



## Yield and economic impact of less-water consumption techniques in tank irrigated rice (*Oryza sativa*) and groundnut (*Arachis hypogaea*) crops

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### ABSTRACT

A study was conducted with a view to reduce uncertainty of inflows in supply channels, weed infestation in tank bed and water scarcity during poor monsoon seasons. The less-water consuming technologies and use of improved implements along with matching crop production techniques were demonstrated to improve water productivity. Altogether, the mind-set of tank farmer that more the irrigation, more the yield was changed to controlled irrigation for more production. The new habit of 'measure and use' policy even in irrigation water was infused. The water productivity was realized in such a way that the productivity of rice (*Oryza sativa* L.) in whole command increased from 4.6 kg/ha/mm in 2005 to 7.3 kg/ha/mm in 2009; in groundnut (*Arachis hypogaea* L.) from 5.6 kg/ha/mm in 2005 to 6.5 kg/ha/mm in 2009. Hence the economic impact of 'measure and use' policy was proved its superiority for less-water consumption management in tank irrigation in the cases of rice and groundnut.

**Key words:** Economic impact, Measure and use policy, Rehabilitation, Tank irrigation, Water scarcity

Tanks support many water uses including crop production, livestock watering, fisheries, domestic and small business water use, and handicraft activities and thus are vital assets in people's livelihood. Governments, donors, non-governmental organizations and communities have made (and are still making) significant investments in tanks (Anonymous 2011). Tanks are also used to store water from the canals and used as and when needed by the farmers, and such a design helps in increasing flexibility of the system and mimics the reliability and timeliness of groundwater irrigation (Amarasinghe *et al.* 2010). However, the investments in small reservoirs have been questioned by some for their high costs, low performance, low levels of community participation, and the collective action required to operate and maintain irrigation infrastructure. Tank irrigation in India has been in decline for decades. The area irrigated declined by 32% between 2001 and 2008 due to lack of technical skills, excessive sedimentation due to catchment degradation, and difficulties in mobilizing sufficient resources for maintenance (Palanisami *et al.* 2010). Problems with communal management and mobilization of village resources for the maintenance and operation are common (Birner *et al.* 2010, Sally *et al.* 2011). In addition

to technical difficulties and poor construction quality, problems relate to the management of common property (Birner *et al.* 2010, Sally *et al.* 2011). To enhance collective action and resource mobilization for the management of tanks, some governments and donors call for the formation or strengthening of water user associations (Palanisami *et al.* 2010, Anbumozhi *et al.* 2001, Birner *et al.* 2010). Overall, this trend has a positive impact on the local economy and boosts the cost-benefit ratios of otherwise low yield in irrigation investments in small reservoirs (Charlotte *et al.* 2014).

Due to the mounting pressure on water resources, protecting these small reservoirs with site-specific technical interventions is urgent requirement as there are 64 000 such tanks exist in Andhra Pradesh alone. It is also important to provide stakeholder and local authorities with the possible options for managing tank system arrived by using socio-economic and hydrological data. The objective of the present study was to evaluate water availability and suggest ways to improve the efficiency by infusing water-saving technologies and site-specific infrastructure facilities to reduce water losses and to improve the irrigation system efficacy.

### MATERIALS AND METHODS

The selected Musilipedu tank command was located 79°39'00" to 79°42'30" East longitudes 13°36'30" to 13°45'30" North latitudes, with catchment area of 7.4 km<sup>2</sup> of nearby hillock (Bathinayyakona) and has water spread area of 54.1 ha. Borewells were dug to supplement the tank irrigation system in the area. This tank is to cater the water

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requirement of agricultural land of 188 ha. The climate of the Musilipedu tank command is characterized as summer from March to May with monsoon season from June to September having some rains in post monsoon season too. Mean daily maximum temperature varies from 26-30 °C in July to 32-33 °C in October. The minimum temperatures are observed in the month of January in the range of 10-15 °C witnessing the winter season. The water users face many challenges to manage their water resources.

Tropical and subtropical tanks display profound temporal and spatial heterogeneity in terms of environmental conditions. This aspect needs to be considered when designing a monitoring program for water quality in tanks (Fidelis *et al.* 2014). Since the study requires more essentially the rainfall and its distribution to assess the spatial and temporal dynamics of precipitation, used from the two closest rain gauges of Yerpedu and Srikalahasti, which are located 12 and 14 km from the tank site respectively.

As water users association has significant role in farmer participation towards water management which in turn will increase the return from water management, strategies were developed involving members of water users association (WUA) to fulfill the objectives of the project (Nanthakumaran and Palanisami 2010). To overcome the uncertainty of water inflows to the tank from catchment even after good rains, the stakeholders were divided into different groups to take care different supply channels and its in-flows. Similarly, weed infestation in the tank area was removed after optimizing the physical and chemical methods of weed removal.

Despite the role of irrigated agriculture as a supporter of food security and competitor for key ecological assets (Anonymous 2006, Castillo *et al.* 2007, Faures *et al.* 2007), numerous studies point to inadequate investment in the maintenance of irrigation water application and delivery systems, which can lead to water waste and leakages (Farmani *et al.* 2007). In the face of increasing transfers of water infrastructure from governments to farmers or irrigation districts, this transfer raises questions about future sources of funding (Simon 2002). The transfer of investment responsibility into private hands may require farmers to seek new sources of funding to raise capital to infrastructure (Frank 2010). A 2008 study found that improved infrastructure can substitute for reduced water quality or quantity (Connor 2008).

Identified challenges through participatory rural appraisal and some were addressed through creating the appropriate infrastructure in the tank and tank command. Keeping the view of the national water policy, 1987 which emphasized the participation of farmers in different aspects of the management of the irrigation system, principally in water distribution (Anonymous 1992) as well as the command area development programme, launched within the sixth five year plan, 1980-81, which adopted the formation of irrigation associations (Mahapatra 2007), the water users association was involved in controlling the

discharge and catering need-based irrigation in the command. The lock-gates for equi-distribution were made feasible to sort out the unrest among the villages in two wings of distribution system in the command. The major dispute in water sharing among the head-reach and tail-end farmers in the command was eliminated through the lining of only head-reach channels (to economize) in water conveyance systems. This also achieved the eliminating field to field water flow. In addition to the lining of channel at head-reach in the water conveyance system, five division boxes were designed and established according to the requirement of stakeholders and their land holdings (using slope differential) to cater right share of water flow on the way to reach tail-end portions of command.

The overall knowledge of the stakeholders on crop production with less-water technologies was observed to be poor, and hence several improved package of practices were demonstrated in the command fields along with training programmes to integrate and train on water-saving technologies so as to improve the water productivity (Grigg 2008).

## RESULTS AND DISCUSSION

### *Strategies adopted for better water management*

Stakeholders of the command initially surprised to see the improved inflows through simple intervention of clearing supply channels and participatory approach which were so useful in poor monsoon season experienced during 2006. The experience made them to adopt and practice as a regular measure every year just before monsoon. Arumugam *et al.* (2009) opined that the major deficiencies that influence the sustainability are inadequate maintenance, reduction in storage capacity, heavy seepage losses in the delivery system and poor water management techniques.

The severe weed infestation (*Ipomea carnea*) was removed by adopting physical and chemical methods during dry season. The labour involvement to reach nook and corner of tank bed to remove physically was very high and felt difficult when compared to chemical method (spraying of 2, 4-D sodium salt, 1 kg a.i/ha) of removing the weeds. The effect lasted for two years and can find tank bed apparently free from *Ipomea carnea*. The practice became popular among neighbouring tank commands to eliminate the weed.

Project inculcated various water-saving techniques among stakeholders and aspects of water scheduling and made them to utilize the controlled water supply to the crops. Even though the villages noticed the benefit of the water management, they were reluctant to accept. The scenario was completely different during 2006, as it was poor monsoon, and only 3/4<sup>th</sup> of tank got filled. The water users association along with project staff developed a strategy that owners of bore-wells to utilize only ground-water and non-owning (well) farmers to depend on tank-water. The strategy was well worked out through participatory mode and the entire sown crop irrigation needs were met from

comparatively less stored tank-water. This season made them to realize the benefits of interventions by the project and the participatory mode to solve their challenges.

#### Infrastructure benefits

The following are the site-specific infrastructure developed to address the identified water management problems.

**Main gate:** The controlled water supply based on crop area was regularly adopted, and water supply during rainy days and nights. These could limit the water used and find water in tank even after end of crop season.

**Lock-gates:** These gates were installed at bifurcation of main channel where the water from main sluice divides into two flow channels and reaches different commands (Musilipedu and Saraswathi Kandriga commands). The quarrel between two stakeholders emerges at this point for want of water share. In this connection, WUA operates the gates at main bifurcation depending on the stakeholders share and needs. Since the stakeholders could find the water at their field channels without any tussle. This act greatly reduced the unrest among two wings (villages) of command.

**Lining of channels:** Seepage losses greatly reduced estimated to be 10-15% due to lining at head-reach channels and field to field water flow was completely eliminated. In many irrigation systems in Asia, there are no field channels or 'tertiary' irrigation or drainage channels. Water flows from one field into the next through breaches in the bunds. With such plot-to-plot irrigation the amount of water flowing in and out of a rice field cannot be controlled and field-specific water management is not possible (Anon. 2009). This also envisaged the head-reach farmers to adopt less-water technologies like AWD and SRI and they can restrict fertilizer application to the field where they apply.

**Division boxes:** The designed division boxes could divide and cater the share of stakeholders without any involvement and completely eliminated pooling of water due to energy loss which intern effects the flow parameters. This had more impact in reducing differences among neighbouring stakeholders. Division boxes also use full in maintaining energy of flow to reach tail-end.

#### Impact of technical interventions

Apart from the permanent measures explained on water management practices, certain technical interventions on production technologies extended to the stakeholders through participatory research. In rice (*Oryza sativa* L.) cultivation,

Table 1 Effect of improved implements on water-saving in low land transplanted rice

Implement	*Water applied to main field (mm)	**Total water applied (mm)	Water-saving over control (%)	Yield (kg/ha)	WUE (kg/ha/mm)
Rotovator	456	706	40	4 580	7.0
Vishnu puddler	457	707	40	4 360	6.7
Disc harrow	671	921	13	4 480	6.1
Farmers' practice	764	1014	—	4 320	5.6

\*For an area of 4 000 m<sup>2</sup>; \*\*including 250 mm for field preparation and nursery

less-water technologies and land preparation through improved implements were imparted. Puddling is wet cultivation of land that mixes soil and water to produce an impervious layer (Ponnamperuma 1981). Seepage and percolation flows from rice fields are major pathways of water loss (Anonymous 2009). Hence comparative study was conducted in farmers' field on participatory mode with different implements designed for wet tillage, i.e. puddling and results were depicted in Table 1.

The results indicated that there was significant saving of irrigation water just by using right tool for right operation, i.e. using rotovator or Vishnu puddler while land preparation alone saved irrigation water up to 40% over farmers' practice. The results are in concurrence with the results of De (1981). It was also observed that use of improved implements especially Vishnu puddler became popular for land preparation, among the several extended technologies due to low operating cost of the passive tool. In order to sustain agriculture and to achieve the optimum utilization of the valuable water resources and maximum production per unit of water, these tanks have to be modernized in a comprehensive and holistic way.

In addition, system of rice intensification (SRI) and alternate wetting drying (AWD) were introduced and demonstrated on participatory mode and the results were analyzed and presented in Table 2. The water-saving of 22-25% and improved yields of 6 635 kg/ha and 22-24% of water-saving and 6 459 kg/ha increase in production over farmers' practice were registered through SRI and AWD respectively. This result was in conformity with that of results published by Directorate of Rice Research, Hyderabad (Anonymous 2007). If water supplies are not controlled, i.e. if continuous inundation of soil creates hypoxic conditions

Table 2 Performance of rice cultivation

Method	Yield (kg/ha)			Water applied (mm)			WUE (kg/ha/mm)			Water-saving (%)		
	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
SRI	6 319	6 950		1 179	995		5.40	6.98		22.2	25.7	
AWD	5 897	7 020	7 026	1 141	1 011	1 167	5.20	6.94	6.0	24.7	24.5	22.6
Farmers' practice	5 523	6 180	6 660	1 514	1 340	1 506	3.67	4.61	4.4			

SRI - System of rice intensification; AWD - alternate wetting and drying

that adversely affect root growth and functioning and also constrains biodiversity in the soil, we cannot expect particularly impressive results with SRI. Nor can good results be expected if soil management practices and the application of agrochemicals inhibit or impair the functioning of soil biota. These diverse, interacting organisms are largely ignored in conventional rice science analyses; however, they become central figures in SRI evaluation and practice (Randriamiharisoa *et al.* 2006).

#### *Impact of study interventions on water productivity*

Though high yielding varieties and other modern inputs of farming are widely adopted, in respect of water use and water regulation the farmers in the tank command area still poorly informed and have not paid their attention. Even though there was initial resistance towards interventions of the project, later on stakeholders realized the benefits through participatory research in the command. It made the farmers to be confident about the technologies. Moreover the specific infrastructural development provided by the project in the command started catering their needs without much of farmers' involvement. These developments also envisaged the feel good atmosphere between the two village stakeholders (Musilipedu and Saraswathi Kandriga) and the unrest among the farmers greatly reduced over division of water at bifurcation points.

By implementing the modernization program, it is expected that more than 25% of the water will be saved. Past experiences show that by physical (hardware) modernization alone, irrigation efficiency was improved by 32.25% and subsequently yield increased by about 30% (Anonymous 1996). The water users association of the Musilipedu village is now fully trained in monitoring the discharge for day to day requirements of the command. The overall inferences observed by the project during project period were depicted in Fig 1. The results confirm that the technical interventions introduced by the project in the command significantly improved overall water productivity of the Musilipedu pilot area, from 4.6 kg/ha/mm to 7.3 kg/ha/mm in rice and 5.6 kg/ha/mm to 6.5 kg/ha/mm in groundnut (*Arachis hypogaea* L.) under study.

- Site-specific infrastructural developments and need-based technical interventions improved water productivity which led to improvement in the socio-economic status of the stakeholders in tank irrigation system.
- The severe weed infestation was removed by adopting physical and chemical methods during dry season and the effect lasted for two years and can find tank bed apparently free from *Ipomea carnea*.
- Using rotovator or Vishnu puddler while land preparation alone saved irrigation water up to 40% over farmers' practice.
- A water-saving of 22-25% and improved yields of 6 635 kg/ha and 22-24% of water-saving and 6 459 kg/ha increase in production over farmers' practice through SRI and AWD respectively were registered.

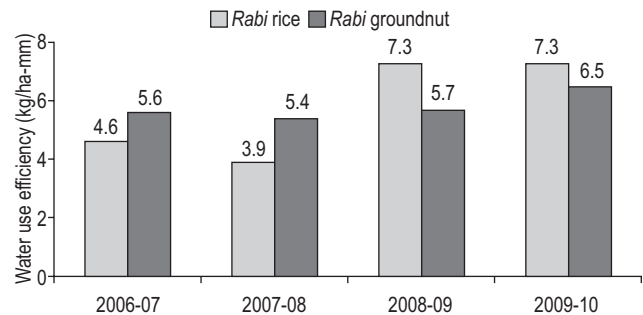


Fig 1 Overall command water use efficiency of major crops

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