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# Computer aided conjunctive use of water


## Abstract

Water, a single finite natural resource, is one of the most important critical inputs for agricultural production. National Water Policy, 1987 in India recognized the need for conjunctive use of surface water and ground water and recommended that conjunctive use should be ensured from project planning stage and should form an essential part of project. Many theoretical studies were carried out by researchers, planners and policy makers and it was concluded that conjunctive use should be promoted but except few studies of conjunctive use of fresh water and saline ground water, in reality there is no evidence of conjunctive use in practice. Though good quality shallow ground water zones are available in Bihar, India, but due to large difference in cost of canal water and ground water farmers don't adopt conjunctive use practice.

In order to convince the farmers about concept of conjunctive use and its' economical benefits, a decision support tool is developed in English using Visual Basic platform. This interactive tool calculates (i) annual fixed and operational costs of irrigation from tube well and canal, (ii) yield and total cost of produce, (iii) excess expenditure incurred in tube well irrigation over and above the canal water charges, and (iv) required yield increase needed to compensate for the additional cost of irrigation from tube well.

The tool was demonstrated to water users in the command of RP Channel V of Patna Main Canal in Sone command. Data was collected through the specified format in participatory mode. Users were found capable of making the required analysis and were convinced of making decisions about ground water use under their prevailing constraints. Along with canal irrigation the economic viability of tube well irrigation under three situations (i) own tube well, (ii) renting pumping sets to run tube well for irrigation, and (iii) purchasing water from tube well owners, were analyzed to understand the constraints and possibilities of conjunctive use in the area.

The results reveal that conjunctive use of tube well and canal water has tremendous scope in canal command and it can be propagated in the area provided water users are convinced about yield improvement resulting in economic benefits, which compensate the additional cost of irrigation. Analysis showed that compared to owning tube well, water purchasing is the most economical option followed by getting only pumping sets on rent basis to run tube wells for irrigation.


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## Introduction

Survival of the agrarian economy of world largely depends upon the sustainable use of land and water resources. India is perceived to be endowed with large and reasonably good land and water resources, but with alarming increase in population since last 30 to 40 years per capita resource availability is progressively decreasing. On global basis the irrigated agriculture covers only 16% of the total land under cultivation while it contributes about 36% of the total food production. This supports the fact that irrigation is the most potential and effective means of increasing agricultural productivity. It is however realized that water is a scarce resource, which goes into many competing and conflicting processes and requires a comprehensive planning for appropriate utilization. Development of these resources by individuals has not only created unfavorable conditions for crop production and environmental sustainability but also raised the energy uses in agriculture for irrigation. At the same time intensive irrigation in various canal commands has created the problems of water logging and salinity, making the soil unproductive while overexploitation of groundwater in certain parts of the country has resulted in lowering of water tables and causing decline in yield and productivity of wells, saltwater intrusion along the coast, drying of springs and shallow dug wells, increase in cost of lifting etc. Hence, it is advantageous to look water as a single resource irrespective of its source of development, rain, surface or groundwater. Planning for conjunctive use requires basic understanding of the processes and principles involved in water resource management. A well-formulated conjunctive use programme, must consider fulfilling the irrigation requirement of crops during lean period by other sources of water when supply through canal is not enough to meet the irrigation requirement. In addition it must also take in to account the conservation of rainwater along with augmenting the groundwater storage through recharge.

Hence, Conjunctive use management can be defined as the management of multiple water resources in a coordinated operation such that the total water use of the system over a period of time exceeds the sum of water uses of the individual components of the system resulting from uncoordinated operation. This reflects that conjunctive use planning has a major demand in areas, essentially facing a resource management problem and needs a proper planning at farm, project and regional level.

Conjunctive use models developed earlier may be classified as simulation models, dynamic programming models, linear programming models, hierarchical optimization models, nonlinear programming models and others as reported by Vedula et al.[1]

The conjunctive use models developed and employed by various researchers like Bredehoeft & Young,[2] Latif & James,[3] Belaineh et al.,[4] Marino,[5] Barlow et al.,[6] Rao et al.[7] can be classified under a single or combination of categories mentioned above. Vedula et al.[1] attempted to model conjunctive use and developed a stable operating policy for optimal allocation of surface and ground waters for irrigating multiple crops in a canal command area.

Lakshminarayana & Rajagopalan[8] studied the problem of optimal cropping pattern and water releases from canals and tube wells in the Bari Doab basin, India using a linear programming model. The model is deterministic and the dynamic response of ground water aquifer is not considered. In most of the cases of conjunctive use programmes in India, what is being practiced in the country at the moment does not really envisage the optimal use of rain, surface and groundwater resources.[9] None of the states, so far have formulated clear-cut operational plan for conjunctive use in any irrigation projects though bulk of attempts through research and extension agencies have been undertaken and developed technologies have been disseminated in the country. Reviews indicate that no irrigation project, however, has either been planned, or designed and operated, on conjunctive use principles so far, which can incorporate the institutional framework, socio-economic factors of wide range of stakeholders and policy guidelines for development of water resources along with the technical aspects of canal management due to unresolved technological issues, absence of a methodological framework, and certain inhibiting policy and socioeconomic factors. Upadhyaya et al.[10] developed a conceptual framework for a decision support system based on prevailing constraints faced by farmers and opportunities available to them.

In this paper attempts have been made to present the constraints in conjunctive use identified through survey and interaction with farmers to explore and promote conjunctive use options in the canal command with the help of an interactive decision support tool.

Upadhyaya[11] discussed conjunctive use model and Upadhyaya[12] demonstrated the model to farmers and reported the results and analysis'

## Study area

In order to understand the constraints related to conjunctive use and explore possibilities for its promotion RP Channel V distributary of Patna Main Canal under Some Canal system in Bihar was selected. In this area conjunctive use of rain, surface and ground water is poorly developed, despite the chronic unreliability and shortage of canal water. Tube well irrigation is practiced mostly at the tail end of RP Channel-V, where canal water supply is poor. Although many wells and tube wells have been created, as shown in Table 1, yet farmers use them rarely.

**Table 1** Wells and pump sets in RP channel V

| Reach | Number of wells | | | Pump sets | |
|---|---|---|---|---|---|
| | Open | Tube wells | Open+Tube wells | Motor | Diesel |
| Head | 57 | 26 | 2 | - | 28 |
| Middle | 69 | 46 | 4 | 2 | 45 |
| Tail | 131 | 101 | 14 | 17 | 98 |

The cost of tube well water varies from Rs. 40/- to Rs. 70/-per hour depending on location, time and amount of water supply, whereas cost of canal water supply in the command varies from Rs. 217 to Rs 370.50per ha depending on the crop. The cost of canal water supply is given in Table 2 below.

**Table 2** Cost of canal water (Rs/ ha per crop season)

| Sl. no. | Crop | 1985-95 | 1995-2001 | 2001-02 till date |
|---|---|---|---|---|
| 1 | Rice | 89.41 | 172.9 | 217.36 |
| 2 | Wheat | 51.13 | 148.2 | 185.25 |
| 3 | Sugarcane and vegetables | 157.59 | 296.4 | 370.5 |

Low cost of canal water misleads cultivators into avoiding use of water sources that are more expensive. Hence they avoid the cost of paying for water from wells or tube wells in the belief that this would be unnecessary in the event that canal water becomes available, or rain occurs. Because canal water is inadequate, irregular, untimely and uncertain, many farmers wait to buy water until it is too late and their crops fail.

### Constraints in conjunctive use based on farmers' survey

Before propagating the concept of utilizing rain, surface and ground water conjunctively in the canal command farmers were interviewed through a questionnaire and their responses towards conjunctive use were analyzed. Major constraints in adoption of conjunctive use as reported by farmers are:

### No land consolidation

55% farmers in the head reach, 35% farmers in the middle reach and 32% farmers in the tail reach of RP Channel V distributary reported that small and fragmented land holding and non-existence of land consolidation were the major problems in owning a tube well and utilizing groundwater along with canal and rain water conjunctively.

### Uneconomical because it needs high initial investment

All the farmers reported that utilization of ground water has become uneconomical because initial investment ranges from Rs. 25,000/- to Rs. 40,000/- depending on the selection of pump, engine/motor and other accessories, whereas canal water though irregular and unreliable, but available at much cheaper rate.

### High recurring expenditure due to increase in price of diesel

All the farmers were of the opinion that due to hike in price of diesel recurring expenditure increases and it discourages the farmers to withdrawal ground water and utilize it for crop production.

### Frequent power failure

Power supply in the villages is totally unreliable and there is a frequent failure so electric motors are very limited in use and farmers are compelled to use diesel engine in place of electric motors.

### Lack of awareness about selection of pump, motor/engine as per farmers' requirement

60% farmers reported that they don't have knowledge about selection of pump, motor/engine and other accessories and they purchase either on the basis of experience of other farmers or on the advice of supplier. Due to this they don't get the expected output of pump and face problem due to early failure.

### Lack of trained manpower to efficiently operate and timely maintain the pump, engine/motor and other attachment

All the farmers reported that trained and efficient mechanic is not easily available and accessible in affordable price. Due to this repair and maintenance of pumping unit is not done at proper time, which results in frequent loss of time and money.

### Transportation from one place to another is difficult

Some people have boring in their fields but don't have pumping unit, whereas some people have pumping unit but no boring. These people face problem in transportation of pumping unit due to heaviness of whole assembly.

## Advantages of conjunctive use quoted by farmers

When farmers were asked about the advantages of conjunctive use, they reported that ground water is assured source of water supply and we can use it efficiently and economically as per requirement of the crop. 63% farmers in the head reach, 60% farmers in the middle reach and 95% farmers in the tail reach, who are also using ground water, reported that use of ground water only during nursery period, helped them in attaining higher yield of rice. The farmers requested to demonstrate the concept of conjunctive use and conditions under which it is economically beneficial to them.

This response of farmers inspired for development of a decision support tool in order to analyze the possibility of ground water utilization and promotion of conjunctive use in the canal command.

## Decision support tool for conjunctive use

An interactive decision support tool in Visual Basic was developed in English. A pictorial view of English version with example is given below (Figure 1 & 2)

This tool calculates:

I. Annual fixed and operational costs of irrigation from tube wells and canal.

II. Yield and total cost of produce.

III. Excess expenditure incurred in tube well irrigation over and above the canal water charges.

IV. The required yield increase needed to compensate for the additional cost of irrigation from tube wells.

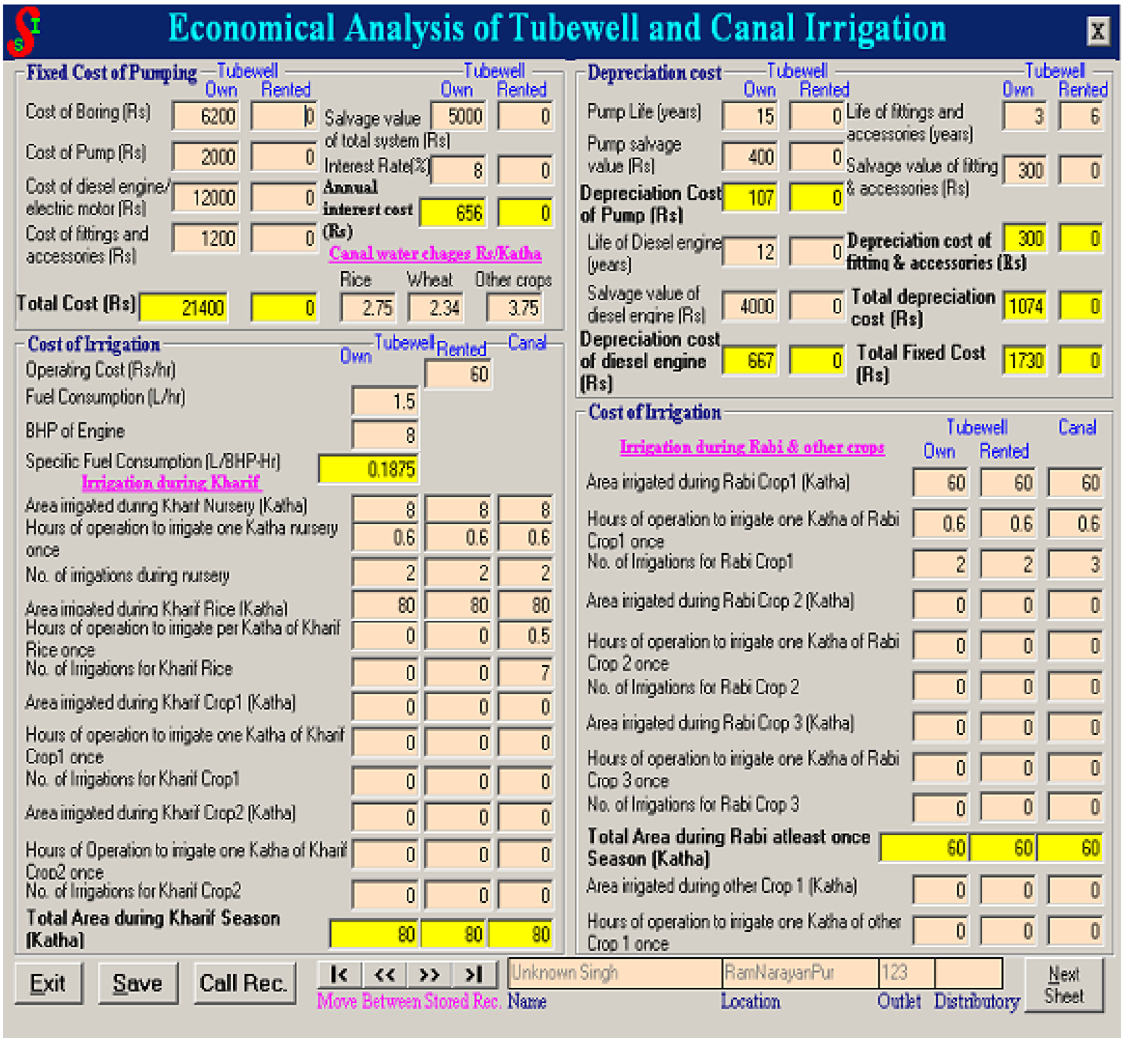


**Figure 1** Economical analysis of tube well and canal irrigation.

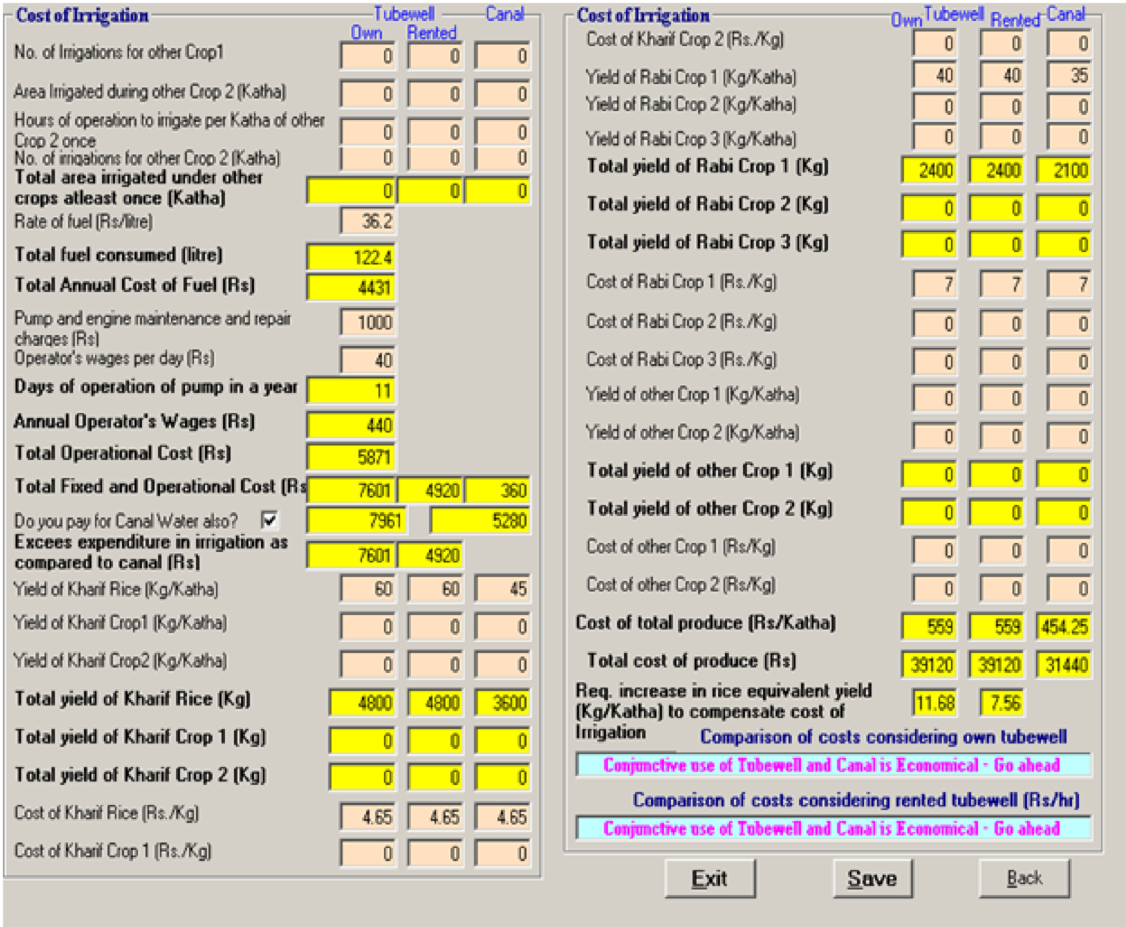


**Figure 2** Excess expenditure incurred in tube well irrigation over and above the canal water charges.

The tool was demonstrated to water users and data was collected through the specified format from 150 farmers (50 farmers each at head, middle and tail reaches). The tool was found capable of making the required analyses and of convincing them to use it to make decisions about ground water use under the prevailing constraints they face. Along with canal irrigation the economic viability of tube well irrigation under three situations were also analyzed to understand why conjunctive use is not so popular in this region? These three situations are:

a. Own tube well.

b. Renting pumping sets to run tube wells for irrigation.

c. Purchasing water from tube well owners.

analyses showed that farmers applied 2 to 3 irrigation during rice nursery and 2 to 3 irrigations during Rabi season to irrigate wheat, the required yield increase to compensate the additional cost of irrigation from tube well in case of the water users owning tube well varied in the range of 0.069 to 1.28t/ha in head, 0.067 to 1.51t/ha in middle and 0.13 to 1.32t/ha in tail reach of the canal, whereas for the water users renting pumping sets to run tube wells for irrigation the required yield increase varied in the range of 0.078 to 0.8t/ha in head reach, 0.052 to 0.81t/ha in middle reach and 0.16 to 0.78t/ha in tail reach, and in case of water users purchasing water from tube well owners it varied in the range of 0.13 to 0.26t/ha in head reach, 0.16 to 0.35t/ha in the middle reach and 0.18 to 0.52t/ha in tail reach of canal. The results reveal that compared to owning tube well, water purchasing is the most economical option followed by getting only pumping sets on rent basis to run tube wells for irrigation.

## Conclusion

Conjunctive use is defined as operation of surface and groundwater in such a way, which enhances their combined output. Since long, researchers and planners are trying to recommend the concept of conjunctive use in canal command as well as salt affected areas and many theoretical studies have been conducted in the past, but so far there is hardly any evidence about wide adoption and acceptance of conjunctive use practices among water users due to many constraints and mainly due to tremendous difference in cost of canal water and ground water. Since canal water is available at much cheaper rates, water users don't prefer ground water utilization unless they feel that their production will reduce drastically in the absence of water.

A user interactive decision support tool was developed and English versions using Visual Basic platform and demonstrated among water users in order to create awareness and explore the possibility of conjunctive use in the canal command. Farmers found this tool quite helpful in understanding and analyzing the concept of conjunctive use and taking appropriate decision for its adoption under the prevailing constraints.

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## Conflict of interest

The author declares no conflict of interest.

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