SYSTEM OF RICE INTENSIFICATION (SRI) - A WAY TO IMPROVE WATER PRODUCTIVITY IN RICE

VibhuNayar & V.K. Ravichandran

ABSTRACT:

Tamil Nadu is one of the water stressed states in India where the total water resource available is 46540 Mm^3 (both surface and Groundwater)as against the demand of 54395 Mm^3 leaving a gap of 7855 Mm^3 (Report of the Expert. Committee on Development of Water Resources of Tamilnadu- March 2003) The Agricultural sector consumes around 86 percent of the available water with Rice as one of the important food crops. The rice production in the state is 3.22 million tonnes from an area of 1.40 million hectares with the productivity of 2308 Kg/ha. Among the several production constraints, availability of irrigation water is a major factor as rice crop consumes about 70 percent of the water available for agriculture.

In the Context of alarming Climate Change a paradigm shift is essential to adopt conservation techniques and new farm practices to reduce the consumption of water in agriculture. An agronomic option to use less water through water saving practices is one method to conserve water. System of Rice Intensification (SRI) is a holistic agro-ecological crop management technique seeking alternatives to the high-input oriented agriculture. It focuses on scientific management to achieve maximum crop production per unit of water applied over a unit area in unit time. Additionally farmers depending on ground water will also realize the saving of water, time and electricity under SRI method.

Studies conducted in four locations to compare the efficiency of SRI irrigation with the conventional irrigation under IAMWARM (Irrigated Agriculture Modernization and Water Bodies Restoration and Management) a World Bank assisted project during 2007-2010., confirm that for SRI, water requirement is low and crop productivity is high.

The enhanced water productivity in SRI in irrigated sub basins could be attained only when irrigation service delivery in the command area are properly maintained. This objective was achieved in IAMWARM Project where Water Resource Organizations (WRO) in collaboration *with agriculture, rehabilitated the irrigation structures, developed water budgeting with peoples participation and adopted SRI in sub-basin command.*

The details of the studies and results are discussed in the paper.

Key Words: Water - SRI - Alternate Wetting and Drying - CCWM

WATER SCENARIO:

Water Resources development and its efficient management poses a complex challenge globally and particularly in India and China. Growing population, urbanization and rapid industrialization combined with the emergent need for improving food production generates competing demands for water among various sectors.

Globally the per capita availability has decreased from 19,900 cubic metre (1950) to 6800 cubic metre (2000). This is estimated to decline to 5400 cubic metre by 2025.

The agricultural sector is the major consumer of water, to the extent of 70% of all water withdrawals (IWMI 2010). In developing countries about 85% of all water withdrawals are used in agricultural Sector. Asia uses 50% of all irrigation drawls in the world. In Asia, India and China are the biggest consumers.

The World population of 6.07 billion in 2000 is projected to grow to 8.13 billion in 2030 and 8.92 billion in 2050. The FAO and world food programme (2009) reported that more than a billion people worldwide do not have enough food. A declining trend in crop yield and an increasing water shortage are apparent in many nations (Rosegrant and Cline 2003).

The opportunities for the development of new water resources at reasonable financial and environment cost is very meagre. The demand for water in 2025 is projected to be met by increasing the Water Productivity in agriculture, which seems to be a viable and implementable alternative. The productivity of irrigation water in agriculture can be increased by diversification from water guzzling lower valued crops to less water requiring high valued crops. Despite this, World needs more grain for food under the climate change scenario.

India with 2.4% of the world's total area 16% of the world's population has only 4% of the total available fresh water. The estimate of Central Water Commission puts the total water resources of India at 1869 billion cubic metre (bcm). The per capita availability of water has been steadily declining since 1950 due to varying climate and population growth (Planning Commission Report 2007).

In India the requirement of water for various sectors has been assessed by National Commission on Integrated Water Resources Development (NCIWRD) and MoWR is furnished in Table 1.portraying a stressful situation on the availability of water for Agriculture Sector

Table - 1 Water Demand in BCM

Sector	**Water Demand in BCM**					
	Standing Sub-Committee of MoWR			**NCIWRD**		
Year	2010	2025	2050	2010	2025	2050
Irrigation	688 (84.6%)	910 (83.3%)	1072 (74.1%)	557 (78.5%)	611 (72.5%)	807 (68.4%)
Drinking Water	56 (6.9%)	73 (6.7%)	102 (7.0%)	43(6.0%)	62 (7.4%)	111 (9.4%)
Industry	12 (1.5%)	23 (2.0%)	63 (4.4%)	37 (5.2%)	67 (7.9%)	81 (6.9%)
Energy	5 (0.6%)	15 (1.4%)	130 (9.0%)	19 (2.7%)	33 (3.9%)	70 (5.9%)
Others	52 (6.4%)	72 (6.6%)	80 (5.5%)	54(7.6%)	70 (8.3%)	111 (9.4%)
Total	**813**	**1093**	**1447**	**710**	**843**	**1180**

(Figures in Parenthesis is percent to the total) **(VibhuNayar, 2011)**

Tamil Nadu is one of the driest states in India, averaging only 925 millimeters of rainfall a year. Per capita availability of water resources in Tamil Nadu (population about 62 million) is only 900 cubic meters a year, compared with an average of 2,200 cubic meters for all of India.

Tamil Nadu's geographic area can be grouped into 17 river basins, a majority of which are water-stressed. There are 81 major reservoirs, about 40,000 tanks (traditional water harvesting structures) and about 3 million wells, that heavily utilize the available surface water (17.5 BCM) and groundwater (15.3 BCM). Agriculture is the single largest consumer of water in the state, using 86% of the state's water.

AGRICULTURE:

Tamil Nadu is one of the water stressed states in India where total water resource available is 46540 Mm^3 as against the demand of 54395Mm^3 leaving a gap of 7855 Mm^3. Rice is the predominant crop accounting for nearly 70 per cent of total irrigated area in Tamil Nadu. Therefore it is necessary to develop suitable strategies and technologies that recognize and adequately address the challenges in the years to come for reducing water resources since achieving food security has been the overriding objective of agricultural policies.

Among the production constraints, availability of irrigation water is a major one, since rice as a predominant crop in Tamil Nadu consumes 70 percent of the water available for agriculture. The gap between water supply and demand for irrigated crops in Tamil Nadu is projected to increase beyond the current gap of 7855 Mm^3.

IAMWARM PROJECT:

In Tamil Nadu the agricultural sector using 86% of states available fresh water resources suffered from a syndrome of low water productivity due to slow and disjointed functioning of various Departments in the Water

Sector and poor application and convenience efficiencies. This juxtaposed with conventional farm choice inclined towards water guzzling crops coupled with age old practices pushed the state in to a water scarcity trap. IAMWARM Project began in 2007 mainly to increase the irrigated agricultural productivity wiht sustainable water resources management in a sub-basin framework with convergence of 8 departments (viz., Water Resources Department, Agriculture Department, Horticulture Department, Tamil Nadu Agricultural University, Agricultural Marketing Department, Agricultural Engineering Department, Animal Husbandry Department and Fisheries Department.) related to Water Sector. The project aims at improving the effective service delivery of irrigation systems in a multi-disciplinary approach besides enhancing the productivity of land and water under irrigated agriculture. The Tamil Nadu Agricultural University (TNAU) works in convergence with other line departments promoting the Water saving technologies among the farming community.

SYSTEM OF RICE INTENSIFICATION (SRI):

SRI is the best solutions available to farmers and nations to promote community-led agricultural growth while managing soil and water resources more sustainablyand even enhancing their future productive capacity. The System of Rice Intensification (SRI) not only reduces the use of irrigation water but also increases yields significantly and enhances the livelihood of rice farmers.

The SRI is an agro-ecological approach enabling farmers to increase yields while using less seed, water, fertilizer, and often less labor. This has the potential to increase food security, raise incomes, conserve water, and buffer crops against adverse effects of climate change on a very large scale. Apart from these, SRI has the potential to reduce production costs, and chemical inputs. Available data from SRI experiments across Tamil Nadu show an increase in grain yield of up to 68% (Annual report, 2010).

SRI consists of several management components applied in an integrated manner viz., transplanting of 14 days old young seedlings in a square grid with wider spacing (25cmx25cm), weeding by mechanical weeders from early vegetative stage and alternate wetting and drying water management during vegetative phase followed by shallow submergence after panicle initiation stage. (Uphoff and Randrianiharisoa, 2002; Uphoff*et al.* 2002 andSatyanarayana*et al.* 2007).

Despite the various dispute among the rice researchers SRI has been disseminated to the farmers in and around 45 countries mostly in South and Southeast Asia. A compilation of results from 11 surveys in 8 countries including 16000 SRI farmers has shown on an average 47% yield increase, 40% water saving, 23% lower production costs and 68% farmers income compared to conventional rice cultivation (Sato and Uphoff 2007 Africare*et al.* 2010). The SRI root system are much larger with root pulling resistance per clump almost double that of the conventional paddy. Increased exposure to solar radiation with increased spacing is an important factor for improved photosynthesis the prime phenomenon for plant growth.

The SRI is the enabling crop practice for conservation of water in the prevailing water stress scenario.

METHODS:

The SRI was freshly adopted in this project including raising of seedlings in a smaller area (100 m^2 / ha) of nursery, using the seed rate of 8 Kg/ha and transplanting of young seedling (14 days old) with two to three leaf stage in square spacing of 25 x 25 cm using marker. Mostly single seedlings per hill (at times two in few places) alternate wetting and drying (AWD) irrigation and mechanical weeding 1-3 times 10-15 days after transplanting are followed by the farmers.

So far SRI demonstrations and upscaling were conducted in an area of 1,50,000 ha by IAMWARM Project since 2007 in 61 different sub basins in Tamil Nadu. The SRI activity carriedout in Varahanadhi sub basin is furnished in Fig1. Field studies were conducted in non

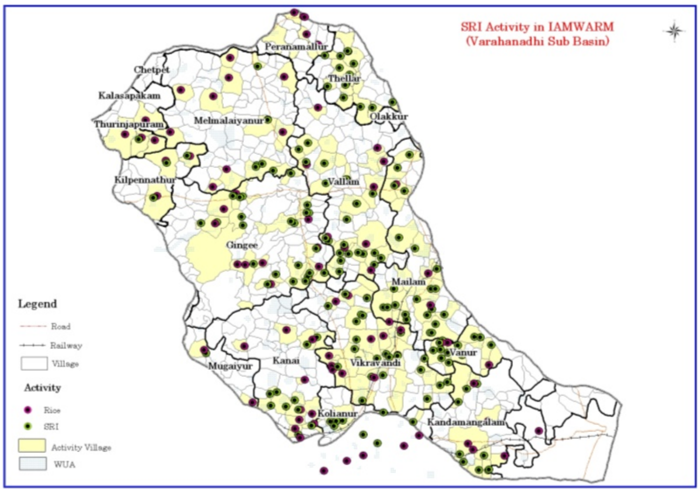

Fig 1.SRI Activity in IAMWARM (Varahanadhi Sub basin)

replicated trials to assess the water requirement in selected sub basins.

Site - I

The irrigation water requirements were measured at 10 different locations in the Ponnaiar sub basin (Fig 2.) during 2009 - 10 using 105-110 days duration paddy varieties. The water measurements in SRI fields at 8 locations were made in an area of 0.4 ha similar water measurements weremade in two places in the same location for conventional paddy cultivation.

Site - II

Another study on irrigation water requirements were conducted at four different sub basins viz., Karumeniar (L1), Sevelapperiyar (L2), Ongur (L3) and Nallavur (L4) during 2010-11 in the same season using short duration 105-110 days paddy varieties.

Alternate Wetting and Drying (AWD) is a water saving technology advisedto the low land rice farmers to reduce their water usage in Paddy. In AWD method the irrigation water is applied to flood the field to a depth of 2.5 cm (perfect leveling should be ensured) initially. Then the submerged water is allowed to disappear and the field is allowed to develop small hair line cracks to enable more rhizosphere aeration. Again the field is watered to 2.5 cm depth. The number of days between successive irrigations can vary from 3-10 days depending upon the climate and soil type. After the panicle initiation 2.5 cm of water was maintained continuously up to the formation of grain.

OBSERVATIONS:

In all the SRI fields AWD i.e., intermittent irrigation system is being practiced. SRI involves the combined use of Best Management Practices(BMP) like young age single seedling, soil churning with mechanical weeding coupled with AWD. This provides better growing condition for rice particularly in the root zone enabling higher yield.

The mean water measurement observations in SRI Field at 8 different locations in the Ponnaiar sub basin (Fig 2.) clearly demonstrated that the SRI Paddy requires only 679 mm of water as against 869 mm (mean of two locations) in the conventional Paddy cultivation. The 28% water saving was observed due to the adoption of SRI.

The data (Table 2) clearly indicated that the water requirement was less under SRI (885 mm) as compared to conventional (1180 mm). SRI registered higher grain yield and Water Use Efficiency of 6,406 kg ha^{-1} and 7.31 kg ha^{-1} mm^{-1} respectively as compared to conventional (5,284 kg ha^{-1} and 4.51 kg ha^{-1} mm^{-1}). It is evident from the above discussions that in SRI, there is significant quantum of saving of irrigation water apart from higher water productivity, higher yield& higher net incomes.

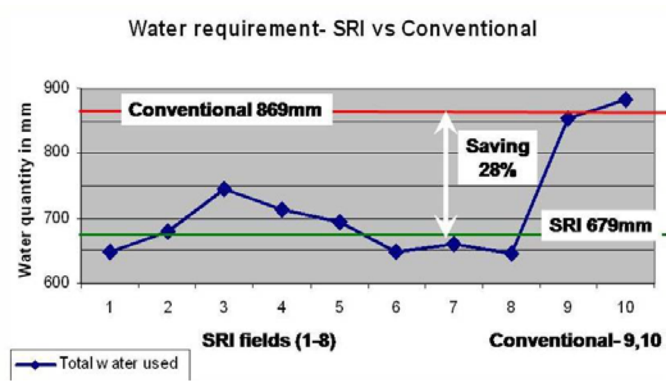

Fig 2. Water Measurement studies at Pennaiyar sub basin

Table 2. Water Productivity in System of rice intensification (SRI) 2010-11

Observations	L1		L2		L3		L4		Overall average	
	SRI	Convl.	SRI	Convl.	SRI	Convl.	SRI	Convl.	SRI	Convl.
No. of irrigations	20	19	19	18	14	20	11	17	16	19
Water used (mm)	923	1252	973	1223	827	1148	818	1098	885	1180
Productive tillers per m^2	470	350	612	505	720	580	780	704	646	535
Grain yield (kg/ha)	5810	4450	5982	5032	7046	5965	6784	5689	6406	5284
Water use efficiency (kg/ha/mm)	6.28	3.55	6.14	4.11	8.51	5.20	8.29	5.18	7.31	4.51
Water productivity (lit/kg of paddy)	1588	2813	1626	2430	1174	1924	1205	1930	1398	2274

L1 – Karumeniar sub basin (Tirunelveli Dt.), L2 – Sevelapperiyar sub basin (Virudhunagar Dt.), L3 – Ongur sub basin (Chengalpattu Dt.) and L4 – Nallavur sub basin (Villupuram Dt.)

i. It is estimated that if the SRI is adopted even on just 25 per cent the irrigated rice area in India (5.3 mha), there would be a saving of paddy seed worth Rs.500 crore. The increase in production because of increased yield (40 per cent) and better water productivity (32 per cent water saving) thus bringing more area under irrigated rice cultivation is estimated to be about five million.
ii. The expected increase in annual net income would be about Rs.6,741crore. Assuming that 50 per cent of the irrigation is groundwater-based, SRI would save energy (40 per cent) equal to 632.61 million kWh which means a savings of Rs.253 crore, as well as 10,000 million cu.m of irreplaceable priceless groundwater for future generations.
iii. The saving of around 20 bcm if SRI is adopted by mere 25% of the entire Rice growing area the projected water demand during 2025 can be met out within the water potential available without any dependence on any extra capital resources.
iv. Majority of the tank irrigation system have common problem of inequitable water distribution in their command area. The over utilization of the channel flows by the upstream users resulting in the water shortages for downstream creating a water conflict. The introduction and expansion of SRI in upstream areas of the command has the more potential to generate irrigation benefits for downstream users by decreasing upstream water consumption. By encouraging more sustainable and equitable water distribution within the command area of the irrigation systems SRI can also be termed as "Sustainable Participatory Water Saving Method",with scope for reduced conflict on sharing of Water.

The glimpses about the IAMWARM Project in SRI adoption and the reactions of the few farmers were also furnished below.

(a) Ms. Vijayalakshmi, (Varaghanadhi sub basin) could increase the cropping area by 40% with the same quantity of water after the adoption of SRI during subsequent seasons.
(b) Mr. Shanmugam aged 67 from Mahibalanpatti Village (Manimuthar sub basin) feels elated with the new learning that the early grown weeds can be controlled effectively even without flooding water.
(c) Mr. Srinivasan from Pannaivayal village (Agniar sub basin) clearly experienced non lodging of SRI Paddy due to the better anchoring of the plants with effective functional roots apart from 60 percent increase in yield.

The rapid assessments made by ISD (2010) about IAMWARM indicated that SRI Paddy growers harvested 2.2 t more yield and increase in income of Rs.27,000 per hectare. The water productivity due to SRI is 6.88/m^3 as compared to 3.81 kg/m^3 in the conventional system of Paddy.

COMMUNITY COLLABORATIVE WATER MANAGEMENT:

Many who are concerned about Water believe that the most appropriate response to the present day water crisis is reviving and rejuvenating the Community Based Water Management practices at the grass root level, with traditional knowledge and wisdom in water management still valid as it is environmentally sustainable and socially equitable.

This objective was achieved in IAMWARM Project where Water Resources Organizations (WRO) converged with agriculture rehabilitated the irrigation structures, developed water budgeting with people participation as a confidence building exercise with a thrust for adoption of SRI in sub-basin command. This resulted not only in enhanced water productivity in rice but also brought gap areas under cultivation in the tail end command area.

The CCWM exercise empowered the farmers to alter their cropping system based on their food need and water foot print. Rice being the staple food and as the inevitable crop during monsoon season in heavy clay soil - SRI proved to be feasible and practical option for demand management in saving the water in the context of food security.

ISSUES:

Maintaining a thin film of water to a depth of 2.5 cm after the development of hairline cracks is a problem in those areas where canal system of irrigation is being practiced. In such cases, irrigation infrastructural facilities have to be channelized to deliver the required quantum of water to the field and to drain the excess water or to employ a storage well system.

The erratic power supply under well irrigated areas has changed the farmers' mindset to store more water. Besides perfect field leveling should be ensured to maintain thin film of 2.5 cm water. The feasibility of adopting AWD method of irrigation is less wherever the cascade irrigation is being practiced.

However these constraints surmountablewhen compared to the water savings as the principal objective in the adoption of SRI by sizeable farmers.

CONCLUSION:

Already the AWD method of irrigation is an accepted and well documented practice leading to an increase in water productivity and yield (Wv 199; Belder*et al* 2004). AWD has already been a recommended BMP in countries like India (Kumar 2011) and China (Li 2001). Even then AWD could not been adopted by most of the farmers under field condition. Owing to the fact of heavier weed infestation in early stages. The synergistic integration of agronomic managements in SRI like Churning the soil with mechanical weeders during 10 days after planting and subsequently at 10 days interval coupled with AWD override the issue of weed management.

Thakur *et al* 2009 established that AWD water regimes significantly affect the plant architecture and canopy structure with improved Leaf Area Index (LAI), Leaf Area Duration (LAD) allowed greater sun light interception and efficient utilization of photosynthesis from source to sink.

Further Benjamin *et al* (2001) proved that the process of drying and rapid rewetting of soil increases the amount of available water soluble phosphorus. The extensive more functional active root development under SRI would logically translate in to a accelerated vegetative development, consequently increased nutrient uptake presumably leading to effective grain filling (Stoop, 2005).

Innovative crop management is the need of the hour in the prevailing water stress situation and SRI is the best methodology to reduce water consumption with increased productivity of crop as well as water.

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He has been nominated as the Anchor Technical Adviser to assist Department of Drinking Water Supply, Government of India on service delivery and establishing Water Operators Partnerships in India. He has worked on various national and international groups on a very wide gamut of issues in the Water sector over more than two decades. He is credited with initiating Change in many Water Utilities in India culminating in the establishment of Centre of Excellence for Change of which he is the founder mentor. He has many policy papers to his credit and has worked with Governments at both Policy and Implementation levels.

Prof. Dr. V.K. Ravichandran, is a Professor of Agronomy from Tamil Nadu Agricultural University, presently working in World Bank assisted TN IAMWARM Project in the water sector. He has few international and national research paper in his credit. The main area of specialisation is nutrition and water management in the annual crops. His initiative along with the author is highly useful to demonstrate and upscale the SRI system of paddy cultivation under IAMWARM Project in larger area of Tamil Nadu.