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REMOTE SENSING AND GIS BASED WATER RESOURCE MONITORING AND CLIMATE RESILIENT TECHNOLOGY FOR THE ENHANCING THE RICE PRODUCTIVITY.

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Abstract: Climate change has a severe effect on the availability of different natural resources in particular water, which sustains life on this planet. Human health and the quality of life are being adversely affected by changes in the earth, biodiversity and natural resources. Climate change is expected to significantly alter India's hydro-climatic regime over the 21st century. It is widely agreed that the Indo-Gangetic basin is likely to experience increased water availability from snow-melt up to 2030 but face gradual reductions thereafter. As per IPCC, most Indian landmass beneath the Ganges plain is probably going to encounter a 0.5 –1 °C ascend in normal temperatures during 2020–2029 and 3.5–4.5°C rise in 2090–2099. Tamil Nadu accounts for only 3 per cent of the water and 6 % populations of the country. The State gets relatively more rainfall during north east monsoon, especially, in the coastal regions. The normal rainfall in south west and north east monsoon is around 322 mm and 470 mm respectively, which is lower than the National normal rainfall of 1050 mm. The per capita water availability of the State is 800 cubic meters which is lower than the National average of 2300 cubic meter. Water Technology Centre, Tamil Nadu Agricultural University has been carried out studies on water management in the (TNIAMP) Tamil Nadu Irrigated Agriculture Modernization Project funded by World Bank. The Field experiments were conducted at Cauvery Delta viz., Thanjavur, Tiruvarur and Nagapattinam, to study the efficacy of Alternate Wetting and Drying Irrigation method on yield and water use efficiency of system of rice intensification (SRI) by using field water tube. The experiments were conducted in farmer's field of 19 blocks with SRI and conventional method of rice cultivation. For SRI 2.5 cm depth of irrigation water, and for conventional method 5.0cm irrigation water depth was maintained. The experimental results revealed that SRI method with alternate wetting and drying using field water tube registered 30% water saving besides yield enhancement of rice over conventional method. The present study highlights the crop area and water spread in the tank using of remote sensing tool and GIS based satellite images for assessment of ground water resource management and development of their relative parameters for the sub basins of Tamil Nadu, India.

Keywords: Climate change, Rice, System of Rice Intensification, Alternate Wetting and Drying Irrigation and Conventional flooding.

INTRODUCTION

Water scarcity in many countries including India is one of the main challenges that governments face. In such countries, more than 70 percent of renewable water resources are consumed in agriculture. Increasing population and the need

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for more food has made demands on water resources due to crop productions. One of the strategies for preventing the overuses of safe water resources for agriculture is to increase agricultural productivity by reducing the amount of irrigation water with a slight reduction or even maintaining the yields. Droughts and global changes have also made serious problems and crises for the countries having water scarcity. These phenomena have caused some lakes to become dried and the underground water table in many plains of India is drawdown rapidly Climate change is widely acknowledged to be one of the most serious challenges confronting humanity today. It is known to be a direct threat to our food and water supplies, as well as an indirect threat to global security, as a result of anthropogenic activities. Conversely, the excessive use and extraction of surface and groundwater resources in recent years have caused many problems (Zhao *et al.* 2019). These include the drop in groundwater levels, plus erosion and land subsidence, water quality effects, the influence of saline water on coastal aquifers and issues such as rural migration to cities, unemployment, and environmental-socio-economic problems were pointed out (Huang *et al.* 2017). Increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere will undoubtedly have an impact on hydrological regimes. The resulting global warming is expected to have a significant impact on water resource management. India is home to one-sixth of the world's population, one-fifth of the world's water resources, and one-fifth of the world's land. India also supports roughly 20% of the world's total livestock population, with cattle accounting for more than half of that figure. Agriculture consumes the majority of available fresh water (85%). Water scarcity has an impact on agricultural productivity. Rice is a major consumer of water among agricultural crops; minor changes in India's water resources affect rice yield. Water scarcity has a greater impact in rural areas and on resource-poor farmers who rely on rice as a stable food crop. Climate change will also influence rice irrigation water demand through changes in rice physiology and phenology, soil water balances, evapotranspiration, and effective precipitation.

Rice is India's most important food crop, and more than 80% of developed freshwater resources are used for irrigation, roughly half of which is used for rice production. Rice fields require 2-3 times more water than other cereal fields to produce 1 kg of grain. Water scarcity threatens the sustainability of irrigated rice, food security, and the livelihoods of rice producers and consumers (Tuong *et al.*, 2004). By 2025, 17 million hectares (Mha) of irrigated rice areas in Asia may face physical water scarcity, while 22 Mha may face economic water scarcity. There is also evidence that water scarcity already exists in rice-growing areas, necessitating the development of water-saving technologies and the search for ways to grow rice with less available water (Tuong and Bouman, 2002). Water surfaces evaporate at a faster rate than soil. Evaporative water loss can also be reduced by implementing production systems and technologies that reduce the length of time the field is flooded and/or the need for water application. Rice systems such as Alternative Wetting and Drying (AWD) and System of Rice Intensification (SRI), are very effective. Climate change poses significant risks to rice production, but the development of necessary adaptation options can capitalise on an enormous variety of rice production systems in very different climates.

Production of "more rice for every drop of water used" will be a guiding principle for rice cultivation in future. There are several options to improve the water use efficiency in rice production. Zero tillage, Alternate Wetting and Drying (AWD), Aerobic rice, Integrated Crop Management (ICM) and System of Rice Intensification (SRI) are some of the alternative technologies that reduce the requirements of water. SRI among the methods has an edge over other water saving methods as water-saving does not have a yield penalty in this system. Therefore, efforts are being made in many countries to popularize SRI to overcome the challenges of water shortages. System of rice intensification (SRI) management proposes the use of single young seedlings raised in raised bed under aerobic conditions, drastically reduced plant densities (16 hills/m^2), keeping fields unflooded and use of a mechanical weeder which aerates the soil, and use of more organic manures, all the practices with the aim of providing optimal growth conditions for the plant, to get better performance in terms of yield and input productivity. The system of rice intensification (SRI) has been promoted for more than a decade as a set of agronomic management practices for rice cultivation that enhances the yield and reduces water requirements. Remarkable progress in the last 50 years in agricultural production and self-sufficiency of food grains in many countries including India; it has been attained at the cost of soil health (Saravanapandiyan *et.al.,* 2005). Therefore, emphasis should be laid on reducing the use of chemical inputs and to improve input use efficiency. The information on long term effects of organic nutrient application in different methods of rice production (SRI and Normal Transplanting) with regard to water productivity and sustainable rice production under different soil and climatic conditions under India is very meager. Hence, present investigations were carried out to assess SRI-as sustainable intensification of rice production system for enhancing the water productivity.

MATERIALS AND METHODS

The Field experiments were conducted at Cauvery Delta viz., Thanjavur, Tiruvarur and Nagapattinam, to study the efficacy of Alternate Wetting and Drying Irrigation method on yield and water use efficiency of system of rice intensification (SRI) by using field water tube. The experiments were conducted in farmer's field of 19 blocks with SRI Alternate Wetting and Drying Irrigation and conventional method of rice cultivation.

STUDY AREA

The study area is different sub basins in Tamil Nadu, which occupies a total ayacut area of 3, 93, 388 ha falling, Tamil Nadu, India. The latitude of Tamil Nadu, India is 11.127123, and the longitude is 78.656891. Tamil Nadu, India is located at India country in the States place category with the GPS coordinates of 11° 7′ 37.6428′′ N and 78° 39′ 24.8076′′ E. (Fig. 1).

HOW TO IMPLEMENT AWDI

Alternate Wetting and Drying (AWD) is a water-saving technology that lowland paddy farmers can apply to reduce their water use in irrigated fields.field water tube made of PVC tube with 15 cm diameter and 40 cm length. The tube is perforated with 0.5 cm diameter holes in the bottom to 25 cm and top 15 cm portion is non-perforated with 5 cm markings for irrigation monitoring. In AWD, irrigation water is applied to flood the field a certain number of days after the disappearance of ponded water. Hence, the field is alternately flooded and non-flooded. The number of days of non-flooded soil in AWD between irrigations can vary from 1 day to more than 10 days. Practical way to implement AWD is to monitor the depth of ponded water on the field using a 'field water tube'. After irrigation, the depth of ponded water will gradually decrease. When the ponded water has dropped to 15 cm below the surface of the soil, irrigation should be applied to re-flood the field with 5 cm of ponded water. From one week before to one week after flowering, ponded water should always be kept at 5 cm depth. After flowering, during grain filling and ripening, the water level can drop again to 15 cm below the surface before re irrigation. Alternate Wetting and drying method in rice cultivation AWD can be started a few days after transplanting (or with a 10 cm tall crop in direct seeding). When many weeds are present, AWD can be postponed for 2-3 weeks until weeds have been suppressed by the ponded. Water. Local fertilizer recommendations as for flooded rice can be used. Apply fertilizer N preferably on the dry soil just before irrigation. The threshold of 15 cm water depth (below the surface) before irrigation is called 'Safe AWD" as this will not cause any yield decline. In Safe AWD, water savings are in the order of 15- 30%. After creating confidence that Safe AWD does not reduce yield.

RESULTS AND DISCUSSION

Alternative Wetting and Drying (AWD) System

Alternate wetting and drying (AWD) is a type of water-saving rice production system. In this system, the field is irrigated with enough water

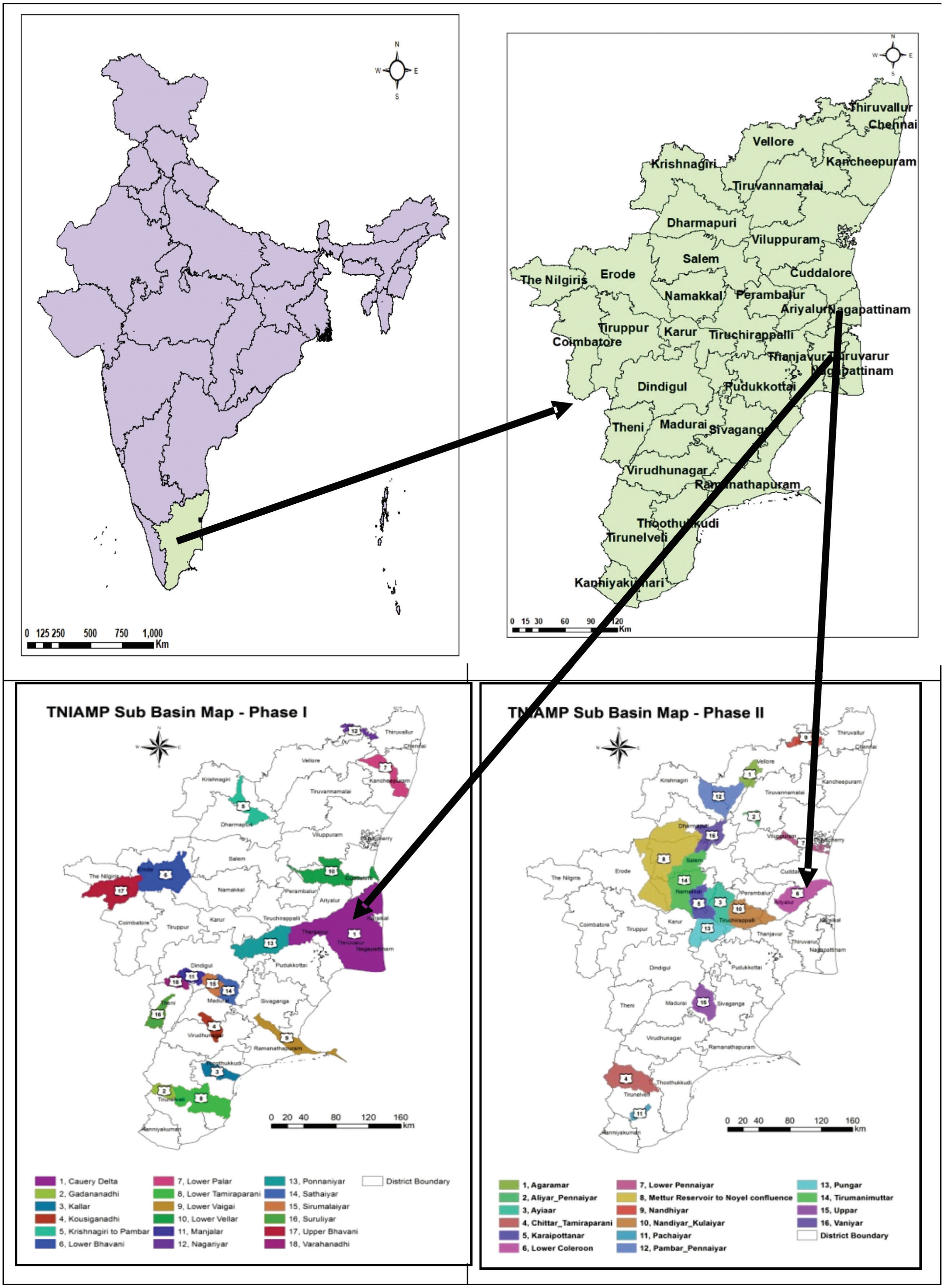
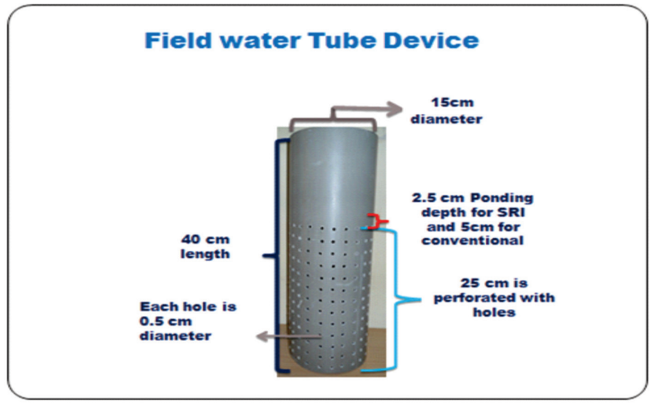


Figure 1: Study area of Tamil Nadu



to flood the paddy for 3-5 days, and as the water soaks into the soil, the surface is then allowed to dry for 2-4 days before getting re-flooded. Compared with the traditional continuous flooding system, AWD using lowland rice cultivars can reduce water input by 15-30% without yield loss. With drought-tolerant lowland rice cultivars, a longer interval of drying in a cycle and thus more saved water can be expected. Key points of this technology are to Transplant 2-3-week-old seedlings into puddled soil and keep a standing water layer of 5 cm in the field. Install a PVC pipe (20 cm in diameter and 40 cm in length) with holes (5 mm in diameter spaced at 2 cm) in the rice field (15 cm above and 25 cm below the soil surface) after transplanting to monitor groundwater. Start AWD at 10 days after transplanting and allow the field to dry out. Re-flood the field to a standing water layer of 5 cm when the groundwater is 15-20 cm below the soil surface. Keep a standing water layer of 5 cm for 1 week at flowering. Continue AWD cycles after flowering until harvest.

The results of multi-location trials (MLTs) clearly indicated that the performance of SRI varied from location to location indicating that response of SRI (AWDI) is location specific. SRI recorded consistently higher grain yield than farmer's practices of flooding method at half of the locations. The mean grain yield increase in SRI method was in the range of 10-17 % as compared to conventional transplanting (Table 1). Out of three sub basins SRI recorded higher grain yield (kg/ha) over Normal transplanting with an average increase grain yield of 17.0%. This study found that SRI management practices increasing grain yield by 10-17% while utilizing 85 % saving of seeds, less nursery area and less water. The total dry weight of above ground parts at harvest was greater in SRI than Normal transplanted rice.

SAVING IN WATER

Irrigation water inputs for different methods of rice cultivation were recorded using digital water meters during the crop seasons indicated that the water saving in SRI ranged from 17-47%. The SRI-organic and SRI Alternate Wetting And Drying (AWDI) received significantly lower irrigation water compared to flooding transplanting in all the three sub basins. SRI saved nearly 25% irrigation water without any penalty on yield compared to conventional transplanting.

Table 1: Productivity Enhancement of Rice – AWDI in CDZ

Name of the sub basins	*Yield (kg/ha)*		*Percent yield increase demo yield*
	Demo yield	*Conven-tional*	
Thanjavur	4101	3555	15.4
Tiruvarur	4250	3246	10.4
Nagapattinam	5167	4442	16.3
Average	4506	3748	14.3

The system of rice intensification aims to make irrigated rice cultivation more sustainable and profitable, as it not only enhances grain yield and net income, but also saves considerable amounts of capital, seed, and most importantly water (Pathak *et. al.*, 2002). For generations, rice has been regarded as an aquatic plant; however, this belief has been repeatedly challenged, as rice is known to be capable of growing under

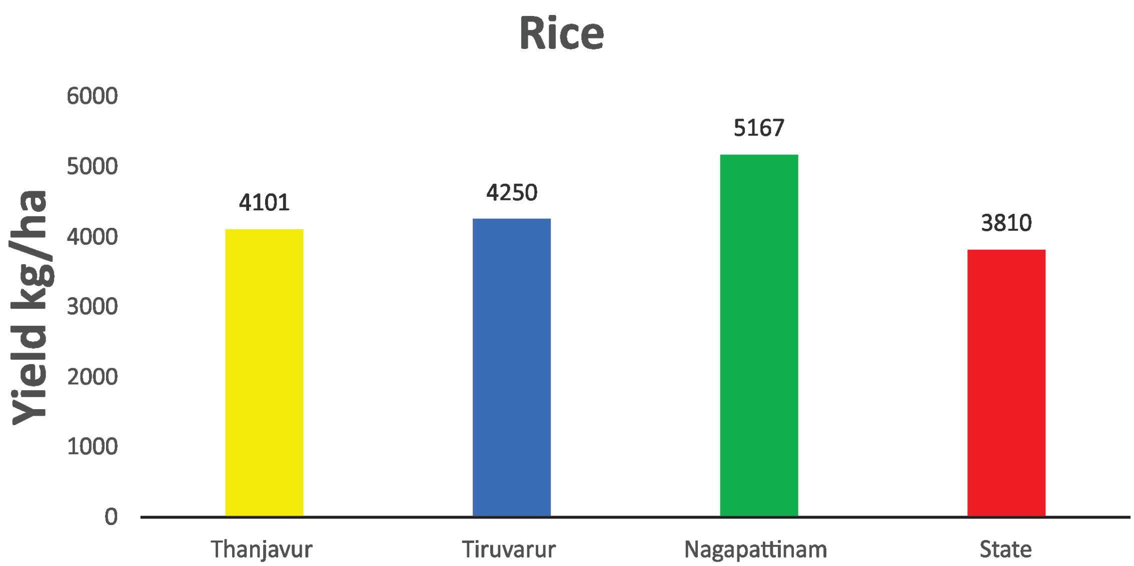


Figure 2: Productivity Enhancement of Rice – AWDI in CDZ

both flooded and non-flooded conditions. Plants grown under intermittent irrigation of three-day intervals were significantly taller compared to the others at both panicle initiation and heading stages, whereas comparable results were observed between Conventional Flooding and intermittent irrigation intervals of seven days at heading. This continues to support the findings of (Thiyagarajan *et. al.,* 2002) among others, who detailed that rice does not need to be continuously submerged to produce high yields if adequate water is provided at critical growth stages. The SRI practices employed enhanced plant growth and tillering ability to improve plant/culm height and strengthen tillers. The wet and dry cycles experienced under SRI enhances air exchange between soil and the atmosphere and may have contributed to more tiller numbers per hill at panicle initiation and heading under both three- and seven-days irrigation intervals. Singh *et al.* (2004) explained that higher number of tillers recorded in SRI may be attributed to practices such as water management undertaken to maintain paddy soils mostly under aerobic conditions, active soil aeration through mechanical weeding and organic fertilization. During the wet and dry cycle enough oxygen is supplied to the root system to accelerate soil organic matter mineralization and inhibit soil N immobilization, all of which should increase soil fertility and produce more essential plant-available nutrients to favor rice growth (Bouman *et. al.,* (2007), Thakur *et. al.,* (2009) also explained that tillering is directly linked to continuous root development (through adventitious roots), which remains active under AWD regime, while the roots under CF degenerate significantly.

This chapter describes the results obtained from the analysis of spatio-temporal satellite derived water spread area information of 34 sub basins, model framework for the extraction of surface water bodies from the Sentinel 1 A SAR satellite of Tamil Nadu. The discussion is made from the satellite derived water spread area with the help of figures. Water body layers derived from Sentinel 1 A SAR satellite sensor through the model for extraction of water body information. The analysis is focused on the surface water bodies over a period of time. This water spread information is shared to irrigation engineers of the different sub basins for decision supporting systems in cropping and water.

Table 2: Details of Water Spread in the PWD Tanks of Phase I Subbasins

Sub Basins	*No. of Tanks*	*Water Spread Area (Ha)*			*Change in Spread (Ha)*		
		Sep 2019	*Nov 2019*	*Jan 2020*	*Sep - Nov*	*Nov - Jan*	*Sep - Jan*
Cauvery Delta	281	1346	1542	1480	196	**-62**	134

CONCLUSION

A successful change from the traditional flooded to improved resilient rice production requires

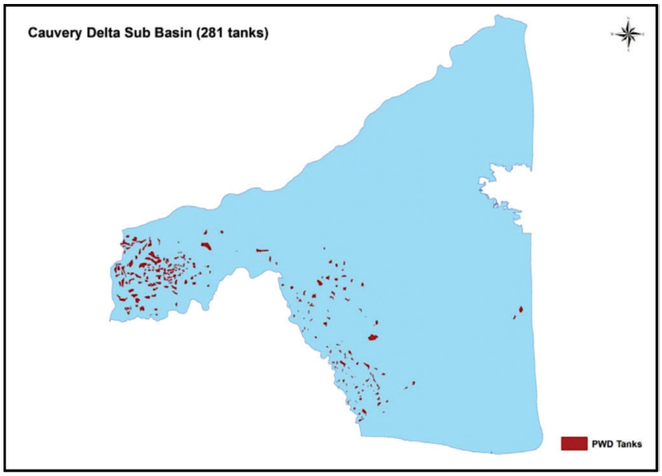


Figure 3: Cauvery Delta PWD Tanks

for increasing the production. The resilient rice production systems like SRI-AWD system, were found very effective in water stress area and for resources poor farmers. The adoption of resilient rice production systems can improve overall productivity and yield potential of rice, especially in rice growing areas, where water scarcity already prevails.

The AWDI method of cultivating rice implies that rice fields are not kept continuously submerged but are intermittently dried during the rice growing stage. Our results have clearly demonstrated that the increase in productivity with SRI based on concomitant increase in factor productivity is possible under certain situations. SRI, however, is a methodology that continues to raise more questions than we have sufficient answers for it. Therefore, there is a need for collaborative research studies to help examine systematically the opportunities that SRI method is opening up for its wider adoptability to benefit the farming community in India where large percentage of farmers are mainly small or marginal farmers and depends primarily on rice cultivation for their lively hood. The practice of AWDI can reduce the irrigation water losses (especially deep percolation losses) by a considerable quantity without affecting the yield. If the irrigation water is so scanty (it means tail end of Cauvery Delta basin), the interval between the irrigation becomes longer, then safe AWDI is quite not possible and the penalty of grain yield is inevitable. When the AWDI is implemented to the communal based irrigation system, it has to be adopted with a certain prototype to the farmers, so that the delivery of irrigation water to the farmers group in uniform manner and they realize the benefits of AWDI. Finally it was recommended that, in clay and clay loam soil the irrigation with safe AWDI at 10 cm was found to be the best in terms of yield and Water Use Efficiency (WUE).

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