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The Relative Economic Benefits of Conjunctive Use of Water over Surface and Ground Water in the Cauvery Command Area

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Authors' contributions

This paper work was carried out in collaboration among all authors. Author MNV wrote the draft in consultation with remaining authors LM and ADR conducted study and carried out the statistical analysis and author BG finalized the paper managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In command areas, overutilization of surface water led to deleterious effects, *viz*. water logging, salinization, alkalinisation of soils results into lower crop productivity and deficit water supply at the tail ends. As consequences, tail end a farmer heavily depends on groundwater will lead to emptying the aquifer and the low-quality water is pumped from deep wells. So, overuse of both the sources of water would leads to imbalance in water management as results into unsustainable water management. Thus, Conjunctive use is a single input to address the physical and economic scarcity of surface water (SW) and groundwater (GW) and it offers the solution to a large extent to hurtful effects of SW and GW. The present study was carried out in Mysuru and Mandya of Cauvery command area with 180 farmers of which 60 each from surface water (SW) groundwater (GW) and conjunctive use regime (CU). The results imply that significant difference in productivity level and gross returns for selected crops at 5 per cent significance. The conjunctive irrigation practicing sugarcane farmers realized higher gross returns over GW and SW to the extent of 24 percent and 5

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percent respectively. There exists a positive relationship between net return and water use efficiency with correlation coefficient of 0.78 in case of maize and ragi crops. The higher water use efficiency found in CU water for all selected crops.

Keywords: Water; conjunctive; net returns; productivity.

1. INTRODUCTION

India achieved remarkable production growth and attained self-sufficiency in production. (8). However, the current production is not sufficient with consumption as production is limited by low yield growth [1]. The binding factor behind low productivity is inefficient use of resources especially water. In fact, water is one of India's most scarce natural resource; India uses 2 to 4 times more water to produce a unit of major food crop than does China and Brazil [2]. The fact that farmers employ highly inefficient flood irrigation system leading to loss of more than 50 percent of water to evaporation and runoff.

Currently, India is the largest exploiter of groundwater in the world next to United States and Europe. India pumps twice the groundwater pumped in the United States, and six times that pumped in the Europeon Union. Since the groundwater resources are extracted indiscriminately, there have been massive initial and premature well failures in Peninsular India and Karnataka is no exception leading to sharp decline in the number of open wells and a sharp increase in a number of bore well failures. Only in exceptional circumstances in Krishna command area in Karnataka, dug/open well are still functioning. In the regions under Eastern and Central Dry Zones of Karnataka, the depth of the bore-wells has gone up to the level of 1,500 feet and 2,000 feet in some areas.

In command areas, overutilization of surface water, especially in the upper and middle reaches in most of the canal commands, have given rise to deleterious effects, *viz*. water logging, salinization, alkalinisation of the soils resulting in general degradation of arable land and overall deterioration in crop productivity and deficit water supply at the tail ends. At the same time, in the deficit areas was irrigated by farmers with high dependence on groundwater having high over extraction and this leads to emptying the aquifer and the low-quality water is pumped from deep wells [3]. So, overuse of both the sources of water would lead to the imbalance in water management and thereby water use efficiency goes down.

Conjunctive use is a situation where both groundwater and surface water are developed (or co-exist and can be developed) to supply a given irrigation canal-command – although not necessarily using both sources continuously over time not providing each individual water user from both sources. The conjunctive use as 'use of surface water and groundwater consists of harmoniously combining the use of both sources of water in order to minimize the undesirable physical, environmental and economic effects of each solution and to optimize the water demand/supply balance. Thus, Conjunctive use is a only alternative to address the physical and economic scarcity of surface water (SW) and/or groundwater (GW) and it offers the solution to a large extent to hurtful effects of SW and GW [4], 5] and [6]. The previous studies indicated the actual socio-economic benefits arising through the conjunctive use of water. One of such studies conducted by World Bank (2006), which indicated that 26 per cent increase in net farmer income, substantial energy savings, and new cropped area under irrigated through the conjunctive use of water. Thus, the present study emphasizes on the relative benefits in terms of returns and water use efficiency (Sugarcane, Maize and Ragi) of CW over the SW and GW in the study area. This study recognizes the parity between both agronomical objective of 'more crop per drop' and economic objective of 'maximizing net returns per rupee of water'.

2. SAMPLING METHODS

The present study was carried out in the Mysuru and Mandya which fall under Cauvery command area. Simple random sampling technique was adopted for the selection of sample farmers. A total of 180 farmers were selected of which, 60 farmers each from surface water (SW) groundwater (GW) and conjunctive use regime (CU) during study period of 2018-19.

2.1 Economic Analysis

The following techniques were used to analyze the data.

2.1.1 Cost concepts

Various cost concepts were employed in order to estimate the cost and returns for three important crops (Sugarcane, Maize and Ragi) in the study area.

2.1.2 Quantification of irrigation water

The measurement of groundwater yield of bore wells was calculated by recording the number of seconds taken to fill in a bucket with groundwater of known volume. Initially, the bore well was pumped for ten to fifteen minutes so that the initial pump yield bias is avoided. The water yield in liters per unit time was converted into gallons per hour (GPH). In the present study, the volumetric water meter was used to calculate the discharge or yield of water from irrigation bore well.

2.1.2.1 Surface water

Quantity of water used = Number of irrigation* Depth of irrigation (inch) *Area of irrigation (ac).

2.1.2.2 Groundwater in conventional irrigation system (CIS)

$$\text{Water yield from BW} = \frac{\{\text{Water discharge by the well in GPH across all seasons} * \text{Number of hours pump put on across all seasons}\}}{22611}$$

2.1.2.3 Conjunctive water

Quantity of water used in both groundwater and surface water was used to estimate the conjunctive water used.

2.1.3 Water use efficiency

Efficiency is an important concept in production economics when resources are meager and opportunities for developing and adopting better technologies are competitive. Economic water use efficiency is worked out by dividing the net returns by the volume of water used which is measured in terms of a per acre - inch.

$$\text{Economic water use efficiency } (₹/\text{ac inch}) = \frac{\text{Net returns } (₹)}{\text{Water used (ac inch)}}$$

3. RESULTS AND DISCUSSION

The TVC, TFC and TC of the selected crops under different irrigation regimes in the study area have been depicted in Table 1. The results imply that there is no significant difference between TVC, TFC and TC for selected crops under different irrigation regimes. However, total cost found to be higher who are practicing conjunctive irrigation for the selected crops perhaps due to higher irrigation cost.

The productivity and water used for sugarcane, ragi and maize under different irrigation regime has been depicted in the Table 2. The result implies that there is significant difference in productivity level for crops at 5% significance for all selected crops. For instance, sugarcane crop productivity was about 495 and 436 q/acre in surface and ground water irrigation. About 543 q/acre in conjunctive use of water with 9.6 percent and 24 percent higher productivity as compared to surface and groundwater irrigation. Similarly Ragi and Maize crop productivity level found to be higher in conjunctive water as compared to SW and GW.

The gross returns and net returns of the selected crops under different irrigation regimes have been depicted in Table 3 and Figs. 1 and 2. The findings imply that there is significant difference in gross and net returns of selected crops as indicated by the ANOVA results 13.65 and 18.56 at 5% significance. The conjunctive irrigation practicing sugarcane farmers realized higher gross returns over GW and SW to the extent of 24 percent and 5 percent respectively. The similarly results were found in maize and ragi crop. The conjunctive irrigation practicing ragi farmers realized 21 percent higher gross returns over surface irrigation farmers mainly because of higher productivity. Perhaps due to greater water security during critical stages of crop growth and higher water use efficiency could be achieved as against the one source of irrigation (7).

3.1 Relationship between WUE and Net Returns under Different Irrigation Regimes

The relationship between the WUE, water used and net returns for different crops under different irrigation regimes helps to know the relationship of water use with net returns.

The relationship between WUE, water used and net returns of Sugarcane, Maize and Ragi crop has been depicted in Fig. 3. The results indicate the positive relationship between net returns and WUE. However, the water used per acre-inch found to be highest in SW as compared to GW

and CW with lower WUE. Similarly, for maize and ragi crops, there exists a positive relationship between the net returns and WUE. The higher water use efficiency was found in case of conjunctive irrigation for all the selected crops as indicated in Figs. 4 and 5.

Table 1. TVC, TFC and TC of selected crops under different irrigation regimes (Rs/acre)

	Total variable cost			Total fixed cost			Total cost		
Crops	**SW**	**GW**	**CW**	**SW**	**GW**	**CW**	**SW**	**GW**	**CW**
Sugarcane	56680	74699	61822	11666	11854	12361	78846	92821	84435
Ragi	25880	24349	31663	3078	3188	3442	30910	28557	36580
Maize	21564	27768	21521	3628	3738	3992	25923	32567	26928
ANOVA test	2.56			3.15			1.89		

Note: SW: surface water; GW: Groundwater; CW: Conjunctive use of water

Table 2. The productivity and water used among the crop under different irrigation regimes

Sl.No	**Crop**	**Water used (ac inch)**			**Irrigation cost (Rs)**			**Yield of main product (q)**		
		SW	**GW**	**CW**	**SW**	**GW**	**CW**	**SW**	**GW**	**CW**
1	Paddy	45.00	?	37.7	727	?	1074	19.1	?	21.4
2	Sugarcane	78.00	35.7	59.5	1260	15160	7330	495	436	543
4	Ragi	15.00	7.1	13	242	3014	268	10.8	9.5	11.2
3	Maize	25.00	11.5	16.6	404	4914	2370	19.8	21.5	22.3
	ANOVA test	12.56			15.63			36.58**		

Table 3. Gross returns and net returns of selected crops under different irrigation regimes (Rs/acre)

Crops	**Gross returns (Rs)**			**Net returns (Rs)**			**Returns per rupee of variable cost (Rs)**		
	SW	**GW**	**CW**	**SW**	**GW**	**CW**	**SW**	**GW**	**CW**
Sugarcane	115578	98437	121635	36732	5616	37200	2.04	1.32	1.97
Maize	34132	28979	38266	13316	422	1686	1.58	1.19	1.21
Ragi	32515	35955	39365	1605	3388	12437	1.26	1.29	1.83
ANOVA test	13.65**			18.56**			10.26		

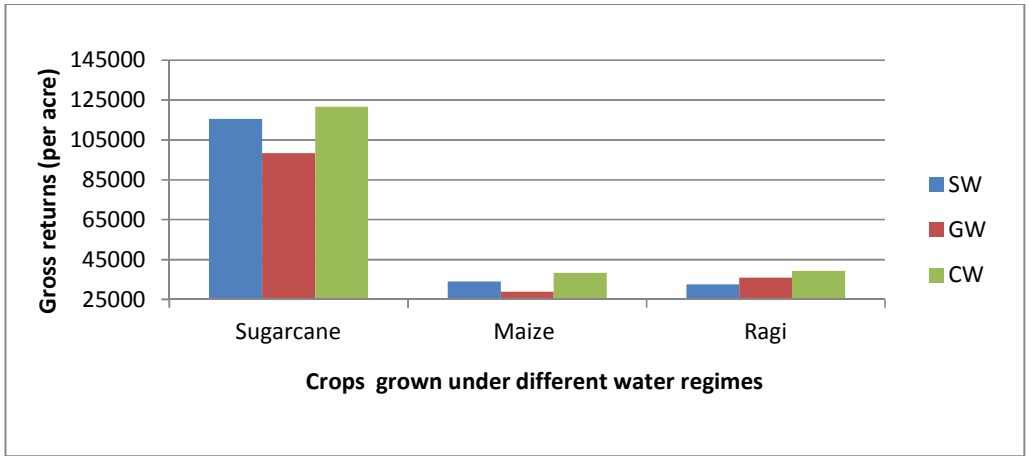

Fig. 1. Gross returns of selected crops under different water regimes

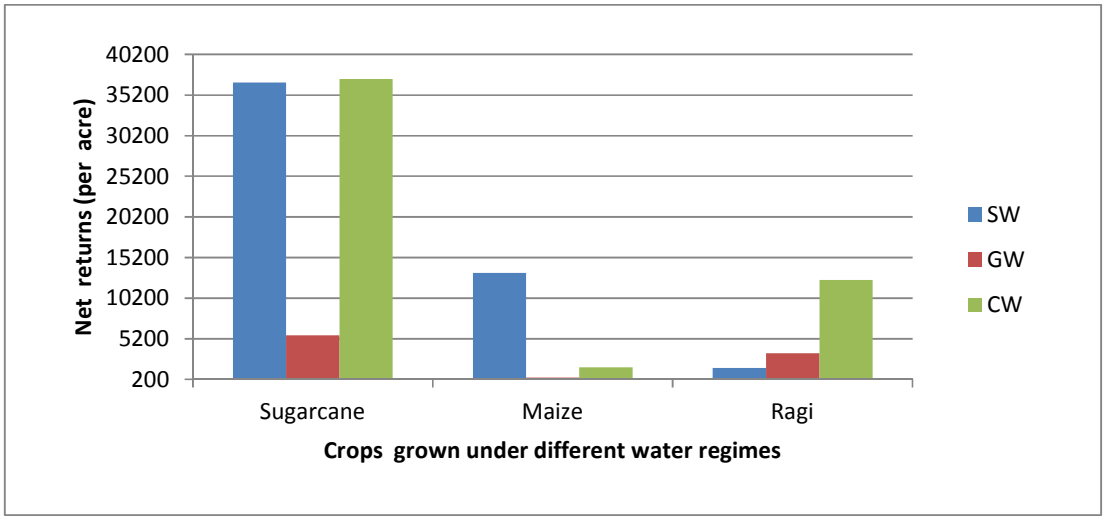

Fig. 2. Net returns of selected crops under different water regimes

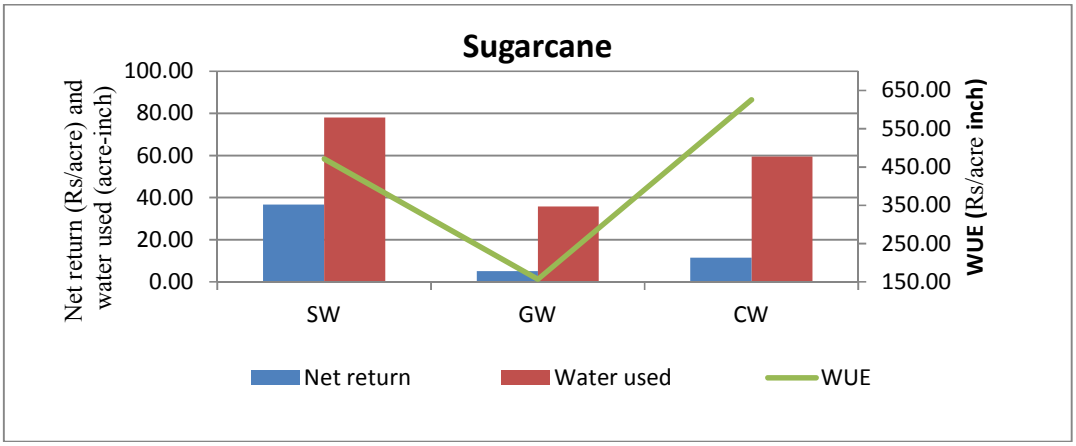

Fig. 3. The relationship between WUE, water used and net returns of sugarcane

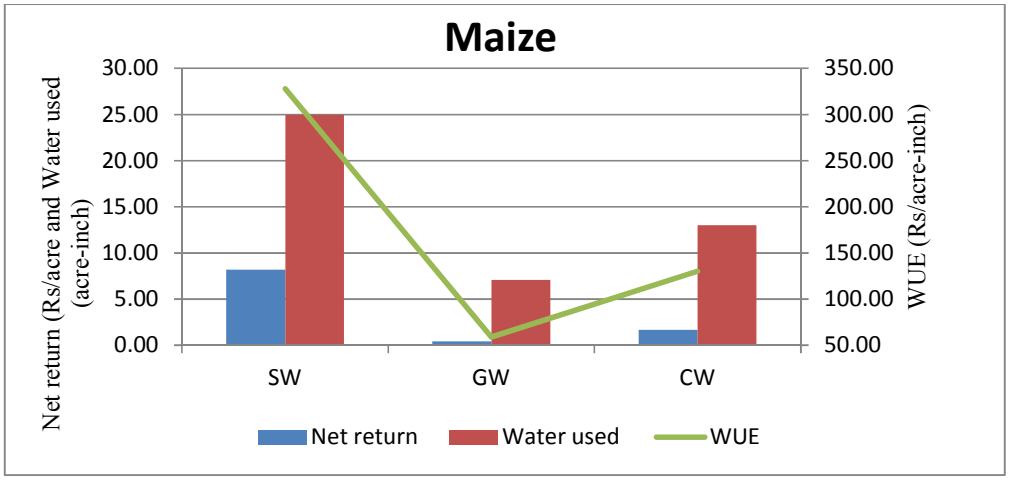

Fig. 4. The relationship between WUE, water used and net returns in maize crop

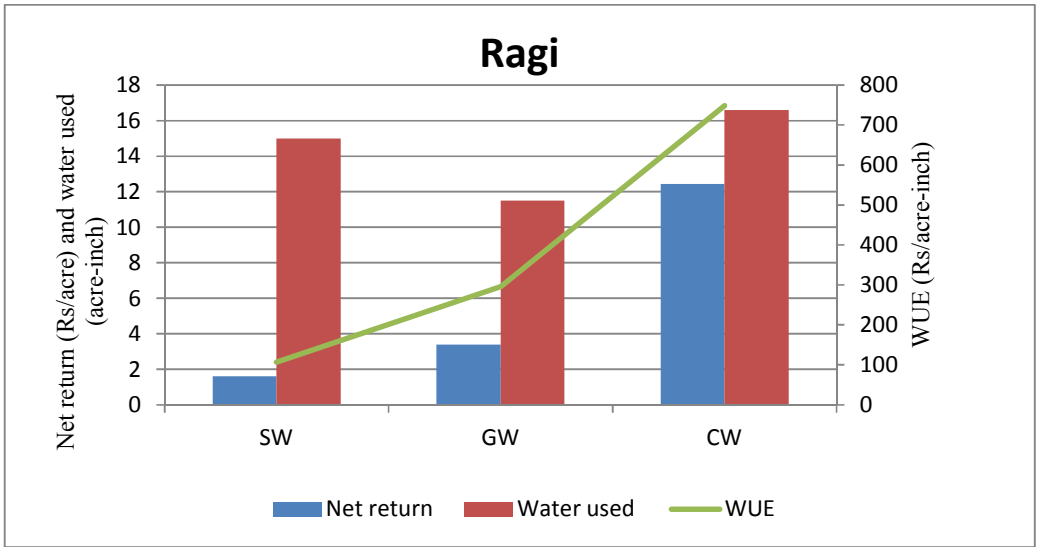

Fig. 5. The relationship between WUE, water used and net returns of ragi crop

4. CONCLUSION

In command areas, the overutilization of surface water has led to the deleterious effects as results into crop productivity and deficit water supply at the tail ends. So, overuse of both sources of water would lead to imbalance in water management as results into unsustainable water management. Thus, conjunctive use is a single input to address physical and economic scarcity of surface water (SW) and groundwater (GW) and which offers a solution to a large extent to harmful effects of SW and GW. The present study was carried out in Mysuru and Mandya of Cauvery command area with 180 farmers of which 60 each from surface water (SW), groundwater (GW) and conjunctive use regime (CU) during the study period 2018-19. The result implies the significant difference in productivity level and gross returns for selected crops at 5% significance level. The conjunctive irrigation practicing sugarcane farmers realized higher gross returns over GW and SW to the extent of 24 percent and 5 percent respectively. The maize and ragi crop exhibits the positive relationship between net return and WUE with a correlation coefficient of 0.78. The higher water use efficiency was found in CU of water for all selected crops. Results have amply indicated the superiority of conjunctive use technology over both separate groundwater use and surface water use technologies in farming. So, it is necessary to expose farmers for conjunctive use of irrigation water, whenever both the sources of irrigation are available to increase the profit of farmers.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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