SRI Cultivation in Andhra Pradesh: Positive Evidence on Yield and GHG Effects but Problems of Adoption*

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I

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 resources.

However, the increasing demand and the resulting pressure on scarce water resources, particularly ground water, calls for water use efficiency in agriculture, especially in semi-arid tropical rice. Water efficiency has also become an important issue in the context of climate change and the rising emission of greenhouse gases (GHGs). The major greenhouse gases are carbon dioxide (CO2), methane and nitrous oxide. Many anthropogenic activities contribute to the release of these greenhouse gases. Agricultural activities in general and rice cultivation- following the conventional flood or submerge method in particular - contribute to emissions (see Gathome-Hardy 2013). In the submerge method, standing water in the rice fields generates water evaporation, methane and nitrous oxide; fertiliser generates nitrous oxide. Especially in semi-arid regions, ground water is lifted using energy generated through the combustion of fossil fuels which are powerful emitters of carbon dioxide (CO2).

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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. 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 prove 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.

1.2 SRI and Greenhouse Gases (GHGs)

As mentioned above, the greenhouse gases with high global warming potentials (GWP) in the atmosphere are in order of 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, the radiative force and their 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). 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 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 variabilities, the principles and practices of SRI have other strengths like drought-coping capacities (SDTT, 2009).

1.3 Evidence on Yield and Cost Advantages

Studies of SRI cultivation in various parts of the world, in India and in Andhra Pradesh have shown that the yield rates and water use efficiency have both improved (see for instance Uphoff, ud1; Lin et al, 2011; Kassam et al, 2011).. The beneficial effects of SRI have been documented in many countries (V & A Programme, 2009). SRI cropping methods can perform better than 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). The Indian experience validates the beneficial experiences of SRI worldwide (Kassam et al, 2011; Thakur et al, 2011, Ravindra and Laxmi, 2011; V & A Programme, 2009). 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, and the high yield differ across the states ranging from 12 percent in Assam to 53.6 percent in Gujarat (Palanisami et.al. 2013). Similar advantages of SRI are also recorded in the study in terms of income margins and reduced costs. The gross earnings margin from SRI, on an average, is 18 percent higher than non-SRI, and the average per hectare costs are 29 percent less in SRI than in non-SRI. Further, the study also reports that yield levels vary with the variation in the extent to which the core practices of SRI are adopted.

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 (2008-09), 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.

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 higher (Ravindra and Laxmi, 2011; Reddy et al, 2006). These relationships were observed under both tank and tube/shallow well based irrigation systems (Ravindra and Laxmi, 2011). The use of other inputs such as chemical fertilisers and pesticides is substantially lower for SRI (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 the conventional system (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).

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
	Rabi	311	7,310	5,777	1,533	21
2005-06	Kharif	2,864	7,476	5,451	2,025	27
	Rabi	12,277	7,390	5,620	1,770	24
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	24.45
	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.

II

As a part of the efforts to gather scientific evidence from different parts of the rice growing world, a study was undertaken in some parts of India to examine the GHGs effects of SRI and the extent of adoption of the method. The second part of the paper presents evidence on costs, yield and GHGs effect of the SRI based on a study of a cluster of villages in Andhra Pradesh, and the last part discusses the efforts made towards the extension of the area under SRI in the state.

2.1 Preliminary Findings of A.P. Field Study

As a part of larger research project[1] a field survey was conducted in this Jangaon region of Warangal District, Andhra Pradesh, with a sample of 25 SRI farmers and 10 control group non-SRI farmers from nine villages[2] Data was collected from the sample household by a detailed questionnaire designed to suit the life cycle approach, that would 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 for 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 by recall method[3].

Table 2
Summary Statement: Yield, Labour Use and GHG of SRI and Traditional HYV Systems

Rice System	GHG - CO_2 EQ (Per Hectare)	Labour Use (Hrs per Hectare)	Yield (Kgs per Hectare)
SRI (A.P.)	10232	1014	7609
Traditional HYV (A.P.)	13980	1445	4834
Difference of SRI Compared to Traditional HYV	-3748	-431	277.5
% Difference	-26.81	-29.82	57.41

GHG – CO_2 EQ: Green House Gas Emissions in Carbon-di-Oxide Equivalent
Source: Field Study in Janagaon, Warangal District, A.P.

Table 2 presents in summary the results relating to the difference in GHG emissions, labour use and yield level of SRI in comparison with non-SRI rice production. The CO_2 equivalent of GHG emissions under SRI cultivation are 26.81 percent less than non-SRI or conventional HYV practices. SRI also involves 29.82 percent less of labour while yielding 57.41 percent more of output per hectare compared to conventional HYV rice cultivation. Table 3 provides broad source-wise details relating to the generation of GHGs. It shows that apart from soil based methane, the other sources of higher GHGs in conventional rice are the

[1]"Measuring Materiality in Informal Production–Distribution Systems", School of Interdisciplinary Area Studies, Oxford University, Oxford.
[2]Field Study villages are: Katkuru, Chinna Ramancherla, Pedda Ramancherla, Nidigonda, Fateshapur, Ibrahimpur, Kasireddy palle, Dabbakuntapalle and Patelgudem.
[3] The major limitation of the data relates to the 'recall method'. It needs to be qualified that the data are as good or as any 'recall method'. Although it was supplemented by field observations on irrigation, marking and transplanting and weeding practices, these were not collected on a daily basis.

energy used in lifting ground water and fertilizers. The methodology used and the conversion factors adopted are discussed in greater detail elsewhere (Gathome-Hardy et.al. 2013). One of the contentious issues in the cultivation of SRI relates to the labour use. There is a general impression that SRI is more 'labour intensive' than conventional rice cultivation. Table 4 shows that SRI actually uses less labour. The notion of higher 'intensity' of labour in SRI may actually refer to better skill needed in marking and transplanting tender seedlings, and higher human energy intensity needed in handling weeders.

Table 3: KgCO_2 – Equivalent of GHG in Paddy

Rice System	Seed	Seed bed Creation	Cultivation	Fertiliser	Pesticides	FYM	Ground Water Irrigation	Methane CH4 soil derived	Nitrous oxide (N2O) soil derived	Harvest	Storage	Total
I Per Tonne												
SRI (A.P.)	1	67	17	73	0	63	353	640	172	8	-43	1351
Traditional HYV (A.P.)	8	129	19	158	3	90	1050	1335	140	7	-107	2833
II Per Hectare												
SRI (A.P.)	8	414	130	548	4	478	2747	4865	1310	58	-330	10232
Traditional HYV (A.P.)	39	554	92	786	18	447	5309	6534	696	32	-525	13980
Difference								-1669 (-25.54)	614 (88.21)			-3748 (-26.81)

*Figures in parantheses represent percentage difference.
Source: Field Study in Janagaon, Warangal District, A.P.

Table 4: Labour use in Paddy Cultivation (Hours per Hectare)

S. No.	Rice System	Family Labour			Hired Labour			Total Labour		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1.	SRI (AP)	408	253	661 (65.19)	97	256	353	505	509	1014
2.	Traditional HYV (AP)	406	251	657 (45.47)	91	696	787	497	947	1445
3.	Difference in the labour use in SRI	Negl.	Negl.	Negl.	6	-440	-434	8	-438	-431
4.	% of the Difference	Negl.	Negl.	Negl.	6.6	-63.22	-55.15	1.61	-46.25	-29.83

Source: Field Study in Janagaon, Warangal District, A.P.

III
SRI in Andhra Pradesh

Agencies Promoting SRI in A.P

To see how SRI might mitigate the serious challenges to agriculture in AP, we will outline the history of the transfer of this technology and the institutions involved in its adoption, adaptation and spread. In the neo-liberal era, there appear to be no incentive for corporate promotion of innovative alternatives of crop practices like SRI which emphasise reduced dependence on purchased inputs and cost reduction. Hence, it is not surprising that it is the state and civil society, that have pioneered the propagation of SRI.

In Andhra Pradesh, SRI was initiated in Khariff 2002 by a progressive organic farmer, Narayan Reddy of Karnataka, who experimented with it on his farm prior to sharing his experience with a civil society organisation, Timbaku Collective, in Anantapur district. The Timbaku 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, 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).

Table 5: 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	AcharyaRanga Agricultural University (AP), 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	Timbaku Collectives, WASSAN, CROPS, RDT, APDAI, , JalaSpandana, Laya, many other local NGOs at grassroot 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 Acronyms at the end of the paper.
Source: Authors' compilation.

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 Khariff 2003. Since then ANGRAU involved other civil society organisations in its project promoting SRI. At the district level the Krishi Vignana Kendras[4] (KVKs) and District Agricultural Advisory and Transfer of Technology[5] (DAATT) Centres associated with ANGRAU worked as a frontline SRI demonstration units. ANGARU has itself conducted field demonstrations of SRI practices. The Directorate of Rice Research (DRR) stationed at Hyderabad joined the endeavour through field trials and research experiments monitoring costs of cultivation and yield rates. Since 2006, the Government of Andhra Pradesh initiated measures for promoting SRI principles and practices. From 2007-08, ANGARU focussed 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 decline in field trials and demonstrations for which the Department was ill suited.

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 the national and international organisations. Since 2004-05, an ICRISAT-WWF project has also played important role in promotion of SRI in AP and further afield in India (Prasad, 2006). Thanks to ICRISAT-WWF and ANGARU, the SRI methodology has been evaluated for its potential in saving water and in increasing productivity under different agro-climatic conditions and different 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 – are working with the farmers to spread the practice of SRI in different parts of the country and Andhra Pradesh (Prasad 2006).

3.2 Coverage under SRI

As pointed out earlier, the Government of Andhra Pradesh has been involved in promoting SRI in the State. Since 2003-04, the Department of Agriculture has organized SRI demonstrations, and since Rabi 2005-06, the objective was at least one demonstration in

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[4]There are 34 KVKs in the state. Of which 23 are operated 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.

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

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), 1680 SRI demonstrations were targeted for 2008-09 (1272 in Khariff and 408 in Rabi) with a financial outlay of Rs.5.0 million (Rs.3000 per demonstration) and further grants of Rs. 3000 for the purchase of 'cono-weeders'[6]. 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 Work Plan (Rice) with an outlay of Rs.26.7 million.

Table 6: Extent of SRI Paddy in Andhra Pradesh

Year	Rice area covered (in 000Hec)			Area underSRI(in Hec)		
	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)[7] which is part of the SHG-based Indira Kranthi Patham (IKP) Programme promoted by the Society for Elimination of Rural Poverty (SERP)[8] in Andhra Pradesh (Table 7). Under the CMSA programme SRI has been encouraged through women's self-help groups (SHGs). In 2008-09, SRI was implemented in around 1000 acres across districts in the state. Targets were given to the districts based on the number of weeders available: 3 acres of SRI paddy

[6]Cono-weeder is a mechanical rotary instrument used for weeding in SRI.
[7]The thrust of CMSA is to promote non-chemical pesticide agriculture with an emphasis on soil rejuvenation and multiple cropping especially in dryland areas.
[8]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).

per weeder. Table 7 shows the slow but steady progress achieved in SRI under the CMSA from about 1100 acres in 2008-09 to about 16000 acres in 2011-12.

Table 7: 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[9] (Rs. 2568.0 lakh) 17 (Rs. 282.9 lakh) are in AP[10] where NABARD collaborates with the local NGOs in the implementation of these projects over a period of three years (Table 8).

Table 8: Details of NABARD's FTTF Targets for SRI

Sno	Details	India	AP
1	*2*	*3*	*4*
1	No of Projects	150	17
2	No of Farmers Targeted for SRI	84000	9240
3	Target Area (in Hec) 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.

[9] 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.
[10] All the 17 projects in the state cover 272 villages across 17 rural districts.

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) has been recorded in SRI in AP. Second, SRI rice has also been found to mature earlier than conventional varieties. SRI also withstands flooding and cyclones because of thicker stems and root systems. SRI 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[11], a simple tool to mark the lines for transplantation in rows, developed in the state, is very popular with SRI farmers in the State and elsewhere. Similarly the innovative agricultural engineering of weeders by ANGARU 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, the coverage remains very low under the system. As recently as in 2011-12, only about two per cent of the total area under rice in the State was under SRI. There are a number of factors that hinder its sustained adoption.

3.3 Problems and Prospects of SRI in AP

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 timely and skilled. In SRI crop production, labour costs are relatively lower than those of conventional practices. But SRI is a more rigorous and exact regime that needs precision-timed operations and constant supervision. The modern factory-like production regime of SRI struggles to penetrate a culture of flexible and more easy-going practices associated with rice cultivation in India. There is also certain physical agility associated with the use of weeder, marker and transplanting single seedlings. The intensity of labour requires male/female labour with a certain minimum physical energy to use the weeder and skills in the use of the marker while female labour requires new skills for transplanting. Since its

[11] It is a 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.

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 in contrast to the reported 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.

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 ‘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 that of the plot awaiting transplanting. Small farmers balance their limited ground-water resources against rainfall but the Khariff rains frequently confound this balancing act. With meagre ground water, producers prepare their nursery expecting the 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.

Another major concern is that the 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.

Despite Andhra Pradesh’s vigorous initiatives, the diffusion of SRI is now lagging behind that of the neighbouring state of Tamil Nadu. TN’s promotional methods also appear to be different. 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.

3.4 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[12], working to propagate SRI principles mainly among farmers in Jangaon 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 Jangaon 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.

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
- BtVs 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
- Implementation of 10 RIDF watersheds - DWMA, Nalgonda and Warangal
- 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.

With the support of two leading civil society organisations (CWS and CSA), CROPS' efforts in sustainable agriculture meaning chemical-free organic agriculture are remarkable. The

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

organisation is developing a model organic farming village, Enabavi, in Warangal District[13]. A feather in its cap is that for the year 2007-8 an Enabavi farmer and Grass Root Motivator, Sri. Ponnam Mallaiah from Enabavi, was chosen along with his village, for the **Krishi Gaurav Award** by Pathanjali Trust[14], 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.

Most of the crop agriculture in the area of Jangaon 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 even to unmanageable levels. The increasing costs in the face of volatile and uncertain prices of cotton, often resulted in costs exceeding returns. 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 to prominence along with cotton and maize. The volume of rice traded in the local grain market increased from 3000 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, Jangaon, was established in 2002 with a capacity of 30,000 MT. A second godown with a capacity of 1,50,000 MT started working in 2009. The phenomenal increase in rice trading is due to local increase in rice production, due to expansion in area as well as yield.

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[13]***Enabavi***, the 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, 300 acres constituting the 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).

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

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 under open wells to a limited extent constrained by the availability of water and it was mostly for home consumption. 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 tank for direct irrigation. While tanks allowed the cultivation of rice only in the Khariff season, irrigation using ground water permits rice to be grown in both main seasons. Bore-well or open-well irrigation also facilitates 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) in lift irrigation. Water and energy saving methods of rice cultivation are therefore needed in the region.

As regards SRI cultivation methods, in Jangaon division since Rabi 2007-8 CROPS[15] 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 Jangaon division. And with the support of ICRISAT, it introduced SRI in 26 more villages in three other mandals[16] (Lingal Ghanpur, Jangaon 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 (Jangaon and Lingal Ghanpur) for the two seasons Khariff 2011 and Rabi 2011-12. The NABARD project then was extended to two further years with increased targets for farmers and acreage.

[15] With the support of the WWF project.

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

Table 9: Coverage of SRI under CROPS in Jangaon 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[17]). 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, SRI extension material published with the support of supporting organisation (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.

[17] 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 have been 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.

Based on CROPS' data on SRI farming we found that most adopters are small farmers. For the most part, even among small and marginal farmers, only a small part of the total area used for rice cultivation was kept on trial for SRI. So far, no farmer has adopted SRI completely (Table 10).

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 over the last five years (Table 11). Very few farmers experimented with SRI on more than two acres.

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				
	Khariff 2008	Rabi 2007-8	Rabi 2008-9	Rabi 2009-10	All	Khariff 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	41.7	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 11: 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. CROPS experience shows that to reduce dis-adoption, SRI needs a continuous follow-up programme for at least five years. Scaling-up needs incentives to expand 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.

V
Concluding Observations

The real effects 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 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 the 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 in controvertible 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 for 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 substantial net reduction in GHGs in rice cultivation under a controlled water regime as compared to conventional practice (Quin et al, 2011). SRI is a strong candidate in this category. In addition, SRI is also suited for the water – scarce semi-arid tropics and for the economic conditions of small-marginal farmers who depend more on family labour.

In spite of these outstandingly positive findings, not only validated at the fields level by 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:

- ❖ Absence of R & D efforts for breeding appropriate varieties to overcome the rigid short-duration transplanting schedule.
- ❖ Failure to invest in the development of simple mechanised ones that would remove the psychological strain from using the current designs of weeders.
- ❖ Failure to develop a major agricultural extension programme for SRI.
- ❖ Political resistance to adopt a framework to integrate training in SRI practices with NREGS so as to overcome certain perceived skill deficiencies etc.

all show that the role of the state in promoting SRI is much below optimal levels. 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 for investing in the promotion of SRI. On the contrary there may be corporate lobbies preventing the state from launching major programmes for implementing SRI. The solution seems to be in public mobilisation in favour of increased public investment and design of appropriate strategies for the spread of SRI. Another sensible strategy is to pay attention to the varying ways 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 six core practices of SRI, and the rest of the 80 percent are either partial or low adopters (Palansami et.al. 2013). Therefore, it is also suggested that farmers be encouraged to adopt specific components of SRI that suits them and at the same time helps in increasing yield and reducing costs (Palanisami et.al. 2013).

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Abbreviations

ATA	- Association of TefySaina
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
CSA	- Centre for Sustainable Agriculture
CWS	- Centre for World Solidarity
DAATT	- District Agricultural Advisory and Transfer of Technology
DRR	- Directorate of Rice Research
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	- KrishiVignana 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