.95	42.32	35.58	57.20	52.01	67.78
Thiruvannamalai	18.46	25.81	40.41	36.82	50.33	51.98
Vellore	16.69	36.70	48.28	61.77	72.39	75.34
Villupuram	22.35	19.30	35.03	45.55	64.38	43.60
North Western Zone						
Dharmapuri	19.68	41.73	45.30	69.55	54.68	89.98
Krishnagiri	21.36	32.83	57.00	80.19	74.59	65.34
Salem	14.28	36.75	61.93	48.35	44.69	61.10
Namakkal	76.20	51.05	71.11	71.85	109.48	39.68
Western Zone						
Coimbatore	43.22	50.52	42.60	41.26	45.64	55.66
Erode	44.32	22.60	41.19	51.01	67.91	56.04
Thiruppur	0.00	0.00	40.98	37.30	52.77	122.45

South Zone						
Dindigul	17.94	24.95	38.45	53.41	57.94	35.88
Madurai	17.62	21.74	29.03	42.91	54.24	57.70
Pudukottai	13.87	10.48	25.92	31.54	40.61	42.59
Ramanathapuram	0.00	0.08	1.49	4.57	6.75	4.29
Theni	24.31	34.66	44.24	55.36	62.44	41.66
Sivagangai	0.00	2.60	21.98	29.07	79.57	78.35
Southern Zone						
Virudhunagar	8.86	7.93	14.36	25.39	18.92	24.01
Tirunelveli	20.91	50.22	55.21	48.17	54.92	48.64
Thoothukudi	24.92	18.06	14.02	11.13	11.14	6.05
Kanyakumari	18.67	23.79	16.41	15.31	15.03	21.29
State	**23.52**	**27.87**	**35.21**	**44.60**	**52.60**	**45.90**

Source: Directorate of Agriculture Tamil Nadu

There are many districts which have been able to maintain their diffusion rate at an increasing rate form 2007-08 to 2012-2013 in the state. These are Ariyalur, Karur, Tiruchirapalli and Thanjavur in Cauvery delta zone and Kancheepuram and Vellore in North Eastern zone. Regardless of its good performance, Cauvery delta zone has uneven distribution of diffusion rate at districts level. There are seven districts in Cauvery delta zone of which Ariyalur, Karur and Tiruchirapalli show increasing trend of diffusion rate of SRI technology while Perambalur and Thiruvarur showing deceleration trend in diffusion of SRI technology. The distribution of diffusion rate of SRI technology is almost even in North Eastern and North Western zones as compared to Cauvery Delta zone. Three districts constitute the Western zone namely Coimbatore, Erode and Thiruppur. Off these Erode district's share is highest compared to other two districts.

The diffusion rate of SRI technology in south zone is very low at macro level. The distribution of diffusion rate of SRI technology in south zone is uneven. Pudukottai in south zone ranks first in terms of area under SRI cultivation as compared to other districts in the same zone and it has sustained its position. But the diffusion rate of SRI technology is much lower than its counterpart in the same zone. Madurai, Theni and Sivagangai have better diffusion rate of SRI technology than Pudukottai district in south zone. Diffusion rate of SRI technology in Dindigul and Ramanathapuram is very low as compared to their counterparts in south zone.

The diffusion of SRI technology is uneven in southern zone. Tirunelveli occupies high share of area under SRI cultivation compared to other two districts in southern zone namely

Thoothukudi and Virudhunagar. This high rate of diffusion in Tirunelveli might be attributed to early government intervention in Tamirabarani river basin. Many districts of Tamilnadu are performing well in SRI cultivation for example Kanchipuram and Thanjavur district. This study selects Tirunelveli district as study area to understand the technical and social constrains of SRI diffusion process. Despite of early intervention by government, Tirunelvei district is standing far behind many other districts in different zones.

System of Rice Intensification in Tirunelveli District

Tirunelveli district is blessed with the Western Ghats from which the perennial rivers flow and drain towards the east. Thamiraparani is the major river system in the District. There are many other streams which are seasonal in nature such as Servallar, Manimuthar, Ramanathi, Pachayar, Chittar and Uppodairivers. They drain into the Thamiraparani basin. Canal, Tank and Well are main sources of irrigation in Tirunelveli district. Paddy occupies the largest area of cultivation, followed by cotton. Paddy is cultivated mainly in Tirunelveli, Palayamkottai, Tenkasi, Shencottai, Ambasamudram and Nanguneri taluks. Besides SRI being practiced in all the districts of Tamilnadu, Tirunelveli is the first district where SRI technology had been implemented in the state along with Cauvery river basin. Over a period of time many districts such as Kancheepuram, Vellore, Dharmapuri and Sivagangai would be able to perform and maintain good diffusion rate. But Thanjavur and Tirunelveli, notwithstanding early intervention, were not able to compete with other good performing districts in Tamil Nadu.

Characteristics of SRI adopted households in the Study area

Diffusion of SRI technology is defined here as the proportion of households adopting SRI out of total paddy cultivating households. As shown in table number 3, there are 169 out of 700 paddy cultivating households using SRI technology. This accounts for 24 per cent of total paddy cultivators of both panchayats. This 24 per cent of SRI households may or may not follow traditional method of paddy cultivation along with SRI technology.

Table 3: Distribution of SRI cultivators

	No of Paddy Cultivating HHs	%
SRI Adopters	169	24.1
Non-Adopters	531	75.9
Total	700	100

Source: Primary Survey 2015.

SRI technology has been advocated as a water saving technology along with other natural resources. There are many studies made an attempt to prove this empirically. This study has shown that the diffusion rate of SRI technology is higher in Thottakudi panchayat (less water endowed region) compared with Melaseval town panchayat (Table. 4). There are variations in the diffusion rate of SRI among SRI adopters in Thottakudi panchayat in terms of size of land holding and sources of irrigation. (The variations are negligible).

Table 4: Distribution of diffusion rate of SRI technology different study areas

Names of Panchayats	Non-Adopter	SRI Adopters	Diffusion Rate	Total
Thootakudi	233	82	26.0	315
Melaseval	298	87	22.6	385
Total	531	169	24.1	700

Source: Primary Survey 2015.

Different Types of SRI Technology

Rope or manual method of SRI cultivation is recommended by the principles of SRI technology. Regardless of SRI principle, SRI has its own flexibility as per local conditions. There are three types of SRI cultivation in selected study areas. These are manual, machine and drum seeder. These methods are categorised based on the way in which seedlings are being transplanted. There are 96 out of 169 SRI households using rope or manual method in total SRI cultivation which accounts for 56.8 per cent of total SRI households. The Drum seeder method of cultivation ranks second after rope method of cultivation. Around 36 per cent of total SRI adopted households use drum seeder method of SRI cultivation.

Table 5: Distribution of different types of SRI Methods

Types of SRI	Frequency	Percent
Rope	96	56.8
Machine	12	7.1
D.S	61	36.1
Total	169	100

Source: Primary Survey 2015.

It is observed from the field that all three methods being practiced in Thottakudi panchayat while Melaseval town panchayats mainly follows only rope method of SRI technology[1]. All the 61 households who use the drum seeder method of SRI cultivation belongs only to Thootakudi panchayat. None of the SRI households in Melaseval town panchayat practice drum seeder method of SRI cultivation. The Drum seeder method of paddy cultivation contributes around 36.1 per cent of total SRI households, which is mostly used by BC and MBC castes when compared to other castes and SC households (table 5).[2]

Among BC, almost all farmers in Nadar community use Drum seeder method of SRI cultivation. They are closely followed by Yadav community. This drum seeder machine cost is around 5000 rupees. This Drum seeder machine is also being given to other farmers for rent. Notwithstanding the availability of subsidy to buy input (even drum seed machine), the method of drum seeder cultivation is restricted only to a particular community.

Landholding Size and Diffusion of SRI technology

The landholding size has been considered as a most important factor in adoption studies. As far as conventional method of cultivation is concerned the farmers are ready to allocate major proportion of land because the farmers have experience and aware of risk. Large holding farmers may do experiment of new technology in small portion of their farm and understand about viability of new technology. But in the case of small farmers they only having small size of land holding they don't want to lose their profit by doing trial and error in their small portion of land. It is also identified through the empirical study that large holding farmers are more dents to adopt new technology as compared to small holding farmers. It is identified in empirical literature that the inadequate farm size constrains to rapid adoption of new technologies (Diederen, 2003 and Feder, G. et. al., 1985). Farm size is being used as one of the important economic factors in diffusion studies (Diederen, 2003 and Feder, G. et. al., 1985). Large holding farmers may do experiment with new technology in small portion of their farm and hence are able to understand about viability of new technology. But in the case of small farmers (observed from the field) they only have small size of land holding so they cannot afford to do trial and error.

Table 6: Distribution of SRI diffusion rate across landholding size[3]

Class Size	Non-Adopters	%	SRI Adopters	Diffusion Rate	Total
Marginal	306	86.4	48	13.6	354
Small	114	70.4	48	29.6	162
Semi-Medium	77	62.6	46	37.4	123
Medium	34	58.6	24	41.4	58
Large	0	0.0	3	100.0	3
Total	531	75.9	169	24.1	700

It is identified that, there is direct or positive relationship between size of landholding and diffusion of SRI technology. As size of landholding increase there is corresponding increase in diffusion rate of SRI. The diffusion rates of SRI for marginal, small, semi-medium, medium and large farmers are 13.6, 29.6 37.4 and 41.4 per cents respectively. As landholding size increases the farmers can do demonstration in their field and if SRI gives potential yield then they continue. It is identified in empirical literature that the inadequate farm size constrains to rapid adoption of new technologies (Diederen, P. et. al., 2003 and Feder, G. et. al., 1985). SRI technology is supposed to be scale neutral technology by its components/ principle as compared to many post green revolution technologies. But this study shows that diffusion of SRI technology is low among small and marginal farmers and seems to be biased to medium and large farmers (Table, 5). The reason is being observed from field that marginal and small farms are not in a position to take risk as compared to their counterparts. The farm size also has impact on adoption costs, risk perceptions, human capital, credit constraints, labour requirements, tenure arrangements and so on (Bonabana-Wabbi J. 2002).

Educational Status and Diffusion of SRI technology

The education plays a major role at the time of decision for the adoption of new agricultural technologies. It is also being argued that for early adopters of new technology, education is most important factor. It is also an important factor that helps the farmer to have a good contact with extension officials. This relationship would help farmers to get more information about new technology. The spread of information about new technology would increases the rate of spread of a particular new technology. Through literature, it is identified that the limited access to information about new technology constrains the rate of adoption of new technology (Blackman, A. 1999; Feder, et. al., 1985; Rosenberg, 1976; Norris and Vaizey 1973; Carolina Oleas et. al, 2010; Weir S. and Knight J. 2000; Anderson et. al, 1999: and others), aversion to risk (Feder, G. et. al., 1985 and Wejnert, B. 2002). It also assumed that educated farmers are more informative and look for appropriate available technologies as an alternative for conventional method of production. As far as SRI technology is concerned, the educational level is an important explanatory variable in explaining adoption decision. This is because, the SRI technology is highly skill and knowledge based technology. From this study, it can be observed that there is a positive relationship between education status of decision makers and diffusion rate of SRI technology.

Table 7: Distribution of SRI diffusion rate across the educational status

Educational Status	SRI -Adopters	Diffusion Rate	Non-Adopters	%	Total
Illiterates	17	21.8	61	78.2	78
Primary	47	19.4	195	80.6	242
Middle	41	24.3	128	75.7	169
Upper Middle	36	28.3	91	71.7	127
Higher S	14	33.3	28	66.7	42
UG	9	37.5	15	62.5	24
PG	4	30.8	9	69.2	13
Dip	1	20	4	80.0	5
Total	**169**	**24.1**	**531**	**75.9**	**700**

Sources of Irrigation and Diffusion of SRI technology

SRI is being propagated as water saving technology. SRI technology follows controlled irrigation (wet and dry) method contrary to traditional method of paddy cultivation namely flooded irrigation method (standing water). It is identified from the field that SRI method of cultivation needs irrigation just to maintain the soil with moisture. The frequency of irrigation depends on soil and weather conditions of a particular location (Durga, A.R. and Kumar D.S. 2016).

Table 8: Distribution of SRI diffusion rate across sources of Irrigation

Sources of Irrigation	SRI – Adopters	Diffusion Rate	Non-Adopters	%	Total
River	80	21.3	295	78.7	375
Well	30	29.1	73	70.9	103
Tank	18	14.2	109	85.8	127
Both (Well+Tank)	37	40.7	54	59.3	91
Both (River+Well)	4	100	0	0.0	4
Total	**169**	**24.1**	**531**	**75.9**	**700**

Source: Primary Survey 2015.

The diffusion of SRI technology is high among farmers who have both tank and well as sources of irrigation. There are 37 out of 91 farming households who have both well and tank as sources of irrigation adopted SRI technology. The diffusion of SRI technology is low among the farmers who have Tank irrigation as main sources of irrigation. River as sources of irrigation occupies highest (80) in numbers but it ranks second in terms of diffusion rate. All the four categories of farming classes are using both river and well as sources of irrigation to adopt SRI technology. SRI technology, by principle, is being promoted as water saving technology but this analysis finds out that diffusion of SRI is very low among the households which have tank irrigation as sources of irrigation. SRI is water saving technology but households need to have ensure minimum irrigation facility to adopt the same. The lower diffusion rate of SRI is being observed, due to the absence of ensured irrigation facility. It is observed that the adoption of SRI technology without ensured irrigation facility would lead to risk for the small and marginal farmers.

Table 9: Distribution of SRI diffusion rate across caste

Castes	SRI – Adopters	Diffusion Rate	Non-Adopters	%	Total
MBC	38	16.7	189	83.3	227
BC	61	26.2	172	73.8	233
SC	67	30.3	154	69.7	221
Others	3	15.8	16	84.2	19
Total	**169**	**24.1**	**531**	**75.9**	**700**

Source: Primary Survey 2015.

The above table depicts the diffusion rate of SRI technology across castes classification of farming households. The diffusion rate of SRI technology among MBC and Other castes is same. Farming households belonging to SC caste secure highest rate of SRI diffusion followed by households belonging to BC caste. The reason for highest diffusion rate among SC caste is that 30 per cent of fund should be provided to SC households as per provisions of SRI technology by Government. Thottakudi panchayat have achieved this scheme of fund allocations for SCs/STs but it is not the case in Melaseval town panchayat.

Land Tenure and Diffusion of SRI Technology

It is more important for diffusion studies to consider the tenure system. Tenure system reduces the probability to adoption of new technologies. The tenure system reduces the probability of adoption of SRI technology as there is no incentive for long term investment by tenants, which SRI technology requires (Malla, R. 2014). Land tenure, insecure property right are also issues that acts as hindrance at the time of accessing institutional credit for tenants.

Table 10: Distribution of SRI diffusion rate across land ownership

Land Ownership	SRI – Adopters	Diffusion rate	Non-Adopters	%	Total
Own Land	101	20.3	396	79.7	497
Leased in	27	28.7	67	71.3	94
Both (own+lease in)	41	37.6	68	62.4	109
Total	**169**	**24.1**	**531**	**75.9**	**700**

Source: Primary Survey 2015.

The diffusion rate of SRI technology is higher among the households who have both own land and leased-in land. The diffusion rate is low among farmers with own land as compared to farmers with leased-in land. The reason behind this is that more than 55 per cent of farmers with own lands are marginal farmers, which have lower diffusion rate (see table 5 above).

Government Intervention

Though India ranks first in terms of numbers of SRI adopters in the world but the diffusion rate of SRI technology is very slow. However, it is observed that SRI has taken root most successfully in some parts of the country particularly in Tamilnadu and Andhra Pradesh. The system of rice intensification was introduced in Tamilnadu in 2004 by Tamil Nadu State Agriculture University (TNSAU). As mentioned earlier, at first SRI practice was experimented among 200 farmers in Cauvery and Tamiraparani river basins of Tamil Nadu (Malla, R. 2014). After considering the advantages of SRI technology, the Tamil Nadu government has included many programmes to promote SRI technology namely NFSM, Whole Village Concept and Integrated Cereal Development Programme. One of the factors behind the progress of SRI technology in Tamil Nadu is that the state government provides a financial incentive of Rs. 4,000 per hectare.

The state also provides training, inputs, SRI tools (weeders and markers), technical assistance and constant monitoring to farmers. In Tamil Nadu, SRI has been introduced as a "Whole Village" concept in 2011-12 in which the entire village is selected for demonstration. This has resulted in increase in area under SRI cultivation for following years, according to data provided by the state government. Moreover, during 2011-12, Tamil Nadu government announced the Chief Minister Special Award for the best SRI technology cultivator. This award contains Rs 5 lakh cash and a medal. The special award has been given to farmers with the highest yield of 20680kg/ha and 15275kg/ha for the years of 2013 and 2014 respectively.

Extension/Social Network

The access to information and knowledge about particular technology from extension department is an important factor for adoption and diffusion of new technology. An empirical study by Diiro, G.M. (2013) identified a positive relationship between accessing extension service\advice and adoption of new technologies. The extension is provided by agricultural extension department (sometimes association with other social networks as mentioned above), which is usually associated with agricultural university. Extension department follows different methods to disseminate information and knowledge about new technologies. These are training, field experiment, demonstration about new technologies through screening movies and street plays in local and colloquial language etc. It also provides these services by organising programmes in government TV channels (Pon Vilaiyum Bhoomi in DD Podhigai). It also disseminates the information about new technologies through all India Radio programmes (e.g. Vayalum valvum).

Social Networks

It has been established that states also encourage, NGOs, SHGs and farmer's clubs to participate in extension activities (Sulaiman, P.V. 2003). It is observed from the field that the SRI adopters are also associated with NGOs to get information, knowledge and training about SRI technology. NGOs are also doing demonstration and regularly monitoring farmers from preparing nursery field stage to harvesting stage. Self Help Group is an institutional innovation which helps the farmers in accessing institutional credit. Many farmers reported that they also depend on Self Help Groups to access institutional credit without any personal collateral security. It is observed, through FGDs, the commercial banks asked the farmers to submit property security for institutional credits but if farmers go through SHG it is not necessary to submit personal collateral securities. Farmer's clubs are also helping the farmers to adopt SRI technology. Farmer's clubs also provide training to SRI farmers and come to the field to demonstrate SRI technology. They provide fertilizers, cono-weeder machine and hand spry machine. They keep informing farmers about SRI practices through mobile phones. Farmer's clubs invite the farmers to have periodical meetings. All these institutional innovation bodies - NGOs, SHGs and Farmers clubs - are restricted with few SRI adopters and working in their own comfort zone.

Conclusion

There are many districts that are lacking behind in diffusion rate particularly in districts where Government have promoted SRI technology first namely Thanjavur and Tirunulveli. The prevalence of SRI technology is low in rainfed regions as compared to river basin or water abounded regions. The observation of this study shows that diffusion rate of SRI is quite predominant in rain-fed region but not at the expected level. This paper suggests that the Government should also make the extension department more active in less resourceful regions and try to concentrate on small and marginal farmers by providing enough complementary infrastructure facilities. As per the SRI provisions, 30 per cent of fund has to reach SCs/STs farmers, Thottakudi panchayat have achieved this scheme of fund allocations for SCs/STs but it is not the case in Melaseval town panchayat. Majority of SRI adopters were not aware of government support schemes due to asymmetric information. Further, it can be observed form above analysis that the SRI prevalence is low among small and marginal farmers. As per principle of SRI technology, it supposed to be scale neutral but not in reality. In order to make SRI technology as more (scale neutral) viable to small and marginal famers, this study suggests that Government should address the location specific issues of labour, institutional credit and supply of fertilizer for small and marginal at right time. Finally, it is evident from this micro level study that the synchronization of these three blocks (i.e. (i) knowledge and technology, (ii) Actors and Network and (iii) Institutions) is not synchronizing. It is therefore expected, as per sectoral system of innovation framework, that all three building blocks should co-ordinate among themselves and function together.

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References

The references to the article is available with the author

End Notes:

1. The soil/mud condition in Melaseval is very slimy which is not suitable either machine

or drum seeder method of SRI technology.

2. All the 61 households practicing drum seeder method of SRI cultivation are in Thootakudi panchayat. There are 58 out of 61 households (95 per cent) use drum seeder method of SRI cultivation which belongs to BC and MBC caste.
3. This study follows the definition of Agriculture Census to classify paddy cultivators based on their landholding size. The main difference between agricultural census and this Study Census is that the former one classifies farmers in terms of hectare while later (this study) classifies farmers in terms of acres. There are five types of famers as follows small, marginal, semi-medium and large farmer