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# System of Rice Intensification (SRI) for Mitigating the Risks of Climate Change: A Study of Three Settings from Tamil Nadu

**A. Narayanamoorthy, P. Jothi and R. Suresh***

ABSTRACT

Climate change is seen not only to reduce the number of rainy days and freshwater availability but also increase crop water requirement due to rising temperature. Therefore, cultivating paddy, which is a water guzzling crop, under the conventional inundation method is going to be very difficult venture for farmers in the future. The new method of paddy cultivation popularly known as the System of Rice Intensification (SRI) seems to be very useful to paddy cultivating farmers to overcome the issue of water scarcity arsing due to climate change. Though SRI has been in practice over the last few years in India, not many studies have attempted to find out as to whether SRI method of paddy cultivation will be useful to farmers to mitigate the risks of climate change covering different ecological settings namely tank, canal and groundwater irrigated areas. In this study, an attempt has been made to fill this gap using data collected from a total of 300 sample farmers from three different settings in Tamil Nadu state. The study shows that SRI farmers are able to save 34 per cent of water in canal irrigated setting, about 41 per cent in tank irrigated setting and about 45 per cent in groundwater irrigated setting as compared to non-SRI farmers. With substantial saving of water, SRI farmers were able to harvest about 46 per cent of higher productivity than non-SRI farmers; the highest productivity difference of about 51 per cent was observed in groundwater setting. Through saving of water, fertiliser and other inputs, about 23 per cent of reduction in the cost of cultivation were also realised by SRI farmers. Because of increased productivity and reduction in cost of cultivation, SRI farmers were able to generate an additional profit of Rs.17,169/acre over the profit earned by farmers cultivating paddy under conventional inundation method.

**Keywords: Climate change, SRI, Paddy cultivation, Water saving, Farm profitability.**

**JEL: Q15, Q21, Q25, Q54**

## I

## INTRODUCTION

The major objective of the paper is to find out as to whether SRI method of paddy cultivation will be useful to farmers to mitigate the risks of climate change, which is expected to reduce water availability and rise temperature (Dinar *et al*., 1998; IPCC, 2007; Government of India, 2008). Paddy is an important foodgrain crop cultivated predominantly throughout the Asia and other parts of the world. Rice is a staple food for over half of the world's population. With the cultivated area of over 44 million hectares, paddy accounts for over 35 per cent of India's total foodgrains area and over 23 per cent of the cropped area in 2016-17. The current production of paddy is over 105 million tonnes, which is little less than 50 per cent of the total

*Senior Professor and Head, Assistant Professor and Research Associate respectively at the Department of Economics and Rural Development, Alagappa University, Karaikudi-630 003 (Tamil Nadu).

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foodgrains production in India (Government of India, 2018). Besides providing livelihood opportunities to millions of farmers in India, cultivation of paddy directly provides employment opportunities to the rural labourers who are relying on agriculture for their livelihood. Unlike the other crops, paddy is also paid as wage (in kind) to the agricultural labourers in most parts of South Asia, which also helps to reduce the rural poverty to a greater extent (Narayanamoorthy, 2001).

Cultivating paddy under conventional inundation method is going to be difficult for farmers because of declining water availability that is reportedly happening due to climate change. Climate change is expected to reduce the number of rainy days and availability of freshwater (IPCC, 2007, Mall *et al*., 2006). With rising temperature due to climate change, the crop water requirement will also increase substantially. The estimate shows that about 70-80 per cent of freshwater withdrawals at the global level are used for the agricultural purpose and rice accounts for about 85 per cent of it (WWF, 2007). Paddy being an important water intensive crop (consumes 3000-5000 litre to produce one kg of rice as against the requirement of only 900 litre for wheat), irrigation water supply is essential to increase its productivity. The inundation method of paddy cultivation, which normally requires large amount of chemical inputs, is also no longer effective in increasing the productivity of crop as the yield increasing inputs do not effectively reach the crop because of leaching and evaporation losses (Narayanamoorthy, 2013; Narayanamoorthy and Suresh, 2013).

Given the expected impact of climate change, there is a need to adopt available technologies like changing variety, planting dates, better agronomy and efficient use of water and nutrient management to offset the impact of climate change (ISAE, 2019, Mall *et al*., 2006. A new method of paddy cultivation popularly known as System of Rice Intensification (SRI) is proved to increase the yield of paddy significantly with less water, less seed and with less chemical inputs than the conventional method of paddy cultivation (WWF, 2007; Reddy, *et al*., 2005; Jagannath *et al*., 2013). SRI is not a new variety or hybrid, but it is only a new method of cultivation, where a set of innovative principles are followed for cultivating paddy. It was first developed in the 1980s by Henri de Laulanie, a French priest and farming practitioner living in Madagascar, and furthered in the 1990s by passionate farmers, scientists and researchers (Uphoof, 2004; World Bank, 2008).

World Bank (2008) surmises that six key elements distinguish SRI farming practices from traditional rice growing methods. They are; (a) transplanting seedlings much earlier than in conventional methods, (b) planting only one seedling per hill, rather than a handful, (c) spacing plants wider apart than in conventional methods and arranging them in a square pattern, (d) applying water intermittently instead of continuous flood irrigation, (e) using rotary weeding to control weeds and promote soil aeration, and (f) applying organic fertilisers to enhance soil fertility and yield. The available studies on SRI method of paddy cultivation suggest that farmers can double the paddy productivity with lesser use of farm inputs and irrigation water. Using SRI method of paddy cultivation, countries like India, Indonesia, Cambodia, Vietnam, and the Philippines have recorded increase of rice yield from 60 per cent to over 170 per cent (World Bank, 2008). The studies carried out in different locations in India do suggest that SRI method can significantly increase productivity of paddy (WWF, 2007).

In view of the importance of SRI method, both the Central and State governments have introduced various promotional measures including subsidy scheme for popularising this method in a big way. While the area under SRI-paddy has been increasing in India, comprehensive studies using farm level data covering different agro-ecological settings are lacking. Further, studies by and large have only highlighted the impact of SRI on its productivity, but ignored the resource and other aspects of SRI. The impact of SRI on water use, productivity, etc., is also expected to be different when different sources of irrigation water are used for cultivation, which somehow has not been adequately covered by the existing studies. Therefore, there is a need to study the varied impact of SRI under different settings using farm level survey data. Especially, one needs to find out credible answers to the questions such as: Can farmers cultivate paddy with reduced water availability? What is the saving of water due to the adoption of SRI? Whether SRI reduces the cost of cultivation or cost of production? What is the total saving in cost of cultivation due to SRI method? Is SRI capable of increasing the productivity of paddy? Can SRI method generate the same amount of benefits when different sources of irrigation water are used for its cultivation? Not many comprehensive studies are available covering all these issues. Therefore, the present study aims to fill this gap using field data collected from three different settings located in Pudukkottai district of Tamil Nadu State.

## II

## DATA AND METHOD

The study has been carried out using field survey data collected from three different irrigated settings in Pudukkottai district of Tamil Nadu state. Tamil Nadu has been one of the important paddy growing states in India. As per the recent data (2015-16), paddy was cultivated in an area of 2.04 million hectares in the State, which was almost 5 per cent of the India's total paddy area. Paddy is cultivated using different sources (tank, canal and groundwater) of irrigation water in the State. Since the impact of SRI method of paddy cultivation on different parameters is expected to be varied under different settings, the study was carried out in three different locations (settings), namely, the areas irrigated by tank, canal and groundwater. One of the objectives of the study is to capture the economic and resource impact of SRI method and therefore, a comparison was made between SRI and non-SRI farmers in all parameters.

Though paddy has been cultivated as a major crop in most districts in Tamil Nadu State, Pudukkottai district was selected purposively as it has (1) large area under paddy, (2) severe water scarcity, and (3) SRI method is practised in all three settings, namely, tank, canal and groundwater irrigated areas. As regards the selection of sample farmers, from each selected setting namely tank, canal and groundwater irrigated region, 100 sample farmers (50 from SRI method and 50 from conventional non-SRI method) were selected for the study. That is, altogether a total of 300 sample farmers were selected for the study from three selected settings to collect field data pertaining to samba season (*kharif*) 2011-12. Since SRI is a newly introduced method of paddy cultivation, its spread is not uniform. Therefore, detailed discussions were made with the officials of the Agricultural Department of Pudukkottai district to identify the suitable locations for carrying out the field survey. While Thirumayam *taluka* was selected as tank irrigated setting, Alangudi *taluka* was chosen as groundwater irrigated setting. Because of very thin spread of SRI method of paddy cultivation in canal irrigated area, both Aranthangi and Avudaiyarkoil *talukas* were selected as canal irrigated setting. Purposive sampling method was followed for selecting the sample farmers because the spread of adoption of SRI method is very limited in each village. The SRI adopter farmers were identified in each selected locations with the help of the Agricultural Officer of the respective *taluka*. As the soil and other locational factors play a considerable role in determining the water use and productivity of crops, farmers who have cultivated paddy using conventional method very close to the field of SRI method were selected as non-adopters of SRI.

In order to capture the impact of SRI on water use and other parameters of paddy cultivation, comparison was made between the two categories of farmers in all the parameters. One of the major advantages of SRI method of paddy cultivation is that it can increase the productivity of paddy significantly as compared to the same cultivated under conventional method. In order to study the impact of SRI method of paddy productivity more precisely, multiple regression analysis was carried out. The variables used in the regression model were age of the farmers (AGE), education of the farmers (EDU), farming experience of the farmers (FEE), fertiliser cost (FER), cost on farm yard manure (FYM), pesticides cost (PST), costs on weeding and interculture (WAI), cost on irrigation application (IRR), cost on machinery spent for field preparation (MCF) and dummy variable representing the method of paddy cultivation (MCD). As the study was carried out at three different locations with three different sources of irrigation, multiple regressions were estimated separately for each source of irrigation and also combining all the three sources of irrigation. The reduced form of the regression model used in the analysis is as follows:

$$PoP = a + b_1\,AGE + b_2\,EDU + b_3\,FEE + b_4\,FER + b_5\,FYM + b_6\,PST + b_7\,WAI + b_8\,IRR + b_9\,MCF + b_{10}\,MCD + u \quad \text{....(1)}$$

where,

PoP = Productivity of paddy (kg /acre)
AGE = Age of farmers (years)
EDU = Education of farmers (years)
FEE = Farming experience of farmers (years)

FER = Fertilisers cost (Rs./acre)
FYM = Farm yard manure cost (Rs./acre)
PST = Pesticides cost (Rs /acre)
WAI = Weeding and interculture cost (Rs./acre)
IRR = Irrigation cost (Rs./acre)
MCF = Machinery cost on field preparation (Rs./acre)
MCD = Dummy variable to represent method of cultivation (SRI=1; non-SRI=0)
u = error term.

III

## RESULTS AND DISCUSSIONS

### 3.1 *Characteristics of SRI and Non-SRI Farmers*

The adoption of any new technology/method in agriculture is not only determined by the economic factors but also the social and personal characteristics of the farmers. It has been established by the studies that the early adopters of any new technology in agriculture are mostly the young and educated farmers. Since SRI is a relatively new method of paddy cultivation in India, let us first understand the characteristics of farmers cultivating paddy before getting into the economic and resource aspects of the study. Table 1 presents the socio-economic characteristics of the sample farmers. It was expected that the average age of farming head would be relatively less among farmers cultivating paddy under the method of SRI as compared to farmers cultivating paddy under conventional method. But, against our expectations, the average age of the farming head was found out to be more or less the same for both the categories of farmers. Except in the case of tank irrigated area where the average age of the SRI farmers was relatively less (47.94) as compared to farmers cultivating paddy under non-SRI method (50.88), the average age was relatively higher among SRI farmers in the other two settings. This suggests that the new method of paddy cultivation is not only adopted by young farmers but also the other farmers in the study area.

The survey shows that farmers having less experience in farming have adopted SRI method. Similar to this, the education level was also marginally better among SRI farmers (7.49) as compared to its counterpart (6.83). The results of both the farming experience and the education level of farmers appear to suggest that farmers with higher literacy rate and with less farming experience are willing to adopt this new method of paddy cultivation. Landholding size of farmer is an important factor which plays a crucial role in determining the adoption of any modern method in crop cultivation. Farmers with larger landholding generally have more resources and also have risk bearing capacity as compared to small size holders. Therefore, the landholding size of SRI farmers is expected to be relatively large as compared to farmers cultivating paddy under conventional inundation method. As expected, the

TABLE 1. SOCIO-ECONOMIC CHARACTERISTICS OF SRI AND NON-SRI FARMERS

| Sl. No (1) | Parameters (2) | TIA CM (3) | TIA SRI (4) | CIA CM (5) | CIA SRI (6) | GIA CM (7) | GIA SRI (8) | ASA CM (9) | ASA SRI (10) |
|---|---|---|---|---|---|---|---|---|---|
| 1) | Age (years) | 50.88 (12.98) | 47.94 (9.36) | 46.66 (6.39) | 47.58 (7.66) | 44.56 (11.10) | 46.61 (13.07) | 47.33 (10.16) | 47.37 (9.85) |
| 2) | Farming experience (years) | 30.16 (14.16) | 23.94 (12.91) | 24.04 (7.67) | 22.72 (10.62) | 22.98 (11.67) | 22.04 (11.10) | 25.84 (11.17) | 19.46 (9.19) |
| 3) | Education (years) | 5.28 (4.30) | 6.70 (4.96) | 8.60 (3.88) | 8.64 (3.67) | 6.62 (3.99) | 7.14 (3.02) | 6.83 (4.26) | 7.49 (3.88) |
| 4) | Per cent of farmers belong to SC | 22 | 12 | 2 | 0 | 0 | 0 | 8 | 4 |
| 5) | Per cent of farmers having agriculture as main source of income | 30 | 70 | 100 | 100 | 90 | 94 | 73 | 88 |
| 6) | Size of holdings (acre/hh) | 1.82 (1.72) | 2.65 (3.24) | 20.20 (26.50) | 21.92 (17.39) | 4.23 (2.21) | 5.23 (3.99) | 8.75 (17.33) | 9.93 (13.47) |
| 7) | Net cultivated area (acre/hh) | 1.82 (1.72) | 2.49 (3.02) | 20.20 (26.50) | 21.92 (17.39) | 4.11 (2.10) | 4.95 (3.85) | 8.71 (17.34) | 9.79 (13.57) |
| 8) | Gross cultivated area (acre/hh) | 2.00 (1.91) | 3.05 (5.98) | 23.42 (34.55) | 23.68 (23.60) | 11.66 (6.63) | 14.05 (11.40) | 12.36 (22.03) | 13.59 (17.58) |
| 9) | Gross irrigated area (acre/hh) | 2.00 (1.91) | 3.05 (5.98) | 23.16 (34.67) | 23.52 (23.68) | 11.66 (6.56) | 14.05 (11.40) | 12.27 (22.04) | 13.54 (17.59) |
| 10) | Cropping intensity (per cent) | 109.89 | 122.51 | 115.94 | 108.03 | 283.70 | 283.84 | 141.91 | 138.90 |
| 11) | Irrigation intensity (per cent) | 109.89 | 122.51 | 114.65 | 107.30 | 283.70 | 283.84 | 140.91 | 138.35 |

*Source*: Computed using field survey data.

*Notes*: CM-Conventional method; TIA-Tank irrigated area; CIA-Canal irrigated area; GIA-Groundwater irrigated area; ASA- All settings average; Figures in parentheses indicate standard deviation.

landholding size of SRI farmers (9.93 acres) in all the three settings is relatively larger than its counterpart non-SRI farmers (8.75 acres). There are two main reasons for the larger size landholding for SRI farmers. First, SRI method of paddy cultivation helps to reduce the labour use, which is a serious problem being faced by the paddy cultivators throughout Tamil Nadu. Therefore, farmers having larger holding size tend to adopt SRI method of paddy cultivation. The other important reason for adopting of SRI method is to save water, which is another problem increasingly faced by the large size farmers.

Irrigation is an important factor for achieving sustained growth in the agricultural sector. The survey shows that the sample farmers own predominantly irrigated lands in all the three settings. The average share of irrigated area to cropped area was almost 100 per cent and there was no much difference in it between farmers cultivating paddy under SRI method and conventional method. This is because both the groups of sample farmers were selected from the predominantly paddy cultivating areas where irrigation coverage is generally higher.

### 3.2 *Water Consumption*

The looming water scarcity experienced in the recent years has been creating lot of constraints not only for paddy farmers but also to the entire agricultural sector. Many new practices/methods have been introduced to conserve irrigation water. SRI method is basically introduced to conserve water and to increase the productivity of paddy.[1] As reported earlier, some of the earlier studies have shown that SRI method can save considerable amount of irrigation water while increasing productivity of paddy. However, the existing studies seem to have not analysed the water use pattern (number of irrigation) and the amount of water use in paddy crop across different areas/locations that use different sources of water. The pattern of water use in paddy crop is expected to be different among the sources of water due to various reasons. Because of uncertainty in water availability, the pattern of water use under tank irrigation is expected to be totally different from the sources like canal and groundwater. Therefore, one must analyse the water use pattern in paddy crop under different sources of water to find out the real impact of SRI method on water saving.

Table 2 provides the details of water use pattern for SRI and non-SRI method of paddy cultivation. Apart from looking at the number of irrigation used by the paddy cultivators, we have also studied the hours of water used for each turn of irrigation and the total hours of water used for paddy crop to have in-depth understanding on the use of water. It is clear that the water use pattern under SRI method is totally different from that of non-SRI method of paddy cultivation in all the three settings. The average number of irrigation used per acre by SRI farmers (15.69 times) is relatively less as compared to its counterpart farmers (16.15 times). However, SRI farmers belonging to groundwater area have used relatively higher number of irrigation than non-SRI farmers. This happened because of increased availability of water in groundwater area as compared to the other two settings (canal and tank areas) where water scarcity is common.

TABLE 2. WATER USE PATTERN UNDER SRI AND NON-SRI METHOD OF PADDY CULTIVATION

| Sl. No. (1) | Details (2) | TIA | | CIA | | GIA | | ASA | |
|---|---|---|---|---|---|---|---|---|---|
| | | CM (3) | SRI (4) | CM (5) | SRI (6) | CM (7) | SRI (8) | CM (9) | SRI (10) |
| 1) | No. of irrigation/acre | 16.70 (4.85) | 14.70 (3.57) | 13.22 (1.94) | 9.76 (1.17) | 18.54 (2.95) | 22.62 (4.79) | 16.15 (3.25) | 15.69 (3.18) |
| 2) | Hours of irrigation for each turn/acre | 8.14 (2.28) | 5.32 (1.30) | 9.20 (1.48) | 8.20 (1.01) | 6.92 (1.56) | 3.06 (0.47) | 8.09 (1.77) | 5.53 (0.93) |
| 3) | Total hours water used/acre (standardised HP hours) | 635.70 (68.88) | 372.00 (40.37) | 594.40 (17.92) | 396.20 (37.41) | 624.90 (105.33) | 338.40 (49.77) | 618.33 (74.98) | 368.87 (48.75) |
| 4) | Percentage of water saved over CM | -41.48 | | -33.34 | | -45.84 | | -40.34 | |

*Source and Notes*: Same as in Table 1.

Although we do not see any difference in the use of number of irrigation across all the three settings, there are differences in the hours of irrigation (standardised in terms of 5 HP pumpsets) used for each turn between SRI and non-SRI method. The SRI farmers (belonging to all the three settings) have used 5.53 hours of irrigation water for each turn of irrigation, whereas non-SRI farmers have used 8.09 hours for each turn of irrigation per acre. This means that on an average SRI farmers have used about 32 per cent less number of irrigation over non-SRI farmers in cultivating per acre paddy. While this is true across all three settings, SRI farmers belonging to groundwater area have used much less hours of irrigation for each turn as compared to non-SRI farmers. Since water availability is assured with well irrigated farmers, they have just provided only dry-wetting irrigation for paddy crop as advocated by the officials of the agricultural department. But, this is not strictly followed in tank and canal irrigated area, where farmers allow more than dry-wetting irrigation because of uncertainty in getting next turn of irrigation water. This means that water used for each turn of irrigation even under SRI method of paddy cultivation is considerably varied across different sources of water.

As a result of less use of water for each turn, the total hours of water used per acre (standardised HP hours of water) for cultivating paddy under SRI method was found to be substantially lower than non-SRI paddy in all the three settings. The estimate reveals that the total water used by SRI farmers was about 369 HP hours/acre, whereas the same was about 618 HP hours/acre for non-SRI farmers. This means that SRI farmers were able to save about 40 per cent of water over non-SRI farmers. Although this same trend was found across all the three settings, water saving due to SRI method was found to be relatively large in groundwater area (about 45 per cent) and small in the canal irrigated area (about 33 per cent). There are reasons for this variation. Water availability is assured in the groundwater irrigated area and therefore, farmers were able to control the water supply by strictly following dry-wetting irrigation system. This allows the farmers cultivating SRI paddy to save substantial amount of water. This was not possible in the canal irrigated area where water control is not in the hands of farmers and therefore, they tend to over irrigate the crop as and when water is available to them.

Since the water saving is substantial under SRI method of paddy cultivation in all three settings, we have made an in-depth inquiry with the sample farmers to know the main reasons for it. The main reasons that emerged from the study are: First, unlike conventional method of paddy cultivation, inundation of water is not advocated for SRI method, but just alternate wetting and dry method is enough for better crop growth. This saves substantial amount of water in comparison to the conventional paddy cultivation. Second, in-depth and repeated ploughing is not needed for SRI method which also saves substantial amount of water. Third, unlike the conventional method, water should be kept very less during the time of transplanting the seedlings. Fourth, in order to run the cono-weeder[2] effectively in the paddy field, plain wetting of land is adequate. Fifth, the branches coming from the transplanted seedlings/hill will be less if more water is given for paddy crop under SRI method. Sixth, irrigation is given only to moist the soil in the early period from transplanting under SRI method of paddy cultivation that allows saving enormous amount of water. On the whole, it is very clear that the SRI method of paddy cultivation can save over 40 per cent of water per acre as compared to conventional paddy cultivation.

### 3.3 *Cost of Cultivation*

Increased cost of cultivation for cultivating crops has been the major problem faced by the Indian farmers especially in the recent years (see, Government of India, 2006; Narayanamoorthy, 2013; CACP, 2013). This is also clearly evident from the data on cost of cultivation published by the Commission for Agricultural Costs and Prices.[3] Not only the labour cost required for cultivating crops has increased but also the cost on seed, fertilisers, irrigation water, pesticides and machineries. Past studies have reported that the cost of cultivation can be reduced considerably under SRI method of paddy cultivation. Given this, it is pertinent to study the impact of SRI method of paddy cultivation on its cost of cultivation. Paddy cultivation involves various operations. Since SRI method follows new practices in each operation, it is expected to have influence on the cost of each operation. Therefore, we have considered all the operations that are practiced in paddy cultivation to find out the cost saving due to the adoption of SRI method. Although CACP has been using nine different cost concepts[4] for estimating cost of cultivation for different crops, we have used cost A2+FL for the purpose of analysis in this study.

As expected, the cost of cultivation for SRI method computed by taking all the three settings was less by about 23 per cent as compared to non-SRI paddy (see, Table 3). SRI farmers on an average incurred about Rs. 18,195/acre, whereas non-SRI farmers incurred about Rs. 23,511/acre for cultivating paddy, a difference of Rs. 5,316/acre. The cost saving due to the adoption of SRI method was more or less the same (about 20 per cent) in both tank (TIA) and groundwater (GIA) irrigated area, but it was relatively higher in the canal irrigated area (CIA) where the saving in cost of cultivation was about 26 per cent. This happened mainly due to large reduction in the cost of machine labour and pesticides due to the adoption of SRI method of paddy cultivation.

An attempt was also made to study more about the operation-wise cost saving because cost reduction is expected to be very high in certain operations under SRI method. Among 11 operations reported in Table 3, a large cost reduction in terms of percentage was found in seed followed by irrigation, nursery preparation, weeding and inter-culture, transplanting and pesticides. In the case of seed, SRI farmers were able to save close to 76 per cent over non-SRI farmers. This is not surprising because single seedling is used under SRI method as against the clump of seedlings followed under conventional method which reduces the seed requirement. For example, SRI farmers have used only about 8 kg (recommended seed rate is only 2 kg/acre) of seed per acre as compared to the conventional method of paddy cultivation where farmers used over 30 kg of seed for cultivating one acre of paddy. The second highest reduction in cost was found in irrigation operation, where saving was achieved about 47 per cent over non-SRI method. SRI method of paddy cultivation is primarily water saving method under which water is not supplied on continuous flooding but alternate wetting and dry method is followed. This also helps in reducing substantial labour requirement on account of irrigation operation that ultimately reduces cost on irrigation.

TABLE 3. OPERATION-WISE COST OF CULTIVATION FOR SRI AND NON-SRI PADDY

(*Rs./acre*)

| Operation | TIA | | | CIA | | | GIA | | | ASA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CM | SRI | SRI over CM (per cent) | CM | SRI | SRI over CM (per cent) | CM | SRI | SRI over CM (per cent) | CM | SRI | SRI over CM (per cent) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Nursery preparation | 677 | 514 | -24.05 | 822 | 386 | -53.11 | 780 | 518 | -33.65 | 760 | 472 | -37.81 |
| | (224) | (68) | | (219) | (96) | | (910) | (104) | | (555) | (109) | |
| Seed | 919 | 254 | -72.34 | 1247 | 285 | -77.14 | 906 | 210 | -76.86 | 1024 | 250 | -75.62 |
| | (247) | (145) | | (60) | (101) | | (175) | (81) | | (238) | (116) | |
| Field preparation | 826 | 787 | -4.72 | 872 | 814 | -6.65 | 894 | 888 | -0.67 | 864 | 830 | -3.97 |
| | (114) | (144) | | (86) | (119) | | (42) | (48) | | (90) | (119) | |
| Transplant-ation | 2823 | 2346 | -16.91 | 2834 | 2115 | -25.38 | 2710 | 1795 | -33.77 | 2789 | 2085 | -25.24 |
| | (523) | (527) | | (367) | (322) | | (308) | (247) | | (411) | (444) | |
| Fertilisers | 2492 | 2082 | -16.44 | 3081 | 2687 | -12.80 | 3070 | 2795 | -8.96 | 2881 | 2521 | -12.49 |
| | (491) | (431) | | (235) | (310) | | (387) | (314) | | (472) | (474) | |
| FYM | 2148 | 2206 | 2.70 | 1874 | 1982 | 5.76 | 2644 | 2375 | -10.17 | 2222 | 2188 | -1.55 |
| | (591) | (389) | | (587) | (629) | | (709) | (814) | | (704) | (651) | |
| Pesticides | 1059 | 869 | -17.99 | 833 | 426 | -48.92 | 1051 | 953 | -9.34 | 981 | 749 | -23.66 |
| | (234) | (151) | | (249) | (283) | | (209) | (228) | | (253) | (324) | |
| Weeding and interculture | 3411 | 2405 | -29.51 | 3253 | 1686 | -48.18 | 2282 | 1815 | -20.46 | 2982 | 1968 | -33.99 |
| | (733) | (339) | | (539) | (528) | | (421) | (287) | | (763) | (505) | |
| Irrigation | 2505 | 1406 | -43.87 | 1983 | 976 | -50.78 | 2053 | 1052 | -48.75 | 2180 | 1145 | -47.50 |
| | (727) | (231) | | (291) | (117) | | (363) | (219) | | (547) | (270) | |
| Harvesting and threshing | 2381 | 1689 | -29.05 | -- | -- | -- | 1582 | 2370 | 49.84 | 1321 | 1353 | 2.44 |
| | (2287) | (2453) | | | | | (2189) | (2317) | | (2069) | (2178) | |
| Machine labour | 4948 | 4107 | -17.00 | 4520 | 4344 | -3.91 | 6091 | 4507 | -26.00 | 5186 | 4319 | -16.72 |
| | (1452) | (1246) | | (507) | (402) | | (1491) | (1449) | | (1397) | (1132) | |
| Others | 395 | 522 | 31.88 | -- | -- | -- | 566 | 422 | -25.44 | 320 | 314 | -1.86 |
| | (525) | (364) | | | | | (476) | (440) | | (471) | (398) | |
| Total | 24585 | 19187 | -21.96 | 21319 | 15699 | -26.36 | 24629 | 19699 | -20.77 | 23511 | 18195 | -22.61 |
| | (2034) | (1401) | | (1125) | (1297) | | (1674) | (1588) | | (2262) | (2282) | |

*Source and Notes*: Same as in Table 1.

The operation of nursery preparation also reduces considerable cost. Unlike the conventional nursery preparation, SRI method does not require much ploughing and large size plot for nursery preparation. For one acre transplantation of seedlings, the nursery bed can be raised by using just 48 square yard plot where the requirement of labour and other inputs are very less. Therefore, the cost required for preparing the nursery plot for SRI was less by about 38 per cent as compared to non-SRI method. Transplantation of seedlings and weeding and interculture are the other two important operations where SRI farmers were able to realise considerable cost saving. While transplantation reduced the cost by about 25 per cent over the same operation under non-SRI method, weeding and interculture operation reduced the cost by about 34 per cent. There are two important reasons for cost reduction in transplanting operation. First, transplanting is done by using single young (12-15 days old) seedlings that do not require much of labour as in the case of conventional transplanting method. Second, transplanting under conventional method involves 5-8 labourers only to plug the seedlings from nursery plot, whereas one can manage the same operation with single labour under SRI method. Thus, SRI farmers were able to realise substantial cost reduction on account of transplanting of seedlings.

Weeding and interculture are very important operations in paddy cultivation. Under conventional paddy cultivation, weeding operation is generally carried out two-three times which involve substantial labour (over 25 labour days) and cost. But, the requirement of labour for weeding operation is very less under SRI method because of use of cono-weeder. One labour can carry out weeding operation nearly half an acre of paddy field per day by using cono-weeder, which is not possible with manual labour. Moreover, the weeds are incorporated by operating cono-weeder between rows at the right time which also help supplying nutrients to paddy as green manures. This way SRI method helped to reduce the labour cost to the extent of 34 per cent over the method of non-SRI paddy cultivation. To sum up, the analysis clearly shows that the cost required for carrying out different operations in paddy cultivation can be reduced substantially by adopting SRI method.

### 3.4 *Productivity of Paddy*

Increased productivity of crop is essential to increase the farm income. But, unfortunately the growth in productivity of many crops including paddy crop has not been very appreciable in spite of increased cost of cultivation in the recent years (see, Narayanamoorthy, 2007; Government of India, 2014; Narayanamoorthy and Alli, 2013). SRI method of paddy cultivation follows new management practices wherein artificial environment is created for the growth of paddy plant for exploitation of its full genetic potential, land and water resources. Because of new practices followed for cultivating paddy, some existing studies (detailed in the introductory section) showed that the productivity under SRI method can be increased substantially and that too using relatively less amount of inputs.

Our survey also shows that the productivity of paddy cultivated under SRI method is substantially higher than the conventional method of paddy (Table 4). The productivity difference between SRI and non-SRI paddy computed by taking all the three settings comes to 46 per cent per acre. Among the three settings, the productivity difference was found to be large in groundwater irrigated area (50.85 per cent) followed by the canal (47.62 per cent) and tank irrigated area (40.90 per cent). This was expected because the productivity of groundwater irrigated paddy is generally higher as compared to the same crop cultivated with canal and tank irrigation because of improved certainty and controllability of irrigation.[5] What is interesting here is that despite using higher inputs or cost of cultivation for non-SRI paddy, the productivity of SRI paddy is significantly higher than that of non-SRI paddy. This suggests that the new practices followed for SRI method might have helped to harvest higher yield over the conventional paddy cultivation.

TABLE 4. PRODUCTIVITY OF SRI AND NON-SRI PADDY

(*qtl./acre*)

| | | | | Increase over CM | |
|---|---|---|---|---|---|
| Sl. No. | Setting | CM | SRI | Quintal | Per cent |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. | TIA | 16.60<br>(2.86) | 23.39<br>(3.25) | 6.79 | 40.90 |
| 2. | CIA | 16.99<br>(1.52) | 25.08<br>(1.52) | 8.09 | 47.62 |
| 3. | GIA | 16.42<br>(2.19) | 24.77<br>(3.18) | 8.35 | 50.85 |
| 4. | ASA | 16.67<br>(2.25) | 24.41<br>(2.85) | 7.74 | 46.43 |

*Source and Notes*: Same as in Table 1.

There are many reasons for the increased productivity of paddy cultivated by SRI method. First, the square planting with wider spacing at 25 cm x 25 cm rather than in clump of seedlings helps to increase the branches (number of tillers per plant) from each paddy seedling. Second, the young paddy seedlings of 12-15 days old with two-three leaves stage have great potential for profuse tillering and root development which ultimately results in increased yield. Third, the alternate wetting and dry method of irrigation allows the roots of the paddy plants grow healthy, deeply in all directions. Extended root growth also takes place due to wide spacing followed for transplanting. Fourth, since the field is intermittently irrigated and dried, the micro organisms grow well which make nutrients available to the paddy plants that help in increasing the growth and yield of crop. Fifth, the cono-weeder used for removing weeds from the field also adds organic matter to the field by incorporating the weed plants into the soil. Sixth, as a result of better growth of paddy plant, the number of panicles per plant, number of grains/panicle, length of panicle and the number of filled grains per panicle are much higher than one can normally obtain from the conventional method of paddy cultivation. All these factors together contributed to the increased productivity of paddy under SRI method.

### 3.5 *Impact of SRI on Productivity: Regression Analysis*

One of the aims of the study is to capture the real influence of SRI method of paddy cultivation on its productivity for which regression analysis has been carried out using variables specified in equation (1). It is expected that all the nine independent variables included in the regression model in one way or the other are expected to influence the productivity of paddy. The influence of SRI method of paddy cultivation on its productivity is expected to be varied under different settings. Therefore, regression has been estimated separately for each setting and also together by including all the samples of three settings. The regression results presented in Table 5 show that the value of adjusted $R^2$ estimated using the data of three different settings varies from 0.60 to 0.88 indicating that the variables included in the model seem to be appropriate in explaining the variation in productivity of paddy.

TABLE 5. FACTORS CONTRIBUTING TO PRODUCTIVITY OF PADDY: REGRESSION RESULTS

| Variables | | | Dependent variable: Productivity (kg/acre) | | | |
|---|---|---|---|---|---|---|
| | Description of the variables | Unit | Tank | Canal | Ground water | All Settings |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| AGE | Age of farmers | Years | 1.98[ns] | 0.99[ns] | -0.01[ns] | 2.43[ns] |
| | | | (0.52) | (0.32) | (-0.00) | (1.02) |
| EDU | Education of farmers | Years | 14.57[b] | -0.04[ns] | -2.84[ns] | 9.44[b] |
| | | | (2.00) | (-0.01) | (-0.25) | (2.22) |
| FEE | Farming experience of farmers | Years | 0.67[ns] | -2.28[ns] | -1.54[ns] | -0.61[ns] |
| | | | (0.21) | (-0.93) | (-0.26) | (-0.29) |
| FER | Fertilisers cost | Rs./acre | -0.09[d] | -0.01[ns] | 0.05[ns] | 0.02 [ns] |
| | | | (-1.39) | (-0.21) | (0.56) | (0.53) |
| FYM | Farm yard manure cost | Rs./acre | 0.12[c] | 0.02[ns] | 0.00[ns] | 0.02[ns] |
| | | | (1.97) | (0.66) | (0.09) | (0.94) |
| PST | Pesticides cost | Rs./acre | 0.33[b] | 0.14[b] | -0.37[a] | -0.01[ns] |
| | | | (2.07) | (2.42) | (-2.83) | (-0.28) |
| WAI | Weeding and interculture cost | Rs./acre | 0.12[b] | 0.05[c] | 0.03[ns] | 0.03[d] |
| | | | (2.24) | (1.75) | (0.38) | (1.44) |
| IRR | Irrigation cost | Rs./acre | -0.03[ns] | -0.03[ns] | -0.07[ns] | -0.07[b] |
| | | | (-0.50) | (-0.46) | (-0.74) | (-1.98) |
| MCF | Machinery cost on field preparation | Rs./acre | 0.07[ns] | -0.07[d] | 0.03[ns] | -0.00[ns] |
| | | | (0.96) | (-1.56) | (0.44) | (-0.09) |
| MCD | Dummy variable: SRI=1 and Non-SRI=0 | - | 790.20[a] | 883.00[a] | 753.61[a] | 731.53[a] |
| | | | (6.94) | (9.26) | (5.89) | (13.02) |
| | Constant | - | 565.71[a] | 1683.94[a] | 1906.89[a] | 1478.90[a] |
| | | | (1.22) | (4.91) | (3.53) | (6.66) |
| | $R^2$ | - | 0.64 | 0.90 | 0.74 | 0.71 |
| | Adjusted $R^2$ | - | 0.60 | 0.88 | 0.71 | 0.70 |
| | F-Value | - | 16.08 | 77.38 | 24.75 | 70.94 |
| | D-W | - | 1.54 | 2.16 | 1.72 | 1.54 |
| | N | - | 100 | 100 | 100 | 300 |

*Source*: Computed using field survey data.

Notes: a, b, c and d are significant at 1 per cent, 5 per cent, 10 per cent and 20 per cent level respectively; ns-not significant; Figures within the parentheses are 't' values.

Of the nine variables included in the model, except MCD variable, none of the other variables consistently and significantly influenced productivity of paddy in all the three settings. This means that the influence of human resource variables, yield enhancing inputs costs and other inputs costs used for paddy cultivation have not made significant difference in the productivity in both SRI and non-SRI method of cultivation. But, as expected, the coefficient of dummy variable included reflecting the method of paddy cultivation (MCD) is turned out to be consistently significant in all three settings. Among three settings, the influence of SRI method on its productivity appears to be relatively higher in canal irrigated area followed by groundwater and tank irrigated area. For instance, the regression coefficient of MCD pertaining to canal irrigated area explains that the productivity of paddy can be increased by about 883 kg per acre when a farmer shifts his method of paddy cultivation to SRI from non-SRI. But, the same influence of shifting to SRI method of paddy cultivation comes to about 790 kg for tank irrigated farmer and about 753 kg for groundwater irrigated farmer. Many farmers following SRI method of paddy cultivation in canal irrigated area have harvested much higher yield over non-SRI farmers and therefore, the coefficient of MCD turned out to be higher in canal irrigated area than in other two settings namely groundwater and tank irrigated area. Notwithstanding the variation across three settings, the regression analysis on the whole clearly confirms the significant influence of SRI method on paddy productivity.

3.6 *Profitability of SRI and Non-SRI Paddy*

One of the serious problems encountered by the Indian farmers over the last one decade or so is the increased cost of cultivation and reduced profitability. No technology or method will be adopted by farmers unless it is economically viable to them. If a new technology/method helps to save only water without increasing yield or value of output in crop cultivation, then that technology will not be adopted extensively. Similarly, if a crop technology promotes only resource conservation without augmenting productivity, then it will not get adequate response from the farmers. Therefore, one must study whether SRI method of paddy cultivation can generate more profit for farmers than that of non-SRI paddy. Here, the profit (farm business income)[6] is calculated by deducting the value of output from the cost of cultivation. Cost of cultivation used in the study refers to cost A2+FL, the definition of which is mentioned elsewhere in the study. The value of output (VOP) is computed by multiplying productivity of paddy with its price (per quintal) received by the sample farmers.

It is clear from the results presented in Table 6 that the value of output and the profit obtained by SRI farmers is substantially higher than its counterpart non-SRI farmers in all the three settings. The average profit computed by taking data of all three settings comes to about Rs.21,738/acre for SRI paddy, whereas the same is only about Rs. 4,569/acre for non-SRI paddy, indicating a difference of about 376 per cent between the two methods of paddy cultivation. This means that by adopting SRI method of paddy cultivation, farmers are able to generate an additional profit of Rs.17,169/acre over the conventional method of paddy cultivation. Among the three settings, the difference in profitability in absolute terms is relatively higher in canal irrigated area (about Rs.18,712) and the lowest is found in tank irrigated area (about Rs. 15,158). But, the difference in profitability in terms of percentage is higher in the tank irrigated area (about 781 per cent) and the lowest is observed in the canal irrigated area (about 197 per cent). These variations occurred mainly because of differences in the cost of cultivation and productivity of paddy among three settings selected for the analysis.

TABLE 6. PROFITABILITY SRI AND NON-SRI PADDY

(*Rs./acre*)

| Setting | Cost of cultivation | | | | Value of output | | | | Farm business income | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CM | SRI | Gains over Non-SRI | | CM | SRI | Gains over Non-SRI | | CM | SRI | Gains over Non-SRI | |
| | | | Rs. | (Per cent) | | | Rs. | (Per cent) | | | Rs. | (Per cent) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| TIA | 24585 | 19187 | -5398 | -21.96 | 26525 | 36284 | 9759 | 36.79 | 1940 | 17097 | 15158 | 781.48 |
| | (2034) | (1401) | | | (3869) | (5640) | | | (3890) | (5668) | | |
| CIA | 21319 | 15699 | -5620 | -26.36 | 30792 | 43884 | 13092 | 42.52 | 9473 | 28185 | 18712 | 197.54 |
| | (1125) | (1297) | | | (2760) | (2377) | | | (2730) | (2637) | | |
| GIA | 24629 | 19699 | -4929 | -20.01 | 26923 | 39632 | 12709 | 47.21 | 2294 | 19933 | 17639 | 768.81 |
| | (1674) | (1588) | | | (3735) | (6392) | | | (3978) | (6655) | | |
| ASA | 23511 | 18195 | -5316 | -22.61 | 28080 | 39933 | 11853 | 42.21 | 4569 | 21738 | 17170 | 375.79 |
| | (2262) | (2282) | | | (3968) | (5957) | | | (4976) | (7049) | | |

*Source*: Computed using field survey data.

*Notes*: TIA-Tank irrigated area; CIA-Canal irrigated area; GIA-Groundwater irrigated area; ASA- All settings average; Figures in parentheses indicate standard deviation.

There are important reasons for the increased profitability for SRI farmers. First, the cost incurred on irrigation was very low under SRI method of paddy cultivation. Second, the labour cost which normally accounts for sizable portion in the cost of cultivation was considerably lower under SRI method. Third, the cost incurred on the yield enhancing inputs such as fertilisers, FYM, etc., were also found to be lower under SRI method of paddy cultivation. Fourth, because of reduction in the cost of different operations, the total cost of cultivation incurred for one acre paddy cultivation was substantially lower under SRI method. Fifth, productivity of paddy cultivated under SRI method was significantly higher even after incurring less cost on various operations that subsequently helped to realise the higher value of output. The profitability analysis also suggests that in order to increase the farm profitability, the new technology/method should not only help increasing the productivity but should also simultaneously reduce the cost of cultivation.

## IV

## CONCLUDING REMARKS

It is clear from the study that SRI method of paddy cultivation can help farmers to cope with the risk of climate change induced water scarcity. In all the three different irrigated settings, farmers adopting SRI method of paddy cultivation were able to save substantial amount of water as compared to their non-SRI counterpart. While the SRI farmers from tank irrigated settings were able to save about 41 per cent of water, the same was 33 per cent and 46 per cent for canal and groundwater irrigated settings respectively. Besides water saving, SRI farmers were able to harvest about 46 per cent of higher productivity than that of non-SRI paddy farmers. With 23 per cent reduction in overall cost of cultivation per acre, SRI farmers were able to realise a profit of Rs. 21,738/acre, which was only Rs. 4,569/acre for non-SRI farmers.

In spite of increased benefits from SRI, its spread of adoption is not very appreciable in India as of today. Although some estimates suggest that the area under SRI may have crossed about one million hectares (Gujja and Thiyagarajan, 2013), it accounts for less than three per cent of India's total paddy area as of today. In fact, the adoption of SRI in most States are taking place either due to state-specific incentive programmes or through the national level incentive programmes like National Food Security Mission (NFSM) introduced by the Government of India during 2007. Due to poor literacy about the benefits of SRI, farmers still continue to cultivate paddy under the conventional inundation method which is no longer viable to India due to looming water scarcity. Presently, paddy is cultivated in 43-44 million hectares of land in India. With fast declining water potential and increased threat from climate change, cultivating paddy under inundation method will be very difficult for farmers in the future. Therefore, to tackle the issue of climate change in the future, the Government must work out dedicated schemes to promote SRI method of paddy cultivation covering all regions in India with strong extension support.

NOTES

1) An estimate released by the International Water Management Institute (IWMI) shows that an amount of 3000 litres of water traditionally needed to grow one kilogram of rice. This is substantially higher than the requirement of water needed to produce one unit of output from other foodgrain crops.

2) Cono-weeder is an instrument by which weeds can be removed effectively when paddy is cultivated by SRI method. By moving it with forward and backward motion at 7-10 days interval from 15 days after planting the seedlings, the weeds can be buried and the soil can be aerated effectively. Operating cono-weeder repeatedly during the initial period of transplantation of paddy helps increasing the branches (culm) from the seedlings. This operation ultimately also helps increasing panicle of paddy. Without operating cono-weeder, productivity of paddy cultivated by SRI method is expected to be drastically lower and therefore, its use is always recommended as part of the practices of SRI method.

3) For details on this, see the publication of CACP (2013).

4) The definitions of nine different cost concepts used by CACP are as follows: Cost A1 = All actual expenses in cash and kind incurred in production by owner. Cost A2 = Cost A1 + rent paid for leased-in land. Cost A2+ FL = Cost A2 + imputed value of family labour. Cost B1 = Cost A1 + interest on value of owned capital assets (excluding land). Cost B2 = Cost B1 + rental value of owned land (net of land revenue) and rent paid for leased-in land. Cost C1 = Cost B1 + imputed value of family labour. Cost C2 = Cost B2 + imputed value of family labour. Cost C2* = Cost C2 estimated by taking into account statutory minimum or actual wage whichever is higher. Cost C3 = Cost C2* + 10 per cent of cost C2* on account of managerial functions performed by farmer.

5) A detailed analysis on the productivity differences by source of irrigation can be seen from Dhawan (1988).

6) The term profitability is used loosely in this study. Since the profit is calculated taking cost A2+FL in this study, it should be ideally called as farm business income instead of profit.

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