SRI Cultivation in Andhra Pradesh : Achievements, Problems and Implications for GHGs and Work

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I

System of Rice Intensification (SRI): Evidence for its Superiority

1.1 Introduction

Rice is one of the most important staple food-grains, and ranks third in production among food-grain crops in the world, next to maize and wheat. It is also the most irrigation-intensive crop in the world: more than two-thirds of irrigated area is under rice cultivation. However, it is the only cereal crop that can grow under both flooded and dry conditions. The practices of rice cultivation have undergone changes over time from simple broadcasting to systematic transplantation. Though an enduring feature of rice is water intensity, it is cultivated not only in the humid and high rainfall areas but also in semi-arid regions, by tapping ground water or surface water resources.

However, the increasing demand and the resulting pressure on scarce water resources, particularly ground water, calls for water use efficiency in agriculture, and in semi-arid tropical rice in particular. Water efficiency has also become an important issue in the context of climate change and the rising emission of greenhouse gases (GHGs). Paddy cultivation along with livestock farming is the leading contributors of GHG emission in Agriculture (FAO, 2011). The major greenhouse gases are carbon dioxide (CO_2), methane, and nitrous oxide. Many anthropogenic activities contribute to the release of these greenhouse gases.

[#] This is one of the background papers of the project "Measuring Materiality in Informal Production-Distribution Systems" (see Hariss-White et al., 2013 for details). Authors are grateful to Prof. Barbara Harriss-White for her helpful comments on earlier drafts of the paper. And, thankful to Dr. Alfred Gathorne-Hardy as we sought his help to get GHG and Labour Use estimates on our field data. Also, greatly acknowledge Prof. Norman Uphoff of Cornell University for his reading of the paper and comments. This is a revised version based on Prof. Norman's comments.

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Agricultural activities in general and rice cultivation -following the conventional flood or submerge method in particular --contribute to emissions (see Gathorne-Hardy 2013a&b). In the submergence method, standing water in the rice fields generates water evaporation, methane, and nitrous oxide; fertiliser generates nitrous oxide[1]. Especially in semi-arid regions, when ground water is lifted using energy generated through the combustion of fossil fuels, these are powerful emitters of carbon dioxide (CO2). Moreover, if we consider the CO2 production as result of fertilizer production and transportation to look at total 'carbon footprint', the problem aggravates.

Strategies and solutions to meet the challenges of GHGs call for new methods and technologies. Potential options for the rice industry sector to contribute to the mitigation of, and adaptation to, climate change by increasing rice production in a physically sustainable manner are attracting growing research interest. One such area of interest is the new method of rice cultivation: the System of Rice Intensification (SRI). SRI is an innovative approach to rice cultivation but not a technology as such. Unlike conventional rice cultivation methods that use flooding/submergence and are prone to the emission of greenhouse gases, the SRI method requires substantially less water, resulting in important energy savings from pumping. In turn, this not only improves water use efficiency but also increases yields and-with less seed, water, pesticides and chemical fertilizers - results in reduced costs of cultivation as will be evident from the data presented later in this paper. The net effect is that SRI is able to improve household incomes and food security while reducing the negative environmental impacts of rice production, and making food production more resilient (Africare_OxfamAmerica_WWF-ICRISAT Project, 2010; Choi et al., 2013).

The evolution of the SRI technique of rice cultivation has shown that the core components of the Green Revolution–high doses of fertilisers, pesticides and water - are not necessary to achieve increased yields (Uphoff, ud 1).The principles of SRI contest the belief that rice plants do better in saturated soils, and show that rice plants can grow in soils under modest moisture condition without being continuously flooded. The development of SRI also established that farmers are not always at the receiving end of science and technology developed by research establishments, for farmers themselves have been shown to make innovations in farming methods and practices.

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[1] Usually little N2O from anaerobic soil conditions, although if excess N is put into the soil system from inorganic fertilizer, some N2O might be emitted.

1.2 The Shift to SRI: Readjustments in Agronomic Practices and Operational Methods

The shift from conventional rice cultivation to SRI involves changes in several agronomic practices. Key changes identifies are the use of single seedlings per hill, transplanting younger seedlings of less than 15 days, square planting (25 x 25 cm), reduced applications of irrigation water, and cono-weeding as the five core SRI-practices (Laulanié, 1992 & 2011, Palanisami et.al., 2013). Timely scheduling of operations takes on considerable significance so will be discussed briefly here. Compost is optional, according to Laulanie, but 'le minimum de l'eau' is not (see Laulanié, 1992 & 2011).

Unlike transplanting relatively older (30 to 45 days) seedlings at the density of three or four per hill as is the convention, for SRI, young seedlings (8 to 14 days old at the two-leaf stage) are transplanted singly in a wider square grid laid out with the help of ropes or a marker[2]. The sparse transplanting of single seedlings under SRI reduces the seed requirement to an eighth to a tenth of that of conventional transplanting, and reduces labour requirement by almost half[3]. But the transplanting of single, young seedlings is a delicate operation, requiring skill gained through experience. Transplanting continues to be an operation confined to women, but with reduced numbers and improved skills, which women acquire without difficulty[4].

Weeding is a second SRI operation differing from conventional cultivation practices in a number of respects. First, for SRI, manual weeding is replaced by a mechanical weeder, either a cono-weeder or rotary hoe or something similar. Whereas under conventional rice production, weeding is an entirely female operation, in SRI it is evolving into male work, although there are exceptional instances of female labourer doing this, given the cultural norm that 'mechanical work' is to be done by men. Then, SRI requires early and more frequent weeding, from the tenth day after transplanting, and followed by three or four iterations with a gap of ten days in between. Early and frequent mechanical weeding crushes tender weeds into the soil to serve as a green manure, enriching both the soil and the crop. One observation often heard at the field level, is that mechanical weeding is arduous and monotonous, especially when a lone worker is engaged in it[5].

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[2] In fact initially marked ropes/strings were used; the marker was a farmer innovation, both rakes and rollers.

[3] It may appear to be controversial; if farmers are using little labor per hectare as was in case of Madagascar, SRI is much more labor-intensive; whereas in India and China where farmers are already putting a lot of labor exhaustively into their rice production, there would be reduction under SRI method.

[4] But most scientists still insist that SRI is 'more difficult' and when people are just starting the methods, like laborers on experiment stations, there are probably a lot of complaints initially.

[5] But often one may hear that mechanical weeding is preferred; it all depends on the design of the mechanical weeder. Ms. Sabarmatee in Odisha (Sambhav) is doing PhD thesis research for Wageningen University, looking

The most critical aspect of transition from the conventional system to SRI is the need for timely and intensive crop management. While conventional practices cope with the need for flexibility at all stages of growth, right from the possibility of transplanting older seedlings (30 to 45 days), through random and relatively dense transplanting (by using five or six seedlings at a spot) and inundating the field with irrigation water without any effort to drain it. By contrast, SRI requires early and more systematic transplanting, timely and frequent weeding, and 'alternate wetting and drying' instead of flooding.

1.3SRI and Greenhouse Gases (GHGs)

As mentioned above, the greenhouse gases with high global warming potentials (GWP) in the atmosphere are, in order of their importance, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The contribution of each gas to the greenhouse effect depends on the quantity emitted, its radiative force, and its atmospheric life-time. Rice cultivation under conditions of flooded irrigation is one of the major man-made sources of these GHGs.

There is a considerable debate over the global warming potentials (GWP) of rice cultivation under different irrigation and water management systems (Jayadev et al., 2009; Quin et al., 2010; and Peng et al., 2011). A recent study in China found that under controlled irrigation, the GWP of rice cultivation is relatively low (Peng et al., 2011a&b). Global warming potentials of methane and nitrous oxide are 62.23gCO_2 $m^{-2}$for rice-paddy under controlled irrigation, 68.0% lower than for rice grown under irrigation by flooding (Peng et al., 2011). Due to large reductions in seepage and surface drainage under efficient conditions of irrigation and drainage and compared with 'traditional' practices, the Chinese research found that nitrogen and phosphorous losses through leaching were reduced by 40.1% and 54.8%, and nitrogen and phosphorous losses through surface drainage by 53.9% and 51.6%. Nitrogen loss through ammonia volatilization was reduced by 14.0%. The Chinese study shows how efficient irrigation and drainage management helps to mitigate greenhouse gases emissions, nitrogen and phosphorus losses, and their pollution on groundwater and surface water (ibid). In the context of challenges due to meteorological variability, the principles and practices of SRI have other strengths like drought-coping capacities (SDTT, 2009).

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at SRI labor and especially at any discomfort or injury; her final results not yet seen, but her initial data seems to show that women systematically report that SRI mechanical weeding is much less arduous, and with less strain on particular muscles and joints (as communicated by Prof. Norman Uphoff).

1.4 Evidence for Yield and Cost Advantages

Studies of SRI cultivation in various parts of the world, in Andhra Pradesh, the site of our field studies, and elsewhere in India have shown that both yield rates and water use efficiency have improved (see for instance Uphoff, ud1; Lin et al., 2011; Kassam et al., 2011, Thakur et al., 2011, Ravindra and Laxmi, 2011, V & A Programme, 2009). SRI cropping methods can outperform the conventional management of rice in flooded, wetland paddy agriculture - whether evaluated in terms of output (yield), productivity (efficiency), profitability, or resource conservation (Kassam et al., 2011). A macro-level study covering 13 major rice-growing states in India, indicates that fields with SRI have 22.4 percent higher average yield compared to non-SRI fields. However the superiority of SRI yields varies across the states, from 12 percent in Assam to 53.6 percent in Gujarat[6] (Palanisami et al., 2013). SRI's advantages also accrue to income and reduced costs. On average, the gross earnings from SRI are 18 percent higher than non-SRI, and average per hectare costs are 29 percent less in SRI than for non-SRI production[7]. Further, yield levels vary positively with the variation in the extent to which the core practices of SRI are adopted[8].

Evidence from Andhra Pradesh also supports the observations of higher yield rates of rice under SRI cultivation (Rao, 2011; Ravindra and Laxmi, 2011; and V & A Programme, 2009). A study of the economics and sustainability of SRI and traditional methods of paddy cultivation in the North Coastal Zone[9], concludes that the benefit-cost ratio (BCR) was higher for SRI (1.76) than for traditional methods (1.25) for the same crop variety (Rao, 2011). It also found a 31 per cent yield gap between SRI and traditional methods. Operating practices had a stronger effect than input use (20.15% versus 10.85%) in explaining this gap.

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[6] It has to be noted that these were on-station results, and one may see many times that researchers' trials cannot replicate the results that farmers get on their own fields, the inverse of the usual relationship where farmers cannot match what researchers produce in their trial plots; we think this is because the soil microbiota and mesobiota in experiment-station soils are less abundant and less biodiverse, making the soil systems there less responsive to SRI management practices; we do not have yet a good systematic/scientific evidence to support this observation, but it is a frequent enough occurrence. The researchers' results are usually get cited with great confidence because they are in the published literature. Although farmer results are seldom considered, they are really representative of the real-world situation.

[7] Wider experience is more positive than this, as one can observe from the Africare/Oxfam/WWF 2010 publication cited above.

[8] It is very true but hard to get people to understand.

[9] The reference agriculture year is 2008–09 and based on the data of costs and returns of crop. The analytical methods used included budgeting techniques, benefit-cost ratio (BCR), yield gap analysis, sustainability index and response priority index.

Field studies have also shown that water use efficiency varies with different rice cultivation systems. Compared to the conventional methods, water use/consumption under SRI is substantially lower and water use efficiency is higher (Ravindra and Laxmi, 2011; Reddy et al., 2006). These relationships hold for both tank and tube/shallow well based irrigation systems. The use of other inputs such as chemical fertilisers and pesticides is substantially lower for SRI[10] (Ravindra and Laxmi, 2011; V & A Programme, 2009). With the savings in water and other inputs, and the consequent reduction in cultivation costs, the overall gains of SRI cultivation are found to be substantially higher than for conventional modes of cultivation (Ravindra and Laxmi, 2011; V & A Programme, 2009).

The Andhra Pradesh Agricultural University (ANGRAU) conducted demonstration trials across the state over a period of five years from 2003-04 to 2007-08, and the results show that yield levels in SRI plots were higher compared to conventional cultivation in all seasons during these years, ranging from 18.6 percent to 41.5 percent (Table 1). The initial high difference

Table 1: Rice Yield Rates under SRI and Conventional Methods

Year	Season	Number of Demonstration plots organised	Yield in SRI Paddy kg/ha	Yield in conventional Paddy/kg ha	SRI yield difference over conventional	
					Kg/ha	***%***
1	***2***	***3***	***4***	***5***	***6***	***7***
2003-04	Kharif	69	8,358	4,887	3,471	41.5
	Rabi	476	7,917	5,479	2,438	31.8
2004-05	Kharif	599	7,310	5,561	1,749	24.0
	Rabi	311	7,310	5,777	1,533	21.0
2005-06	Kharif	2,864	7,476	5,451	2,025	27.0
	Rabi	12,277	7,390	5,620	1,770	24.0
2006-07	Kharif	7,653	6,724	5,005	1,719	25.6
	Rabi	6,201	6,830	5,558	1,272	18.6
2007-08	Kharif	1334	6179	4965	1214	24.5
	Rabi	1293	6650	5225	1425	27.2

Note: The results are from the demonstration farms in A.P. Information after 2007-08 is not available.

Source: Department of Agriculture, Government of Andhra Pradesh.

[10] It is due to the practice weeding using rotary/cono-weeder coverts the weeding into organic fertilizer and wider space between plants allows soil aeration and improves the soil biota. The wider space between rice plant hills is relatively aerated and allows sunrays and thus reduces the chances of pest attack.

1.5 Preliminary Findings of a Field Study in Andhra Pradesh

As a part of larger research project[11] a field survey was conducted in the Janagaon region of Warangal District, Andhra Pradesh, with a sample of 25 SRI farmers and 10 control group non-SRI farmers from nine villages[12]. Data were collected from the sample households by a detailed questionnaire designed to suit the life cycle approach to the computation of GHGs, that would also capture all the processes involved, inputs used, and practices followed in rice cultivation beginning from seed bed preparation to rice harvesting and sales. The field work was conducted over three months during June-August 2012. Information relating to the previous agriculture year (2011-12), for both the Khariff and Rabi seasons, was collected from the sample farmers using their recall.

Table 2 presents some of the preliminary results relating to the difference in GHG emissions[13], labour use and yield level of SRI in comparison with non-SRI rice production. The CO_2 equivalent of GHG emissions under SRI cultivation is 26.8 per cent less than non-SRI or conventional practices. SRI also involves 30 per cent less labour while yielding 59.3 per cent more output per hectare compared to conventional rice cultivation. Our results with respect to the yield enhancement are well within the ranges that one is familiar with published literature on SRI. But the labor-reduction figures goes against much of the conventional wisdom, and some published research, on SRI saying it is too labour-intensive[14].

Table 2: GHG, Labour Use and Yield Differences of SRI and Non-SRI

Rice System	GHG – CO_2 EQ (Per Hectare)	Labour Use (Hrs. Per Hectare)	Yield (Kgs. Per Hectare)
SRI	10232	1006	7609
Non-SRI	13981	1436	4834
% Difference of SRI compared to Non-SRI	- 26.8	-29.9	57.5

Note: 1. GHG – CO_2 EQ: Green House Gas Emissions in Carbon Dioxide Equivalent; 2. Revised Estimates.

Source: 1. Estimates from Field Study in Janagaon, A.P.; 2. Also see Gathome_Hardy *et al*, (2013).

[11] "Measuring Materiality in Informal Production–Distribution Systems", School of Interdisciplinary Area Studies, Oxford University, Oxford.

[12] Field Study villages are: Katkuru, ChinnaRamancherla, PeddaRamancherla, Nidigonda, Fateshapur, Ibrahimpur, Kasireddypalle, Dabbakuntapalle and Patelgudem.

[13] The GHG estimates are done by Dr. Alfred Gathome Hardy of Oxford Univerisity with a bio-chemical science background. He part of the project mentioned above. For the methodology of the GHGs estimate see his paper: Gathome-Hardy (2013).

[14] There are other reports from India and China very often referring labor reductions, in the order of 10-30% and labor neutrality from Indonesia and Cambodia.

The breakdown of labour use in rice cultivation by operations (nursery operations, land preparation, transplanting, weeding, harvesting etc.) too shows that in all operations except application farm yard manure (FYM) and *vermi* compost, there is a reduction in labour use per hectare in SRI method when compared to non-SRI or conventional system of rice cultivation (Table 2a). As organic manure is one of the SRI principles, the application of FYM and vermin compost is promoted by local NGOs for SRI cultivation. Since FYM and vermin compost involves labour use for not only application but also for preparation, so is the relatively high figure for the SRI in this operation.

Table 2a: Labour Use in Rice Cultivation Break Down by Operations

Sno	Operations	Per Hectare		Per Tonne Paddy		Difference (%) over Non-SRI	
		SRI	Non-SRI	SRI	Non-SRI	Hectare	Tonne
1	2	3	4	5	6	7	8
1	Seed bed	54	111	7	24	-51.4	-70.8
2	Cultivating main field (incl. Bund Repair)	96	68	13	14	41.2	-7.1
3	Transplantation	173	314	23	65	-44.9	-64.6
4	Weeding	300	468	40	96	-35.9	-58.3
5	Fertiliser application	26	46	3	10	-43.5	-70.0
6	FYM and Vermi compost	112	90	16	19	24.4	-15.8
7	Pesticide	18	48	3	10	-62.5	-70.0
8	Irrigation	97	156	13	33	-37.8	-60.6
9	Harvesting	120	136	16	28	-11.8	-42.9
Total		1006	1436	133	298	-29.9	-55.4

Note: **1**. Labour use refers field labour only (including family, casual and attached); **2**. Col. 7 and 8 indicate the difference in labour use by operations between SRI and Non-SRI cultivation systems wherein sign indicates the percentage less (-) or more (+) labour in SRI when compared to Non-SRI; **3**. These are Revised Estimates which are significantly differing from our earlier estimates (see Reddy and Venkatanarayana, 2013) which were accounting inflated family labour use in 'supervision' especially in respect of irrigation. It is applicable to both SRI and Non-SRI.

Source: Field Work based estimates.

Since SRI appears to be established as a superior cultivation technology across a number of dimensions, the question arises: how has this innovation diffused in India? The institutions involved in the spread of SRI have been very different from those of the original Green Revolution (Farmer, 1977). We turn to consider its history.

II
The Origin and Spread of SRI

The synthesis of locally advantageous rice production practices known as SRI started accidentally in 1983 in a severe drought in Madagascar, and developed thereafter with continued experimentation under the constant observation of a small work-study school, established by Fr. Henri De Laulanié, a French priest with a background in agriculture. Over time the principles of SRI were refined and results showed very high yields. The Association of Tefy Saina (ATS), an NGO, established in 1990, is credited with the propagation/promotion of SRI in Madagascar as well as in the outside world (Prasad, 2006). Laulanié considered SRI as a practical revolution in farming methods as well as a 'cultural revolution' in the minds of rice farmers (Laulanie, 2011). It is also an interesting case of rural innovations developed outside the formal rice research establishments (Prasad, 2006).

However, until 1994, SRI was unknown to the rest of the world until the Cornell International Institute for Food, Agriculture and Development (CIIFAD) mounted a collaborative project with ATS to propagate the Madagascar innovations[15]. In particular, credit is due to Dr. Norman Uphoff of Cornell[16] for bringing SRI to the notice of others. Following his three-year study of Malagasy farmers, Uphoff carried the idea to Asian farmers and from 1997 started to promote SRI in Asia[17] (V & A Programme, 2009). Since 1999, with the efforts of CIIFAD and a growing number of partners, both individuals and institutions, from the government, research, NGO and private sectors, what was at first a local phenomenon grew to a global movement with farmers in 52 countries[18], especially in semi-arid regions, attempting to adopt SRI to varying degrees (V & A Programme, 2009). In Asia, along with India and China, Cambodia, Indonesia and Vietnam where two-thirds of the world's rice is produced (and consumed) have made notable progress[19] and all now give official support to SRI. Besides, Sri Lanka, the Philippines and Malaysia also made a notable progress in this respect.

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[15] Initially it was to apply and evaluate the innovation, not to propagate it, because CIIFAD drew no conclusions about SRI's merits until after the three years of assessment.

[16] Cornell International Institute for Food, Agriculture and Development (Ithaca, USA).

[17] Actually, Prof. Norman took the idea to Asian researchers, in China and in Indonesia, and it took two years to get them to launch SRI trials, which were successful so that he then from 1999 on started trying to disseminate the ideas and opportunities.

[18] The productivity of SRI methods has been demonstrated as of now in 52 countries, but the number of countries in which farmers taking up SRI' is about 40.

[19] In fact, Cambodia was the first country to endorse SRI and has gone from 28 farmers in 2000 to over 2,00,000 now, with government backing; Malaysia is a late starter, but is coming on fast; Sri Lanka, Philippines and Bangladesh were early starters but SRI seems to be held back by resistance from scientists linked to IRRI and

2.*1 SRI in India*

In India, rice cultivation occupies around one-fourth of the total cropped area. It is the largest crop produced in the country, accounting for two-fifths of total food grains production. The adoption of green revolution technology intensified rice cultivation in India, using more irrigation and other inputs such as chemical fertilisers and pesticides. Around 60% of the rice cultivation in India takes place in irrigated areas - one-third of total irrigated area in India is down to rice (GoI, 2011). Innovations in rice production have been led heretofore by a combination of state and market institutions. The origins of SRI were different.

Initially brought to India through a pamphlet carried by a tourist visiting Pondicherry in 1999, SRI trials were immediately conducted in Aurovelli there. Later a scientist[20] from Tamil Nadu Agricultural University participated in an international seminar dealing with innovations in rice cultivation, and after his return in 2002 a modified version involving principles of SRI was experimented with in Tamil Nadu (Prasad, 2006).

Initially SRI principles and practices were subject to experiments by progressive farmers and promoted by civil society organisations (national and international NGOs). Over the years, state organisations (research establishments, relevant Departments and Ministries) have promoted SRI (Prasad, 2006). At an All-India level, the National Food Security Mission (NFSM) began promoting SRI in several states in 2007, joined subsequently by NABARD and the Sir Dorabji Tata Trust (SDTT). Certainly, the role of SDTT has been one of the most important; and WWF in its collaborative program with ICRISAT was also critical to SRI spread. Several Indian states have responded positively to the adoption of SRI practices – but *at a very slow pace,* until Bihar from 2010. So far there has not been a policy framework that disseminates SRI nationally

Of the 600 plus districts in India, more than a third have instances of where farmers were initiated into SRI, but there is no information on how much of it has been sustained. Civil society groups have made the case for including SRI in the National Rural Employment Guarantee Scheme (NREGS) programme. The proposal is to use the innovative institutional

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maybe also by commercial interests; Indonesia is another major country (as Communicated by Prof. Norman Uphoff).

[20] That is T.M. Thiyagarajan who learned about SRI through a project of Wageningen University funded by the Dutch government on 'water-wise rice,' starting in 2000. With his initiative in the home state (Tamil Nadu), Dr. Thiyagarajan was able to report on his first SRI trials in 2000 in a project workshop held at Nanjing, China in April 2001. Again, he reported on two years of results at the first international SRI conference, held in Sanya, China in April 2002.

mechanisms established for NREGS to support the transition of rice production to SRI by providing incentives to both farmers and workers/labourers to learn the necessary skills and using NREGS to buffer the transition to new methods. Rather than giving a direct labour subsidy to farmers practising SRI (NCS, 2012), the NREGS programme would pay labourers helping small or medium SRI farmers to practise these new SRI transplanting and weeding methods.

Andhra Pradesh is among the several states considered as ‘SRI-adopting’ so its diffusion process is of scientific interest. We move in the following sections to contextualise the position and problems of rice in the agricultural economy of Andhra Pradesh (section III), then to analyse critically the place of SRI in the context of the rice economy (section IV) before turning to a case study of best practice within SRI (section 4.3) and the lessons that may be learned from it. We conclude by assessing some institutional and policy developments that would improve the prospects for SRI in Andhra Pradesh.

III
Performance of Agriculture and Rice Cultivation in Andhra Pradesh

3.1 Agriculture in Andhra Pradesh’s Economy

Andhra Pradesh is the fifth largest state in India in terms of population, and the fourth largest in terms of geographical area. It is the fourth largest economy in India next to Maharashtra, Uttar Pradesh and Tamil Nadu. With respect to value-added in agriculture it ranks second, after Uttar Pradesh. While accounting for 7% of the population, AP contributes approximately11% of India’s total agricultural GDP. It is the fourth largest state in terms of area under cultivation and irrigated area, the third largest in food-grain production, and the second largest in terms of the value of livestock production. In recent years agricultural GSDP in the state has been growing at 5% per annum, considerably above the All-India average (see GoAP, 2012). However, as Table 3 shows that the share of agriculture and allied activities in the GSDP of the state and the share of crops within the agriculture sector have been on a trend of decline.

Table 3: Share of Agriculture and Allied Activities in GSDP in Andhra Pradesh

Year	% to GSDP		% Crop within AA
	AA	Crop	
1	*2*	*3*	*4*
1999-00	27.9	17.4	62.4
2000-01	29.1	18.6	63.9
2001-02	27.5	16.5	59.9
2002-03	24.8	12.7	51.3
2003-04	26.0	14.5	55.7
2004-05	25.1	14.1	56.3
2005-06	24.3	13.9	57.2
2006-07	22.3	12.8	57.3
2007-08	23.3	14.0	60.0
2008-09	22.0	12.8	58.1
2009-10	21.0	11.7	55.6
2010-11	20.8	11.7	55.9
2011-12	19.2	9.8	51.2

Note: AA – Agriculture and Allied Sector.

Source: DES, GoAP.

Andhra Pradesh is one of the states which adopted the Green Revolution from the earliest stages. It is the fourth largest state in terms of area under rice cultivation, next to Uttar Pradesh, West Bengal and Orissa. But it is emerged as second largest in production next to West Bengal[21]. And about a quarter of the total value of output from crop production in the state is from paddy. Here we analyse basic physical and economic parameters of rice production in the state before turning to the problems and challenges arising from them.

3.2 Size class of holdings

As in the rest of the country, the share of small-marginal farmers in agrarian structure of the state has been on the rise. They constitute over 80 percent of operational holdings and account for almost 50 percent of the operated area.

[21] The latest, triennium ending 2011-12, figures based on the Agriculture Statistics in India (2012), Department of Statistics, Ministry of Agriculture and Cooperation, Government of India.

Table 4: Changing Size Class Distribution of Landholdings in Andhra Pradesh by Size Class

Year	Share in Number of Holding					Share in Operated Area					Avg Size
	Marginal	Small	Semi-Medium	Medium	Large	Marginal	Small	Semi-Medium	Medium	Large	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1955-56	38.6	18.3	17.7	16.7	8.7	7.9	9.7	16.1	28.1	38.2	2.43
1970-71	46.0	18.5	17.4	12.7	4.3	8.0	11.3	19.2	30.8	30.7	2.51
1980-81	49.3	20.9	16.0	9.1	2.1	13.1	16.2	23.3	28.7	18.7	1.94
1990-91	56.0	21.2	14.5	6.9	1.3	16.4	19.6	25.2	26.1	12.8	1.50
2000-01	60.9	21.8	12.4	4.3	0.6	21.6	24.8	26.4	19.8	7.5	1.25
2005-06	61.6	21.9	12.0	4.0	0.5	22.7	25.8	26.5	19.0	6.1	1.20

Note: **1**. Refers of operational land holdings only; **2**. Size classes: ***Marginal*** – 0 to 1 hectare; ***Small*** – 1 to 2 has; ***Semi-medium*** – 2 to 4 has; ***Medium*** – 4 to 10 has; and ***Large*** – 10 and above has; **3**. ***Avg Size*** - Average Size of the Holding (in hectares).

Source: Directorate of Economics and Statistics (DES), GoAP, Hyderabad.

3.3 Land Use Pattern and Irrigation Systems

Of Andhra Pradesh's total area of 27.5 million hectares the net sown area (NSA), 10.6 million hectares, accounts for a stable 40 percent of the area. About 2.7 million hectares of this, about 25 percent of NSA, is cultivated more than once in an agricultural year[22]. The state's cropping intensity is one of the lowest, on a slow-paced increase (Table 5). In turn, about 4.6 million hectares or about 40 percent of the net sown area (NSA) is irrigated. Another 1.7 million hectares are irrigated more than once, and thus the gross irrigated area in the triennium ending 2009-10 was about 6.3 million hectares.

Table 5: Cropped Area and Irrigated Area in Andhra Pradesh

Triennium Ending	Area (in lakh Hectares)				Intensity (%)	
	NAS	GSA	NIA	GIA	Crop Int.	Irg. Int.
1	*2*	*3*	*4*	*5*	*6*	*7*
1960-61	109.07	119.50	29.03	34.98	110	120
1970-71	113.88	129.83	30.73	39.97	114	130
1980-81	108.73	125.61	34.48	44.25	116	128
1990-91	110.42	132.00	42.83	54.21	120	127
2000-01	105.24	129.01	44.83	59.18	123	132
2009-10	106.29	133.19	45.60	62.63	125	137

Note: TE – Triennium Ending; NAS – Net Sown Area; GSA – Gross Sown Area; NIA – Net Irrigated Area; GIA – Gross Irrigated Area; Crop Int – Crop Intensity; IrgInt – Irrigation Intensity.

Source: Directorate of Economics and Statistics, GoAP, Hyderabad.

[22] The total cropped area or gross sown area (GSA) in the state is 13.3 million hectares.

Table 6: Source-wise Area Irrigated in Andhra Pradesh

T E	Area (in lakh Hectares)					Source-wise Share (%)			
	Tank	Canal	Wells	Others	Total	Tank	Canal	Wells	Others
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1960-61	11.99	12.90	3.07	1.07	29.0	41.3	44.4	10.6	3.7
1970-71	9.85	14.87	4.93	1.08	30.7	32.1	48.4	16.0	3.5
1980-81	9.30	16.71	7.47	1.00	34.5	27.0	48.5	21.7	2.9
1990-91	10.33	18.76	12.15	1.60	42.8	24.1	43.8	28.4	3.7
2000-01	7.30	16.39	19.17	1.98	44.8	16.3	36.6	42.8	4.4
2009-10	5.22	15.75	22.98	1.65	45.6	11.4	34.5	50.4	3.6

Note: TE – Triennium Ending.

Source: Directorate of Economics and Statistics, GoAP, Hyderabad.

Surface water sources like tanks and canals which accounted for substantial shares of irrigation are on the decline, in both relative and absolute terms. Ground water sources of irrigation, through shallow or tube-wells, are on the increase (Table 6). Negligent management of surface-water minor irrigation systems in the state has diminished irrigation from tanks. According to one estimate, out of 77,472 tanks, around 24,000 are presently defunct. Others have had their command areas compromised and function at reduced capacity (CAD, 2008; Ravindra and Laxmi, 2010).

Heavy and increasing project costs and inter-state water disputes have also constrained the expansion of surface irrigation systems through major dams and distributaries. The emergence of ground water as a major source of irrigation has also resulted in growing dependence of agriculture on diesel fuel and electrical power. According to one estimate, agriculture consumes about a quarter of the State's total electricity (GoAP, 2010), which is in turn increasingly dependent on thermal sources, particularly fossil fuels.

3.4 Cropping Pattern and the Paramount Importance of Rice

Over the years, particularly since the 1980s, there has been rapid change in Andhra's cropping pattern (see Table 7). The share of cereals has come down drastically, largely due to decline in millet production, but the share of rice has actually increased. As the single largest crop in Andhra, it accounts for about 4.0 million hectares[23] out of 13 million hectares, or about 30 percent of the total gross cropped area.

[23] Both in Kharif and Rabi seasons. Kharif refers to the monsoon season. Rabi refers to dry season.

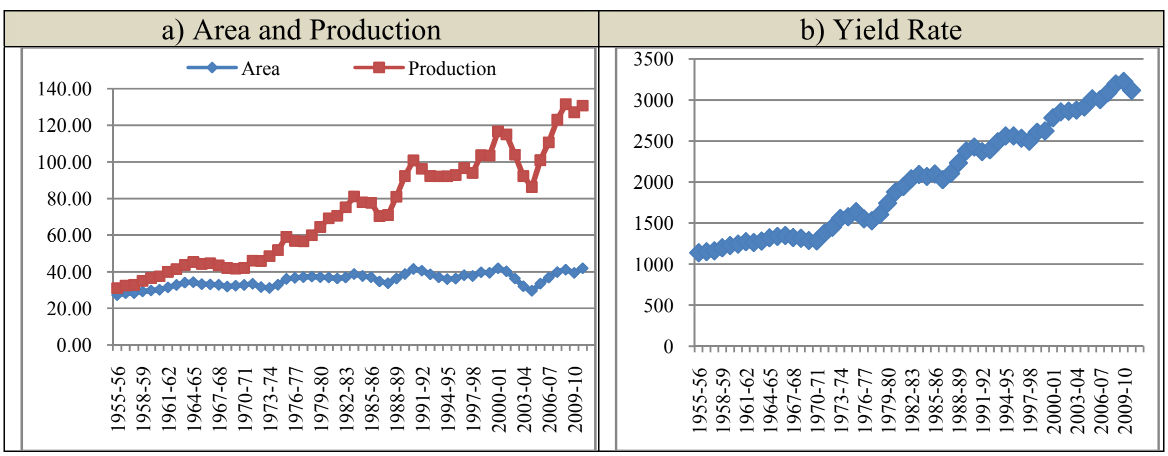
Table 7: Changes in Cropping Pattern in Andhra Pradesh, 1958-2011 (%)

Crop	Triennium Averages					
	1955-58	1965-68	1980-83	1990-93	2002-05	2010-11
1	*2*	*3*	*4*	*5*	*6*	*7*
Rice	23.1	26.3	29.1	29.6	24.4	30.8
Jowar	20.8	19.9	16.8	8.5	4.9	2.2
Maize	1.6	1.8	2.6	2.4	5.2	5.8
Bajra	5.0	4.7	4.1	1.5	0.9	0.4
Ragi	2.5	2.6	2.0	1.2	0.6	0.3
Cereals	***53.1***	***55.3***	***54.5***	***43.1***	***35.9***	***39.9***
Pulses	***10.1***	***10.1***	***11.0***	***12.2***	***16.4***	***14.3***
Food grains(sub-total)	***63.2***	***65.3***	***65.5***	***55.4***	***52.3***	***54.1***
Groundnut	10.5	10.1	11.2	18.5	13.2	12.2
Gingelly	2.2	1.9	1.4	1.3	1.3	-
Sunflower	-	-	-	2.5	3.8	3.0
Castor	2.6	2.2	2.2	2.4	2.2	1.3
Oil Seeds(sub-total)	***15.2***	***14.3***	***14.7***	***24.1***	***20.5***	***19.4***
Sugarcane	0.6	1.0	1.3	1.5	1.8	2.7
Cotton	3.1	2.4	3.5	5.5	7.7	10.0
Tobacco	1.3	1.5	1.6	1.4	1.0	1.2
Chillies	1.3	1.4	1.3	1.7	1.9	1.6
Onion	0.2	0.1	0.1	0.2	0.2	0.3
Fruit & vegetable	-	-	-	4.5	6.7	7.5
Total	**84.9**	**86.0**	**88.0**	**89.8**	**85.4**	**80.4**

Note: Percentage inGross Cropped Area under major crops.

Source: Subramanyam and Aparna (2009).

Figure 1: Trends in Area, Production and Yield of Rice in Andhra Pradesh



Note: Area is in lakh hectares and Production is in lakh tonnes; and yield rate isKgs per Hectare.

Source: Directorate of Economics and Statistics, GoAP, Hyderabad.

Andhra has four rice agro-ecosystems: irrigated rice, rain-fed lowland and upland rice, and a flood-prone rice ecosystem. However, rice cultivation in AP is more water-intensive and irrigated than elsewhere in India. Put differently, of the total area under rice cultivation in the state, around 95% is under irrigation. Conversely, of the total irrigated area in the state, around two-thirds is under rice cultivation.

Table 8: Area, Production and Yield (APY) of Rice in Andhra Pradesh

T E	A P Y in Volume			Growth (%)		
	Area	Production	Yield	Area	Production	Yield
1960-61	30.17	37.54	1244	-	-	-
1970-71	32.80	42.08	1283	0.8	1.1	0.3
1980-81	36.83	69.17	1878	1.2	5.1	3.9
1990-91	41.54	100.78	2426	1.2	3.8	2.6
2000-01	41.91	116.58	2781	0.1	1.5	1.4
2010-11	41.93	130.66	3116	0.0	1.1	1.1

Note: TE – Triennium Ending; Area is in lakh hectares; Production in lakh tonnes; and Yield rate is Kgs per Hectare.

Source: Directorate of Economics and Statistics, GoAP, Hyderabad.

Rice cultivation in the state takes place in both production seasons, about 60% in Kharif and 40% in Rabi. Very sporadically, in the third 'summer' season, rice is cultivated in some parts of the state. While in Kharif, 95 percent of the crop is irrigated (and the rest rain-fed), in Rabi and the shorter summer season, it must be entirely irrigated.

Table 9: Season-wise Area, Production and Yield of Rice in Andhra Pradesh

Sno	Details	2008-2009			2009-2010			2010-11			TE 2010-11		
		Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	Area (in lakh hectares)	28.03	15.84	43.87	20.63	13.78	34.41	29.22	18.3	47.52	25.96	15.97	41.93
2	Production (in lakh tons)	83.8	58.61	142.41	59.56	48.82	108.38	75.1	69.1	144.2	72.82	58.84	131.66
3	Yield (kgs/hectare)	2990	3700	3246	2887	3543	3150	2570	3776	3035	2805	3684	3140

Note: T E - Triennium Ending.

Source: Directorate of Economics and Statistics, Government of Andhra Pradesh, Hyderabad.

Tables 8 and 9 show that the area under rice cultivation in the state which has shown a steady increase. The yield and production levels experienced a quantum jump beginning with the late 1970s and 80s under the spell of Green Revolution with the advent of HYV seeds and rising application of other inputs. Currently more than 80% of Andhra's rice cultivation uses HYV seeds. With an annual production of about 120 to 140 lakh tonnes amounting to around 12-15 percent of the total rice production in India, the state is now the second largest producer of rice in India, exceeded only by West Bengal. Production and yield rates disaggregated by season show that the Kharif rate is lower than that of other seasons, while the Rabi season share in production is higher than its share in Andhra's rice cultivation area.

However, since the 1990s, the rates of growth of rice yield in India in general, and in Andhra Pradesh in particular, *have been experiencing a deceleration*. As the area under rice cultivation is almost stable, the deceleration in growth rate of yields has resulted in a slowing of the growth in total rice production.

3.5 Problems and Challenges of Rice Cultivation in A.P.

While the area under rice has increased over the years, rice cultivation is fraught with problems. One problem is the emergence of *water-logging* in the Krishna-Godavari delta region. A second is the increase in the *cultivation costs* in general, but for rice in particular (GoAP, 2011, Laxminarayana et al., 2011; Ramana Murthy, 2011)[24]. Then, third, the national minimum support *price* (MSP) is now much lower than their costs of cultivation according to farmers in the State. There have been widespread protests by the farmers and threats of a 'crop holiday' in which farmers stop producing the crop for market (GoAP, 2011, Laxminarayana et al., 2011). Fourth, there is increasing *pressure on ground-water resources* especially in the semi-arid region of Andhra where rice is cultivated by water-lifting. SRI has the potential to mitigate problems of stagnating yield growth and higher water consumption as well as onerous production costs and thus to address some of these environmental and economic problems. It thus deserves systematic consideration and evaluation.

IV
SRI in Andhra Pradesh

To see how SRI might mitigate the serious agricultural challenges in AP, we examine the history of the transfer of this technology and the institutions involved in its adoption, adaptation and spread (Table 9). Despite the neo-liberal regime which looks to the private sector for innovation, it is the state and civil society in Andhra Pradesh, not the market, that have pioneered the propagation of SRI.

[24] These will be supplied when they have been computed from field data gathered in the project 'Measuring Materiality in Informal Production-Distribution Systems" – see Hema (2013).

4.1 Agencies Propagating SRI in Andhra Pradesh

In Andhra Pradesh, SRI was initiated in Kharif 2002 by a progressive organic farmer, Narayana Reddy, who having experimented with it on his own farm in Karnataka shared his experience with a civil society organisation, Timbaktu Collective, in Ananthapur district. The Timbaktu Collective began introducing SRI to a few pioneering farmers in Anantapur district. Prior to these activities, as early as 2001, Ajay Kallam, the Commissioner of Agriculture for the Government of Andhra Pradesh, had published an article on SRI in ***Padipantalu***, a magazine published by the State Government on matters relating to agriculture. But his effort was limited to diffusing knowledge of the method through the popular press and sharing the ideas with other officials but not to direct trials of SRI (Prasad, 2006).

The Acharya N. G. Ranga Agricultural University (ANGRAU),a premier agricultural research institute in Andhra Pradesh, played a crucial role in scaling-up SRI principles and practices, first conducting about 250 on-farm trials in 22 districts in Kharif 2003, under the leadership of it Director of Extension. Since then, ANGRAU has been involved with other civil society organisations in its project promoting SRI. At the district level, the Krishi Vignana Kendras[25] (KVKs) and District Agricultural Advisory and Transfer of Technology[26] (DAATT) Centres associated with ANGRAU have worked as frontline SRI demonstration units. ANGRAU has itself conducted field demonstrations of SRI practices. The ICAR's Directorate of Rice Research (DRR) stationed at Hyderabad joined the endeavour through field trials and research experiments monitoring costs of cultivation and yield rates under a joint research project supported by WWF, involving also ANGRAU and ICRISAT scientists. Since 2006, the Government of Andhra Pradesh initiated measures for promoting SRI principles and practices. From 2007-08, ANGRAU focused on capacity-building, handing over front-line promotional activity to the Department of Agriculture, Government of Andhra Pradesh. But with this change of agency, there was a decline in field trials and demonstrations for which the Department was ill-suited.

[25] There are 34 KVKs in the state, of which 23 operate under ANGRAU, 3 are directly associated with ICAR, and 8 are operated by civil society organisations (NGOs). These KVKs are grass-root level institutions devoted for imparting need-based skill-oriented short- and long-term vocational training courses to the agricultural clientele. Besides conducting on-farm research for technology assessment and refinement, KVKs demonstrate latest agricultural technologies through front-line demonstrations.

[26] There are about 22 DAATT Centres, one for each rural district in Andhra Pradesh, and they are all associated with ANGRAU.

Table 10: Organisations involved in Promoting SRI in Andhra Pradesh

Sno	Category of Actors	Organisations
1	State Bodies	WALAMTARI, NABARD, NFSM, CMSA, Agros, I&CAD, DRR, ATMA
2	Research Institutes	Acharya N. G. Ranga Agricultural University (ANGRAU), CRRI, IRRI, DRR, ICRISAT, IWMI, Rice Research Station (Warangal), KVKs, RSS
2	Non-State bodies: National	CSA, CWS, SDTT
3	Non-State bodies: International	WWF, Oxfam, SIDA, SDC
4	Local Organisations: NGOs in AP	Timbaktu Collective, WASSAN, CROPS, RDT, APDAI, JalaSpandana, Laya, many other local NGOs at grass roots level
5	Individuals (officials and progressive farmers)	Ajay Kallam, Narayana Reddy, Mandava Krishna Rao,

Note: For expansion of abbreviated names of organisations see Annexure of Acronymsat the end of the paper.

Source: Authors' compilation.

Certain international agencies like ICRISAT, WWF, Oxfam and others have been party to the promotion of SRI in India and AP. Local-level NGOs scattered across the state also operate to promote SRI with the support of associated national and international organisations. Since 2004-05, an ICRISAT-WWF project has also promoted SRI in AP and further afield in India (Prasad, 2006). Thanks to ICRISAT-WWF and ANGRAU, the SRI methodology has been evaluated for its potential in saving water and in increasing productivity under different agro-climatic conditions and irrigation sources. Results show that yields under SRI are higher by 20-40 percent. Two important State-level intermediary civil society organisations (NGOs) -- WASSAN and CSA - have been working with farmers to spread the practices of SRI in different parts of the country and Andhra Pradesh (Prasad 2006).

In brief, the role of ANGRAU in Andhra Pradesh is the key[27] for the SRI extension in the state. Later, such responsibility was taken up by WASSAN, CWS, Timbaktu Collective and other NGOs, while some ANGRAU faculty persevered, but without university or state Department of Agriculture (DOA) support; ironically, the Department of Irrigation was more supportive than the DOA, a phenomenon seen also in Indonesia and the Philippines – agronomists regarded SRI as an intrusion on their turf, while irrigation managers welcomed the water-saving opportunities.

[27] The initiative and forceful leadership of Prof. A. Satyanarayana, at the time Director of Extension for ANGRAU, gave Andhra Pradesh the chance to become the SRI leader for India.

3.2 Coverage of SRI

As pointed out earlier, since 2003-04, Andhra Pradesh's Department of Agriculture (DOA) too has organized SRI demonstrations, and since Rabi 2005-06, at least one demonstration was targeted for every Gram Panchayat. In 2007-08, in a prominent policy initiative, the state government allocated around Rs. 4.0 crore for state-wide demonstrations and SRI trials. Moreover, since early evaluations had stressed the importance of timeliness of irrigation for SRI, the state government announced an uninterrupted and continuous supply of electricity to areas under SRI.

Under the National Food Security Mission (NFSM), 1,680 SRI demonstrations were targeted for 2008-09 (1,272 in Kharif and 408 in Rabi) with a financial outlay of Rs.5.0 million (Rs.3000 per demonstration) and further grants of Rs. 3000 were awarded for the purchase of 'cono-weeders'[28]. In 2008-9,in 11 non-NFSM districts of East Godavari, West Godavari, Prakasam, Kurnool, Ananthapur, Kadapa, Chittoor, Warangal, Rangareddy, Nizamabad, and Karimnagar, a total of 4,446 one-acre demonstrations were planned under the state's Work Plan (Rice) with an outlay of Rs.26.7 million.

Table 11: Extent of SRI Paddy in Andhra Pradesh

Year	Rice area covered (in 000Ha)			Area under SRI(in Ha)		
	Kharif	Rabi	Total	Kharif	Rabi	Total
1	*2*	*3*	*4*	*5*	*6*	*7*
2003-04	2,109	866	2,975	28	190	218
2004-05	2,215	871	3,086	240	2,451	2,691
2005-06	2,526	1,456	3,982	1,127	6,306	7,433
2006-07	2,641	1,337	3,978	3,061	2,480	5,541
2007-08	NA	NA	NA	NA	NA	NA
2008-09	2,803	1,584	4,387	NA	NA	NA
2009-10	2,063	1,378	3,441	NA	NA	NA
2010-11	2,922	1,830	4,752	44,794	46,664	91,458
2011-12	NA	NA	NA	49,496	72,320	1,21,815

Note:'NA' not available.

Source: Department of Agriculture, Government of Andhra Pradesh.

SRI has also been promoted by Community-Managed Sustainable Agriculture (CMSA)[29] which is part of the SHG-based Indira Kranthi Patham (IKP) Programme, promoted by the Society for Elimination of Rural Poverty (SERP)[30] in Andhra Pradesh (Table 12). Under the

[28] Cono-weeder is a mechanical rotary instrument used for weeding in SRI.
[29] The thrust of CMSA is to promote non-chemical pesticide agriculture with an emphasis on soil rejuvenation and multiple cropping especially in dry land areas.
[30] SERP is a state sponsored civil society organization, with Chief Minister as the Chairman, with objective of social mobilization of women through self-help groups (SHGs).

CMSA programme, SRI has been encouraged through women's self-help groups (SHGs). In 2008-09, SRI was implemented in around 1,000 acres across districts in the state. Targets were given to the districts based on the number of weeders available: 3 acres of SRI paddy per weeder. Table 11 shows the slow but steady progress achieved in SRI under the CMSA from about 1,100 acres in 2008-09 to about 16,000 acres in 2011-12.

Table 12: Acreage Covered under CMSA SRI Programme across District in Andhra Pradesh

Sno	District	2008-09	2009-10	2010-11	2011-12
1	*2*	*3*	*4*	*5*	*6*
1	Adilabad	18.0	80.0	43.0	233.0
2	Ananthapur	182.0	70.0	572.0	1487.0
3	Chittoor	6.0	73.0	273.0	1826.2
4	East Godavari	0.0	0.0	45.0	217.0
5	Guntur	2.0	25.0	162.0	808.0
6	Kadapa	18.0	65.0	55.0	603.2
7	Karimnagar	30.0	92.0	85.0	1240.0
8	Khammam	19.5	60.0	114.0	924.0
9	Krishna	0.0	0.0	23.0	23.0
10	Kurnool	5.0	50.0	91.0	238.0
11	Mahabubnagar	265.0	510.0	2247.0	0.0
12	Medak	297.0	975.0	1200.0	1599.0
13	Nalgonda	9.5	80.0	8.0	529.0
14	Nellore	0.0	170.0	172.0	142.0
15	Nizamabad	14.5	65.0	632.0	685.0
16	Prakasam	0.0	10.0	23.0	81.0
17	Ranga Reddy	2.5	50.0	130.0	38.0
18	Srikakulam	7.5	60.0	139.0	567.0
19	Vishakapatnam	24.0	65.0	186.0	2767.0
20	Vizianagaram	44.4	85.0	211.0	540.0
21	Warangal	152.0	600.0	800.0	674.0
22	West Godavari	0.0	20.0	85.0	677.0
	AP	***1096.9***	***3205.0***	***7296.0***	***15875.4***

Note: 1. Figures in acres; 2. CMSA – Community Managed Sustainable Agriculture.

Source: CMSA, Government of Andhra Pradesh.

Since 2010-11, NABARD, under its Farmers' Technology Transfer Fund (FTTF),has promoted the spread of SRI in 14 states including Andhra Pradesh. Of the All-India total of 150 projects[31] (Rs. 2568.0 lakh), 17 of them (amounting to Rs. 282.9 lakh) are in AP[15.]. NABARD collaborates with local NGOs in the implementation of these projects over a period of three years (Table 13).

[31] There are four clusters in each project with each cluster consisting of four villages: thus 16 villages in each project. The 150 projects cover 2400 villages all over India.

Table 13: Details of NABARD's FTTF Targets for SRI, 2010-11

Sno	Details	India	AP
1	No. of Projects	150	17
2	No. of Farmers Targeted for SRI	84000	9240
3	Target Area (in Ha) under SRI	28800	3172
4	No. of Villages	2400	334
5	FTTF Grant (lakhs)	2568.00	282.85

Note: FTTF - Farmers' Technology Transfer Fund.

Source: NABARD Regional Office, Hyderabad.

Arguably, in Andhra Pradesh there has developed a *unique kind of partnership between state and civil society* which has formed the institutional ecology conducive to the adoption of SRI. Andhra Pradesh is also unusual in adopting SRI *throughout all its districts*. According to Prasad (2006), results from trials are significant. First, the highest ever yield rate (17.2 tonne per hectare) was recorded in SRI in Andhra Pradesh[32]. Second, SRI rice has also been found to mature earlier than conventional varieties, by one week or more, which is an advantage for farmers. Because of thicker stems and root systems, SRI withstands flooding and cyclones better than conventionally-grown rice[33]. It is associated with better quality of grain which fetches higher prices. Lastly, higher yields have been observed in drier regions.

Over and above its institutional ecology, Andhra Pradesh is also notable in terms of the *agency and technical expertise of individual farmers*. For instance, the Mandava Marker[34], a simple tool to mark the lines for row-transplanting was developed in the state and is very popular with SRI farmers both in Andhra and elsewhere. Similarly the innovative agricultural engineering of weeders by ANGRAU and the adaptations of SRI practices to local conditions based upon feedback from farmers are two further examples of agricultural innovations by civil society organisations in a variety of sites in the State. However, in spite of all these efforts to popularise SRI, its *coverage remains relatively low*, while some other states have been more rapid advance. As recently as in 2011-12, only about 2 per cent of the total area

[32] It is in fact no longer the highest because 22.4 t/ha has been reached in Bihar; despite the controversy over it, these are Dept. of Agriculture figures checked out and confirmed the Directorate of Rice Development and PRADAN team leader.

[33] It is a relative advantage, not an absolute advantage – SRI rice can succumb to these climatic hazards.

[34] It is an iron frame marker, to draw vertical and horizontal lines in the field ready for transplantation, developed by an innovative farmer Mandava Krishnarao, hailing from Mandava village in Khammam district of Andhra Pradesh. It is now widely used in Andhra Pradesh. Prior to that, ropes were used to get marks of horizontal and vertical lines. In fact the roller-marker has been developed by a number of farmers in different states. But Mr. Krishna Rao's marker is widely used in Andhra Pradesh.

under rice in the State was under SRI. There are a number of factors that hinder its sustained adoption.

4.2 Problems of SRI in Andhra Pradesh

Debates about the adoption of SRI practices focus on SRI's being more-*labour intensive* than conventional methods. Labour intensity here does not refer to labour per unit of output, rather to labour being needed in a timely way and skilled in the new practices. In SRI crop production, labour costs are actually relatively lower than those of conventional practices. But SRI has a more rigorous and exact regime that needs precision-timed operations and constant supervision. The more factory-like production regime of SRI struggles to penetrate a culture of flexible and less precise practices associated with rice cultivation. There is also a certain *physical agility needed for the use of weeders, line markers, and for the transplanting single seedlings*. The intensity of labour requires male/female labour with sufficient physical energy to use the weeder and appropriate skills to use the marker, while female labour also needs to acquire new skills for transplanting. Since its invention, the weeder has been improved to make it move with less friction, and it was observed in the field that the employment of two labourers weeding together reduces the fatigue and isolation associated with the monotony of working alone.

There appear to be no clear specifications regarding the designs of markers and weeders appropriate to different soil types. Labourers are slow to take to SRI practices, particularly in using weeders in their currently designed forms. So farmers face operational difficulties in adopting SRI especially on larger areas[35]. Of the three critical stages/operations of SRI cultivation (nursery, transplantation and weeding), a study of the economics of SRI observed that the most important constraint in SRI cultivation is the *'nursery to transplanting management'* (Rao, 2011), because this stage is relatively labour-intensive, and needs certain management skills and constant supervision. The preparations of the nursery need co-ordination with those of the plot awaiting transplanting. Small farmers balance their limited ground-water resources against rainfall but the Kharif rains frequently confound this balancing act. With meagre ground water, producers prepare their nursery expecting the

[35] When the Govt. of Andhra Pradesh first decided to promote SRI by giving out 'free weeders,' the quality of those provided was inferior, probably due to the contract for producing them being given to a crony of the Minister or somebody – part of the problem with SRI extension in Andhra Pradesh was this legacy of SRI being promoted like an input-dependent innovation.

monsoon to help them ready the main plot. If the rain fails or is delayed, the nursery seedlings will cross the 8 to 15 days threshold beyond which older seedlings are inappropriate for SRI. The older practice of flexible transplanting between 25 to 45 days accommodates the vagaries of the weather, but SRI does not. R & D to evolve varieties that would reduce the vulnerability of seedlings to their transplanting age is urgently needed. Otherwise, rather than seeking a 'seed solution,' there can be a management solution, which takes some persuading and experimentation, but is ultimately available right now without any breeding program. Since SRI nurseries are very small and take only 10% as much seed as 'normal,' there is the option which PRADAN promotes with rain fed SRI farmers in the eastern Gangetic plains, of planting two or even three 'staggered' nurseries, two weeks apart, so that they will have 'young seedlings' when the rains come; they plan on sacrificing 10 or 20% of their 'normal' seed, to have the benefit of young seedlings, which can add 1-2 t/ha to yield, with a very high benefit/cost ratio, even figuring the added labor costs.

Another major concern is that *dis-adoption rates exceed those of adoption* (Reddy et al, 2006). In many cases when supported by civil society organisations or other organisations encouraging SRI, farmers adopt SRI with an eye to *support measures* such as free fertilisers. Once this is stopped they tend to switch to conventional system. Indeed, there are many instances of withdrawal from SRI once the agency sponsorship end. But this is a flaw in the extension and promotion methodology, trying to 'bribe' farmers to use SRI, not a flaw in SRI methods as such[36].

Despite Andhra Pradesh's vigorous initiatives, the diffusion of SRI is now lagging behind that of the neighbouring state of Tamil Nadu. One of the factors behind the faster progress of SRI paddy in Tamil Nadu is that the state government provides a *financial incentive* of Rs. 4,000 per hectare for a farmer adopting SRI. Of course this has its own vulnerabilities, as just discussed. TN's *promotional methods* also differ. For instance, neither the State Government, research bodies, nor civil society organisations insist on strict adherence to all the SRI principles and practices. Instead SRI principles are followed flexibly. In Andhra Pradesh there is no financial incentive to producers, and the extension advice is rigid. But 'flexibility',

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[36] Bribed people may not stay bribed; if you get people to try SRI with a bribe, it implies that the changed practices are really more in promoters interest than in theirs; rather than the supportive of subsidization for SRI promotion it maybe a few payments or better, guarantees – to get SRI demonstrated and started; but the productivity gains that are available if the methods are properly used are great enough that adoption should not require subsidies or bribes – Indian government extension methods are wedded to subsidies and material inputs; they can hardly think outside the 'subsidy raj' box.

in fact, deprives farmers of many/much of the productivity advantages that SRI can give; farmers should know what they are giving up when they use SRI methods only partially or sub-optimally – this approach has not been used.

4.3 The Case of an NGO ('CROPS') in promoting SRI in Andhra Pradesh

Here we present a case study of a civil society organisation (NGO), CROPS[37], working to propagate SRI principles mainly among farmers in Janagaon division of Warangal District of Andhra Pradesh, but also further afield. CROPS is a registered non-profit, non-religious, non-governmental, social development grass-root organization established in 1991.

In the dry-land agriculture of Janagaon division, the only irrigated crop is paddy, mostly grown using ground-water. When the traditional system of dry land farming shifted to modern technology with the use of chemical pesticides, the cost of cultivation increased, and so did farmers' environmental problems such as soil and water contamination with chemical residues. Over-use of these chemical inputs resulted in reduced soil fertility and increased resistance to pests. Pesticide consumption peaked when the cropping pattern shifted from coarse cereals to cotton cultivation. It was at this stage, in the mid-1990s that CROPS, supported by the Centre for World Solidarity (CWS) started to promote non-chemical pesticide management techniques[38].

With the support of two leading civil society organisations (CWS and CSA), CROPS' efforts in sustainable agriculture (by which is means chemical-free organic agriculture) are remarkable. The organisation is developing a model organic farming village, Enabavi, in Warangal District[39]. A feather in its cap is that for the year 2007-08, an Enabavi farmer and

[37] An acronym for Centre for Rural Operations Programme Society (CROPS).

[38] Besides, the organisation is also involved in formation of thrift groups of women called Sanghams at village level. **Sri Shakti** is a registered **Mutually Aided Cooperative Society (MACS)** for Women, initiated by CROPS. Under this programme the whole village is a unit, *Sangham*. Sri Shakti Women MACS was established in the year 1995 with merely 5 groups and 40 members and in due course it has developed to 44 groups and 5,467 members. Women in more than 40 villages have formed as *Sangham* thrift groups facilitated by the CROPS. Presently there are 7,467 women actively involved in 74 groups. Their savings worth Rs. 91.93 lakhs were pooled from these members, and against this credit worthiness Messrs. Andhra Bank has sanctioned loans worth Rs. 1.3 lakhs to SRI SHAKTI MACS. Total loans amounting to Rs. 363.27 lakhs have been issued to these members for various productive purposes.

[39] ***Enabavi***, a hamlet of the Kalyanam Revenue village, Lingala Ghanapur Mandal, Warangal District, Andhra Pradesh has created history in organic farming in India. The entire village involving about 55 families, cultivating 300 acres and constituting the whole hamlet population of about 200 has become fully organic. Hence 'organic' is used in an informal sense to include farming free of pesticides, chemical fertilisers and genetically-modified crops. It is the first village in the country to declare itself, chemical-free and GM-free (CROPS from http://www.crops.co.in/enabavi.html).

grass roots motivator, Sri Ponnam Mallaiah, was chosen along with his village, for the **Krishi Gaurav Award**by Pathanjali Trust[40], Haridwar. All the practices leading to reduced chemical use in agriculture, either SRI or other types of organic farming in the informal sense, are promoted by civil society organisations like CROPS.

Box 1: CROPS Activities related to Sustainable Agriculture

- Dry land agriculture in 20 villages - Supported by AEI, Luxembourg
- Promotion of NPM in 3 Mandals - Centre for Sustainable Agriculture (CSA), Hyderabad, India
- Promotion of permaculture in 1 village - Deccan Development Society (DDS), Andhra Pradesh
- Bt Vs. Non-Bt study in Warangal district - Deccan Development Society
- Implementation of 10 RIDF watersheds - DWMA, Nalgonda and Warangal
- Promotion of Organic Cotton in 4 villages - Oxfam India
- Promotion of sustainable agriculture practices under the flagship of Telangana Natural Resource Management Group (TNRMG) in 25 villages - SDCIC
- Promotion of community-based Tank Management in 5 Villages - SDCIC
- Promotion of NPM in 30 villages of 3 Mandals - SERP - IKP, Government of Andhra Pradesh
- Promotion of IPM, Chilly in 2 Mandals - Spices Board, Secunderabad

Source: CROPS.

Most of the crop agriculture in the area of Janagaon that CROPS selected was limited to traditional, non-hybrid and non-GM dry land cereal crops (jowar, redgram, maize, etc.). Since the 1990s, the area under cotton cultivation has recorded a rapid increase in this region. Increasing cotton cultivation also meant greater use of fertilisers and pesticides, which in turn increased the cost of cultivation to unviable levels. CROPS developed the goal of non-pesticide management (NPM) for dry land crops to lower the cost of cultivation.

Moreover, the availability of, and access to, bore well technology over the last two decades increased the number of bore wells, in turn increasing the area under irrigated crops, particularly rice. Prior to the 1990s, rice was not a major crop sold in the local grain markets. But from 1990s onwards, it came into prominence along with cotton and maize. The volume of rice traded in the local grain market increased from 3,000 to 30,000-40,000 quintals per day over the last fifteen years. Twenty commercial rice mills, mostly parboiling mills, were established. The procurement of rice by the Food Corporation of India (FCI) has also increased. The first FCI godown in this area, Janagaon, was established in 2002 with a capacity of 30,000 MT. A second godown with a capacity of 150,000 MT started working in

[40] The Trust gives annual awards to innovative farmers who work towards practices that reduce farming risks.

2009. The phenomenal increase in rice trading is due to local increase in rice production, due to expansion in area as well as of yield.

Most of the rice cultivation in this area has become ground-water dependent, through bore wells. Historically rice cultivation was confined to a limited area, with tanks as the main source of water. In a few cases, rice was cultivated to a limited extent and for home consumption with open wells constrained by the availability of water. Changes in the last two decades mean that even the rice fields under tank irrigation are watered from bore wells replenished from tanks. Many farming communities under the tank command areas agreed to abandon the use of the tank for direct irrigation. While tanks allowed the cultivation of rice only in the Kharif season, irrigation using ground water permits rice to be grown in both main seasons. Irrigation with bore-wells or open-wells also facilitates the water control sometimes associated with better yields. However, the increased reliance on ground-water has depleted subterranean water resources and has increased energy consumption (mostly electricity) by lift irrigation. Water and energy saving methods of rice cultivation are therefore needed in the region.

As regards SRI cultivation methods, in Janagaon division since Rabi 2007-08, CROPS[41] has taken up certain initiatives for SRI (Table 14). CROPS is one of the collaborators involved with the ICRISAT-WWF Project to develop SRI in AP as well as All-India. Under the WWF project, for seven continuous seasons, CROPS has spread SRI cultivation to seven villages in two mandals (Bachannapet and Maddoor) in Janagaon division. And with the support of ICRISAT, it introduced SRI in 26 more villages in three other mandals[42] (Lingal Ghanpur, Janagaon and Devaruppala). Under these two projects, the number of farmers and acreage under SRI cultivation promoted by CROPS increased gradually. But both the WWF and ICRISAT support was limited to a few seasons until Rabi 2010-11. After that, the number of farmers and acreage under SRI drastically declined. Under the NABARD support, CROPS implemented SRI in 16 more villages in two mandals (Janagaon and Lingal Ghanpur) for the two seasons Kharif 2011 and Rabi 2011-12. The NABARD project then was extended to two further years with increased targets for farmers and acreage.

[41] With the support of the WWF project.
[42] Mandals, which cover population of about 30,000, are administrative units below the District Administration. In Andhra Pradesh, erstwhile Taluks/Blocks were replaced with Mandals in the early 1980s.

Table 14: Coverage of SRI under CROPS in Janagaon Division of Warangal District in Andhra Pradesh

Season	No. of Farmers and Area under different projects							
	WWF		ICRISAT		NABARD		Total	
	Farmers	Area	Farmers	Area	Farmers	Area	Farmers	Area
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Rabi 2007-08	120	86	-	-	-	-	120	86
Kharif 2008	143	110	-	-	-	-	143	110
Rabi 2008-09	466	354	96	77.5	-	-	562	431.5
Kharif 2009	334	201.5	98	65.5	-	-	432	267
Rabi 2009-10	649	407.5	212	117	-	-	861	524.5
Kharif 2010	674	353.75	1142	371	-	-	1816	724.75
Rabi 2010-11	906	540	1928	1022	-	-	2834	1562
Kharif 2011	-	-	-	-	460	230	460	230
Rabi 2011-12	-	-	-	-	800	600	800	600

Note: 1 Farmers in number; Area in acres; 2. '-' indicates none.

Source: CROPS, Jangaon, Warangal District, Andhra Pradesh.

A high spot in the promotion of SRI by CROPS was the participation of a 38-year-old woman farmer Duddeda Sugunamma from Katkur village in a global event organised by World Food Prize Foundation at Iowa, (USA), in October 2011. She presented her experience of rice cultivation before and after SRI. Initially motivated by CROPS, she has been propagating SRI in among fellow farmers in her village and locality (*Deccan Herald*, 2011[43]). Box 2 shows that CROPS has also made notable local modifications to the process of SRI. In response to the experience of monotony in mechanical weeding when SRI labour is alone, CROPS has experimented successfully with multiple weeding teams.

Box 2: SRI Promoting Activities of CROPS

- Motivation of farmers;
- Educated and enthusiastic farmers have been trained to act as master trainers for farmer groups and Farmer Field Schools. Each master trainer is attached to a group of 25-30 farmers
- Organising training programs on the principles and practices involved in SRI method of paddy cultivation;
- Organising exposure visit;
- As part of communication strategy in the newly identified project villages, wall writings at the important public places have been done with messages of SRI practices, and SRI extension material published with the support of supporting organisations (WWF-ICRISAT project, NABARD) has been distributed;
- Films on SRI have been screened for spreading the awareness on SRI practices;
- ***Kaljatha*** (local folk media) programs were organized in the villages to promote BMP and disseminate information about SRI paddy;
- Data on water, fertilizer and pesticide application was collected regularly;
- Strengthening of linkages established with local government agriculture staff.
- Creating awareness among all the family members about SRI method and among the school children, though pamphlets/booklets and other IEC material.

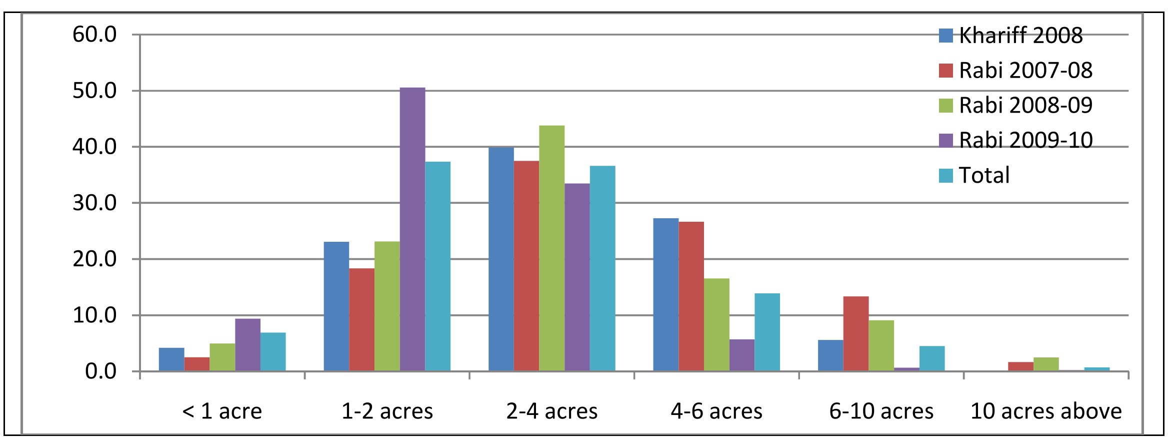
Source: CROPS.

[43] Accessed through http://www.deccanherald.com/content/110687/she-has-become-villagers-envy.html#

However, once WWF and ICRISAT project extension support finished, *dis-adoption rates were very high*. In one particular village visited in 2012, the highest number of farmers adopting SRI with WWF project support had been about 180. Thereafter it had dwindled to only 30. One of the reasons could be as mentioned elsewhere above, there is a flaw in the promotional activities. The promotional activities are supported with supplying some material - vermin compost bag, weeder or marker etc., - as an incentive to adopt the new practice. When the incentive is withdrawn the dis-adoption rate increases. Again, the grass root motivators of promoting agency become inactive once the agencies support is withdrawn. Another issue is timely operations that SRI requires wherein farmers feel like they cannot bind by such regimentation due to certain uncertainties like rains during the main plot preparation and transplantation and electricity supply for irrigating the field day by day; they also feel like it restricts (diversification) their chance to taking up non-agricultural activities.

Based on CROPS' data on SRI farming we found that most adopters are small farmers (see Figure 2). For the most part, even among small and marginal farmers, *only a small part of their total area* used for rice cultivation was kept on trial for SRI. So far, no farmer has adopted SRI completely (Table 15). This is not necessarily typical, however. Although the range between the minimum and maximum area under SRI varied with season and year, *the average SRI area per farmer never exceeded one acre* during the last five years (Table 16). Very few farmers experimented with SRI on more than two acres. It indicates that as if SRI is suitable to small and marginal farmers and holdings. The small and marginal farmers have not gained confidence to extend SRI to all that area they cultivate paddy.

Figure 2: Distribution of SRI Farmers by Size of Holding



Note: Total including all years and seasons.

Source: CROPS.

Table 15: Percent of area under SRI in the total area under rice cultivation by size of the holding – CROPS' Sample Farmers

Size of the Holding	% of rice area in total cultivated land					% of SRI area in total area under rice				
	Kharif 2008	Rabi 2007-8	Rabi 2008-9	Rabi 2009-10	All	Kharif 2008	Rabi 2007-8	Rabi 2008-9	Rabi 2009-10	All
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Below 1 acre	100	73.3	66.7	93.0	91.3	41.7	141.7	91.7	80.6	80.3
1 – 2 acres	62.1	54.6	56.0	69.0	66.2	52.3	68.2	71.3	47.8	51.7
2 – 4 acres	42.3	40.8	51.4	74.3	59.5	51.0	56.9	55.6	31.8	43.2
4 – 6 acres	39.5	34.2	38.5	70.5	44.8	45.8	42.9	42.5	25.4	39.9
6 – 10 acres	32.8	31.4	34.3	75.0	36.0	34.9	38.9	38.8	13.4	36.0
10 acres above	0	14.6	20.8	33.3	20.8	0	37.5	41.7	50.0	41.7

Note: 1. Size of the holding implies the total operational holding of the farmer; 2. For sample size of SRI farmers see Col. 9 in Table 4.3 below.

Source: CROPS.

Table 16: Size of the Farm Holdings under SRI Paddy Cultivation among the CROPS' Sample Farmers

Season/Year	Area under SRI (acres)			% of SRI Farmers by Size of SRI Area				Total SRI Farmers
	Minimum	Maximum	Average	Below 0.5 acre	0.5 to less than 1 acre	1 to 2 acres	2 acres and above	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Rabi 2007-08	0.50	1.0	0.73	49.2	50.8	0.0	0.0	120
Kharif 2008	0.25	2.0	0.78	48.3	44.8	7.0	0.0	143
Rabi 2008-09	0.25	3.0	0.89	38.8	51.2	9.1	0.8	121
Kharif 2009	-	-	-	-	-	-	-	-
Rabi 2009-10	0.20	3.0	0.62	58.0	27.8	14.0	0.2	457
Karif 2010	0.20	2.5	0.84	-	-	-	-	-
Rabi 2010-11	-	-	-	-	-	-	-	-
Kharif 2011	0.25	3.0	0.50	0.7	31.1	33.9	34.3	460
Rabi 2011-12	0.25	1.5	0.70	-	-	-	-	-

Note: ' - ' Not Available.

Source: CROPS.

The experience of CROPS with SRI is similar to the ones obtained in other studies discussed earlier. It shows that to reduce dis-adoption, SRI needs a *continuous follow-up programme* for at least five years. *Incentives* are needed to scale-up the proportion of adopters in a given village. A *critical mass of adopters* would make it possible to have a larger pool of farmers and labourers familiar with the skills of SRI type transplanting and weeding and the synergies that result from 'clustering externalities'.

V
Concluding Observations

The causes of climate change are increasingly apparent in that more or less all forms of production processes, including agriculture, contribute to global warming. The challenge is to identify the sources of greenhouse gases (GHGs), understand the processes through which these are generated, and then intervene in ways that reduce GHGs.

It is widely believed that one of the world's major staple foods, rice, is also one of the larger contributors to GHGs (Jayadev et al., 2009; Quin et al., 2010). The search for alternative ways of growing rice, in a manner that substantially reduces GHGs, has resulted in the identification of SRI as one of the important alternative. By reviewing the results of some of the studies across the globe and the experience in Andhra Pradesh in India, we find that there is incontrovertible evidence, including the preliminary result from our own field study, that SRI uses less water and fewer inputs including energy; reduces costs substantially, and results in higher yields compared with conventional cultivation practices (see e.g., Lim et al., 2011; Kassam et al., 2011; Thakur et al., 2011; Ravindra and Laxmi, 2011; Rao, 2011 and Palanisami et.al., 2013). There is, moreover, substantial net reduction in GHGs under SRI rice cultivation under a controlled water regime as compared to conventional practice (Quin et al., 2011). In addition, SRI is also well-suited for the water–scarce semi-arid tropics and for the economic conditions of small and marginal farmers who depend more on family labour.

In spite of these outstandingly positive findings, not only validated at the field level in our own research which corroborates that of other scientists, but also widely recognised by national, state and local governments, civil society organisations and small-marginal farmers themselves, *the spread of SRI to rice growing areas is extremely slow*, if not retarded. It has failed to make any significant dent on conventional practices and technologies.

Obstacles like the need to follow rigid, time-bound practices, the shift to relatively monotonous isolated work like mechanical weeding, are shown to be *not* insurmountable. Ingenious modifications to tools and practices have been invented. But a further array of factors such as:

i) the lack of resources for research and development in breeding appropriate varieties to overcome the rigid short-duration transplanting schedule,

ii) the appropriate type of weeder including simple mechanised ones that would remove the psychological strain from using the current designs of weeders,

iii) the failure to develop a major agricultural extension programme for SRI and

iv) political resistance to adopt a framework to integrate training in SRI practices with NREGS so as to overcome certain perceived skill deficiencies,

all show that the role of the state in promoting SRI leaves much to be desired. Unlike the agri-technologies for hybrids, GMOs, the design of combine harvesters, and other agricultural machinery, the *corporate sector does not see a profitable market in the promotion of SRI*. On the contrary, there may be corporate lobbies preventing the state from launching major programmes for SRI. The next step *seems to be a public mobilisation in favour of increased public investment and in the design of appropriate strategies for the spread of SRI*. Another sensible strategy is *to pay attention to the varying ways that farmers try to adopt SRI depending on their local conditions*. It is evident now that only 20 percent of adopters of SRI take to all the four core practices of SRI, and the rest of the 80 percent are either partial or low adopters (Palansami et al., 2013). This reflects also laxness in the AP extension system. So finally, farmers need encouragement to adopt incrementally those specific components of SRI that suit them while also helping to increase yields, reduce costs and in so doing generate the co-benefit of lower greenhouse gases.

* * *

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Abbreviations

ATA	- AssociationTefySaina
ANGRAU	- Acharya N. G. Ranga Agricultural University
ATMA	- Agricultural Technology Management Agency
CIIFAD	- Cornel International Institute for Food, Agriculture and Development
CMSA	- Community-Managed Sustainable Agriculture
CROPS	- Centre for Rural Operations Programme Society
CRRI	- Central Rice Research Institute, Cuttack
CSA	- Centre for Sustainable Agriculture

CWS	- Centre for World Solidarity
DAATT	- District Agricultural Advisory and Transfer of Technology
DRR	- Directorate of Rice Research, Hyderabad
FTTF	- Farmer's Technology Transfer Fund
ICRISAT	- International Crop Research Institute for Semi-Arid Tropics
IIED	- International Institute for Environment and Development
IRRI	- International Rice Research Institute
KVK	- Krishi Vignana Kendra
MSSRF	- M. S. Swaminathan Research Foundation
NABARD	- National Bank for Agriculture and Rural Development
NADP	- National Agricultural Development Programme
NGO	- Non-Governmental Organisation
NFSM	- National Food Security Mission
NREGS/A	- National Rural Employment Guarantee Scheme/Act
PRADAN	- Professional Action Development Action Network
SDC	- Swiss Agency for Development and Cooperation
SDTT	- Sir Dorabji Tata Trust
SIDA	- Swedish International Development Cooperation Agency
SRI	- System of Rice Intensification
TNAU	- Tamil Nadu Agricultural University
WASSAN	- Watershed Support Services and Activities Network
WWF	- Worldwide Fund for Nature