SYSTEM OF RICE INTENSIFICATION IN INDIA

This summary document provides an overview of the state of system of rice intensification in India. And also covers a literature review of impact studies conducted on system of rice intensification in India. **It is a part of the larger CEEW study,** *Sustainable Agriculture in India 2021: What We Know and How to Scale Up.*

Sustainable Agriculture in India 2021: What We Know and How to Scale Up, is a handbook on the prevalence, practices and state of affairs of the 16 most promising sustainable agriculture practices in the country. It presents the economic, social and environmental impacts of these practices with recommendations on their potential to scale-up sustainable agriculture in India.

The study is available at: https://www.ceew.in/publications/sustainable-agriculture-india-2021

Image: Unsplash

System of rice intensification, or SRI, is a climate-smart agroecological methodology for increasing the productivity of rice and other crops by changing the management of the plant, soil, water, and nutrients. It was developed in Madagascar in the 1980s by French Jesuit Father Henri de Laulanié, not as an outcome of scientific research, but instead through personal experiments and observations. SRI is based on four main principles that interact with each other:

1. Early, quick, and healthy plant establishment
2. Reduced plant density
3. Improved soil conditions through enhancing soil organic matter
4. Reduced and controlled water application.

These principles give rise to a set of practices that farmers can adapt to their specific agroecological and socioeconomic conditions. The most common methods are summarised below.[1,2,3]

1. **Transplanting of very young seedlings**: Generally, between 8 and 15 days old to preserve the plant's inherent growth potential for rooting and tillering.

2. **Planting seedlings singly**: Transplanting a single seedling per mound instead of many seedlings often plunged into the soil, inverting and damaging the root tips.

3. **Wider spacing:** Reducing the plant population radically by spacing mounds further apart, at least 25 x 25 cm and in some cases even 50 x 50 cm, and in a square pattern rather than in rows, so that both the roots and canopy have room to grow and can have greater access to nutrients and sunlight.

4. **Unflooded irrigation:** Provide growing plants with sufficient water to meet the needs of roots, shoots, and soil biota, but never in excess during the plants' vegetative growth phase (up to the stage of flowering and grain production), so that the roots do not suffocate and degenerate.

5. **Inter-cultivation:** Using a simple mechanical hand weeder (or a rotary hoe) to aerate the soil and control weeds. Active soil aeration improves rice crop growth by benefiting both roots and beneficial aerobic soil organisms.

6. **Using more organic manure or compost:** To improve the soil organic matter and support beneficial soil organisms.

System of rice intensifications's linkages to FAO's agroecological elements

SRI shares many agroecological principles as defined by the FAO, but incorporates only some agroecological practices.

Elements	Description of agroecological linkages
Co-creation and sharing of knowledge	Unlike other farming methods, SRI is not based on material inputs. Instead, it evolved as a knowledge-based system, and hence knowledge sharing is crucial. In India, it was traditionally practised in the southern states as single seeding planting. Over the years, the practice has emerged as a technology through experimentation and knowledge-exchange between farmers, civil society organisations, and the scientific community.
Synergies	The root and shoot elongations with SRI indicate the promising potential for biological synergy through the interaction of different elements.
Efficiency	Water efficiency is the most crucial aspect of SRI. The use of alternate wetting and drying (AWD) for crop management under SRI results in less water consumption. It increases yields, making the water-saving method profitable for farmers.[4]The practice also encourages less use of synthetic agro-inputs.
Recycling	Weeding in SRI is mostly mechanical – a simple push weeder. The incorporation of weeds into the soil enables nutrients to be recycled.
Resilience	Rice plants under SRI have larger, deeper, non-senescing, and stronger root systems, making the crop more resilient in water-stressed areas and to the pounding of rain and wind during storms.[5]The reduced cost of seeds (especially the expensive hybrids) and fertilisers, along with increased yields, build economic resilience.

A brief context in India

Research on SRI was promoted in 2002-03 by the state agricultural universities in Tamil Nadu and Andhra Pradesh. The extension of SRI techniques began slowly in India due to yield-loss apprehensions surrounding SRI principles. However, farmers' success stories have enabled its adoption to be scaled up, especially in the last five years. Thus 'seeing is believing' has been a powerful prompt for SRI adoption. SRI's water-saving potential was one of the most important levers to convince many farmers and civil society organisations to adopt and experiment with SRI and its practices in India's southern states. Since then, many civil society organisations and institutional entrepreneurs have popularised SRI principles in different states of the country. At the policy level, SRI is considered a necessary means of boosting national rice production under India's *National Food Security Mission (NFSM)* in 133 food-insecure districts.

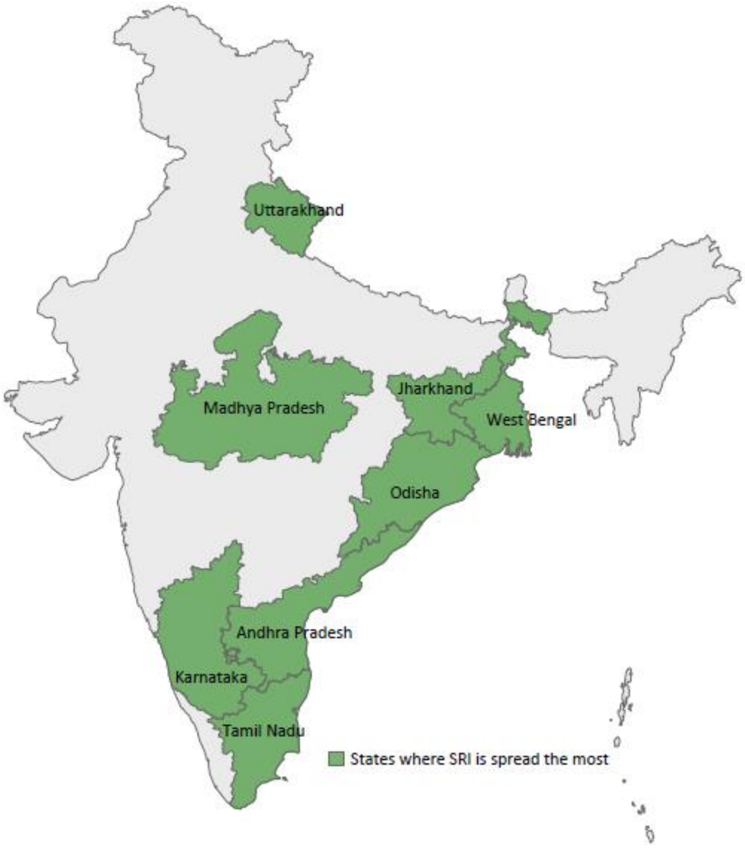
System of rice intensification: acreage, geographies, and cultivation details

How much area in India is under SRI? There is increasing involvement by farmers, civil society organisations, government institutions, research agencies, and funders to promote SRI adoption in India. While there is no information on the area under SRI in India, the consultations suggested it could be anywhere between 3-4 million hectares across different states.

How many farmers in India are practising SRI? There is no reliable recent information on the adoption rate of SRI in India. However, a National Consultative Meeting on upscaling SRI at the National Academy of Agricultural Sciences (NAAS) in New Delhi in 2016 suggested that more than three million farmers across the country have recognised SRI's benefits and adopted these practices. Consultations with civil society organisations hinted this number could be higher.[6]

Where in India is SRI prevalent? The first few states to adopt SRI were Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, and Pondicherry. States such as Tripura, Bihar, Chhattisgarh, Uttar Pradesh, Punjab, Gujarat, Odisha, and Jharkhand are also actively engaged in SRI promotion (Figure 1). It is also being promoted in other states by the Tata Trusts.

Figure 1. 50-95% of the districts in highlighted states practice SRI



Source: SRI India Website

Which are the major crops cultivated under SRI in India?

In addition to rice, the SRI principles are now applied to other crops as well. This includes wheat, sugarcane, pulses, finger millets, mustard. When applied to other crops, the practice is referred to as the System of Crop Intensification.

System of rice intensification promotion by non-government organizations

Since 2008, a Tata Trust project has been promoting SRI with a consortium of NGOs across several states in India. Thus far, the program has covered over 170,000 farmers in 3,500 villages, spread across 104 districts in Odisha, Bihar, Chhattisgarh, Assam, Manipur, West Bengal, Jharkhand, Maharashtra, Madhya Pradesh, Uttar Pradesh, and Uttarakhand. In Odisha, NGOs like Sambhav and PRADAN have been spreading SRI in different parts of the state.[7]

Impact of system of rice intensification

The SRI website of Cornell University (SRI-Rice), the SRI website of the Watershed Support Services and Activities Network (WASSAN), and popular journals have all documented SRI's impact on various indicators in India. At the close of 2019, the number of items in the India SRI research collection maintained by SRI-Rice was 648, of which 548 journals address SRI in India.

ECONOMIC IMPACT

1. Yields

There is substantial evidence documenting an increase in yields for various paddy varieties under SRI in different parts of the country than conventional rice systems.[8]The basis for this increase is visible in larger root systems, the greater number of tillers, and more and longer panicles.[9,10]The papers suggest the average increase in yields can vary anywhere between 20-50 per cent (and more in a few cases). This variation in yields depends on many factors – the rice variety, climatic conditions, how well the SRI practices are implemented and managed, and the crops' biological dynamics.[11]

The efficient use of natural resources under SRI, when compared to conventional agriculture, is also well documented. Under SRI, paddy nursery is raised using 5-8 kgs of seeds per hectare on average, compared with the usual 40-50 kgs. This saves input costs for farmers and reduces workloads, especially for women. However, drudgery in the weeder operation is a significant constraint. The direct and indirect input requirements for rice cultivation using an input-output model decreased when cultivation shifted from traditional to SRI.[12]Another benefit of SRI, which is less frequently documented, is that improved grain quality causes less breakage of grains during milling, resulting in about 10-15 per cent more edible rice produced per bag of harvested paddy than conventional methods.[13]More research is required on this subject.

Despite the improved yields and low-cost benefits of SRI, India's adoption rate is still very low. One of the significant challenges highlighted in the literature and our interviews was the labour-intensive nature of the practice and the lack of skilled workforce available at the right time for planting operations.[14,15]However, with experience and knowledge, the labour requirement per hectare can decline. In the absence of a wide range of appropriate equipment, especially seed drills, transplanters, weeders, and markers, many farmers (especially large farmers) do not find SRI an efficient and feasible rice cultivation method.

2. Income

Increased net income and greater profitability are the quantifiable benefits of SRI. However, these economic impacts are "very context-specific and depend on micro-level socioeconomic and agroecological conditions." One of the significant savings under SRI is the reduction in seed costs. Since it requires only a single seedling to be transplanted per hill at a wider spacing, fewer seeds are needed in SRI than conventional rice cultivation, resulting in lower production costs. The savings are even more significant for hybrid seeds, which are usually more expensive than the other traditional varieties. Similarly, there is evidence of reduced nursery preparation costs under SRI.

Simultaneously, the need for higher and more skilled labour (initially) is considered a significant constraint under SRI. Being a knowledge- rather than input-intensive innovation, the lack of skilled labour hinders its adoption. On the other hand, some studies indicate that SRI is not any more labor demanding for countries like India, where labour-intensive rice cultivation already happens. Instead, SRI methods have substantially reduced farmers' need for hired labour as family members now manage many operations. In this case, low-earning opportunities for agricultural labourers could be a social cost of the system.[16]

SOCIAL IMPACT

1. Human health

There is a scope for more research to develop the methodology for studying SRI's impact on health outcomes.

2. Gender

SRI reduces the workload and drudgery for women farmers. As mentioned before, seed requirements are reduced significantly due to wider spacing. This reduces women's workload as they now have smaller nurseries to manage. Similarly, traditionally weeding is done by hand, mainly by women. However, using a mechanical hand weeder saves time and, most importantly, improves the working posture. This lighter workload gives women time for other things, allowing them to generate more income (stakeholder consultation).

In India, many NGOs engage especially with women farmers in SRI as part of their development programmes. The training and skill enhancement women receive empowers them, builds grassroots leadership, and in some cases, has also resulted in women starting to exert their influence on sustainable farming policies (stakeholder consultation).

ENVIRONMENTAL IMPACTS

1. Soil and nutrients

The impact of SRI practices on root development and functioning is a growing area of research in India, with several studies documenting the positive effects. The use of single young seedlings reduced plant densities, mechanical weeders, and AWD helps in soil aeration, enhances organic matter, and improves soil physio-chemical and biological properties.

One of the criticisms of SRI has been the exploratory nature of evidence. Given that soil biological parameters vary greatly and are sensitive to different soil chemical, physical and hydrological conditions, there is a need for more systematic research into these specific causes.

2. Water

SRI's positive impact on water productivity is well established in the literature worldwide, including in India. At an individual plant level, phenotypes from SRI practice are "physiologically more water-efficient, synthesizing more carbohydrates in their leaves per unit of water taken up by their roots."[17]Areas where water constraints have become more challenging, such as a phenotypic increase in water use efficiency, will benefit.

A meta-analysis of water productivity under SRI management reviewed 29 published studies with 251 comparison trials conducted across eight countries reported lower total water requirements per hectare (irrigation and rainfall) under SRI. This averaged 12.03 million litres, compared with 15.33 million litres under the best non-SRI management practices in those areas.[18]. Further, with alternate wetting and drying (AWD) practices, not only is less water consumed, but yields also increase, making water-saving more profitable.[19]

However, efficient water control, both for irrigated and rainfed conditions, is frequently mentioned as an SRI challenge. It is difficult to have young seedlings ready for transplanting in the rainfed areas due to a lack of control over the water supply. It is also not easy to fix a schedule for AWD and have an in-field irrigation water application. In the irrigated areas, farmers can have difficulties "controlling the timing and volumes of water applied as they depend on field-to-field flows or have to work within fixed and uniform water distribution schedules. In areas where irrigation is free of charge, there is no incentive to economise on water applications."[20]

3. Energy emissions

Conventional rice cultivation demands a large amount of water, which is a highly energy-intensive resource. SRI reduces the water demand significantly; it could be superior in energy consumption, net energy, energy use efficiency, energy productivity, energy intensity, and energy profitability. However, there is very little research done in India on this indicator.

A field experiment conducted in the Red Lateritic zone of West Bengal to compare the energy use and energy input-output relationship of SRI with conventional transplanting (CT) showed that CT consumed almost 62 per cent more energy than SRI. Maximum energy input was associated with non-renewable and indirect sources. Higher doses of nitrogenous fertiliser contributed 32.35 per cent and 26.26 per cent to the total input energy in CT and SRI, respectively.[21]

4. Emissions

Many studies document the lower methane (CH_4) emissions from SRI globally. In India, however, there is still scope for creating such evidence in different climatic conditions.

Reductions in CH_4 emissions under SRI are often less marked for rainfed areas than for irrigated production. Still, they could be reduced further by avoiding rainwater as possible on lowland rice paddies during and after rain.[22]However, while SRI rice paddies with less flooding would produce less CH_4, they may produce more N_2O. "Compared to soils that are always saturated and thus hypoxic, aerobic soils have a greater supply of nitrate-nitrogen (NO_3–N) through the process of nitrification."[23]

At the Indian Agricultural Research Institute site in New Delhi, SRI methods were found to reduce CH_4 emissions by 62 per cent, but to increase N_2O emissions by 23 per cent compared to conventional irrigated rice crop management with the same integrated nutrient management.[24]Considered together, these effects amounted to a 28 per cent net reduction in global warming potential (GWP) per hectare.[25]A life-cycle assessment of total Greenhouse gas (GHG) emissions in Andhra Pradesh reported that SRI reduced total

GHG emissions by more than 25 per cent per hectare. In addition to the increased yield, net emissions per kgs of rice were lowered by more than 60 per cent.[26]

Nonetheless, the long-term carbon sequestration effects of growing rice plants with SRI methods remain to be evaluated more systematically.

5. Biodiversity

No literature available.

Impact evidence

State of available research discussing the impact of SRI on various outcomes.

Evidence Type	Yield	Income	Health	Gender	Soil and nutrients	Water	Energy	GHG emission	Bio-diversity
Journals	34	10	1	2	12	36	2	0	0
Reports	6	8	0	4	1	9	0	0	0
Articles/case-studies	7	7	0	15	1	7	0	0	0
Others **	3	3	0	0	1	0	0	0	0
Total	**50**	**28**	**1**	**21**	**15**	**52**	**2**	**0**	**0**

*** Thesis, guidelines, conference papers, etc*

Source: Authors' compilation

Note – The evidence is from the first 75 results examined in Google Scholar Advanced search and the first 30 results from Google Advanced Search. Only those papers which clearly established the evidence for different indicators were selected.

Stakeholder mapping

The following institutions are involved in the research and promotion of SRI; a few were consulted for this research:

Government institutions	Research/implementation institutions	NGOs/civil society organisations
Indian Institute of Rice Research (IIRR) - Hyderabad	SRI - an initiative of ICRISAT - WWF project	Watershed Support Services and Activities Network (WASSAN)
Krishi Vigyan Kendra	ICRISAT - Patancheru	AME Foundation
National Bank for Agriculture and Rural Development (NABARD)	Tamil Nadu Agricultural University (TNAU)	VOICE Trust
Indian Council of Agricultural Research (ICAR)	M S Swaminathan Research Foundation	PRADAN

JAI SRI- AP (Joint Action Initiative on SRI - Andhra Pradesh).		EKOVENTURE
		Timbaktu Collective

Source: Authors' compilation
Note: The stakeholders list is indicative and not exhaustive

Endnotes

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FOLU Coalition: Established in 2017, the Food and Land Use Coalition (FOLU) is a community of organisations and individuals committed to the urgent need to transform the way food is produced and consumed and use the land for people, nature, and climate. It supports science-based solutions and helps build a shared understanding of the challenges and opportunities to unlock collective, ambitious action. The Coalition builds on the work of the Food, Agriculture, Biodiversity, Land Use and Energy (FABLE) Consortium teams which operate in more than 20 countries. In India, the work of FOLU is being spearheaded by a core group of five organisations: Council on Energy, Environment and Water (CEEW), the Indian Institute of Management, Ahmedabad (IIMA), The Energy and Resources Institute (TERI), Revitalising Rainfed Agriculture Network (RRAN) and WRI India.

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