ASSESSMENT OF CONJUNCTIVE USE IN MAHARASHTRA MINOR IRRIGATION SYSTEMS

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1. INTRODUCTION

The State of Maharashtra in India, like much of South Asia, has witnessed a striking growth in the number of wells used for irrigation. The use of groundwater for irrigation greatly benefits agricultural production and farmer welfare. Farmers in Maharashtra typically construct, operate and maintain wells on their own initiative. The state-run irrigation agencies indirectly support the use of groundwater for irrigation, but there is a marked absence of a single agency that specifically manages the conjunctive use of both groundwater and surface water. Donor agencies would like to assist in improving the status of conjunctive use, but it is sometimes difficult to identify the areas in which to help and the agencies through which to work.

The objective of this paper is to provide a brief assessment of the status of well irrigation and conjunctive use in Maharashtra. In light of the assessment, we will note areas where assistance could be used to improve the status of conjunctive use. The focus of the paper is on minor irrigation systems. Minor irrigation systems serve less than 2,000 ha and usually consist of a small tank for storing water and a canal distribution system. The development of surface irrigation has led to a rise in wells due to canal seepage in the command areas.

First presented in the assessment is a physical and socio-political overview of conjunctive use in minor irrigation systems, where we will briefly describe the physical, agricultural, and institutional settings for use of groundwater. Based on this presentation, we will then assess the strategies for managing conjunctive use of ground and surface water. We will then assess the strategies and give recommendations on what can be done to improve conjunctive use.

Conjunctive use is a common irrigation term usually referring to a means of coordinating the use of surface and groundwater supplies. Todd (1980) defines conjunctive use as the 'coordinated and planned operation of both surface and groundwater resources to meet water requirements in a manner whereby water is conserved.' Chavan (1984) defines it as 'the coordinated and harmonious development of the two sources in a basin or group of basins to maximise agricultural production.' Often times 'optimal use' of water resources is used with the term conjunctive use.

For conjunctive use to be successful, it is often felt that there must be active management, including central agencies for planning, monitoring, setting, and enforcing conjunctive use policies. In Maharashtra, there is no such agency, and the style of management allows farmers to make most of their own decisions regarding groundwater use. This style of management may seem to go against the grain of the definitions of conjunctive use, yet we will argue that there is conjunctive use of ground and surface water in minor irrigation systems in Maharashtra, and that conjunctive use is quite successful.

2. PHYSICAL AND SOCIO-POLITICAL OVERVIEW

This section provides a background description of the physiography and irrigation practices in the region (both for the state of Maharashtra and for minor irrigation commands), as well as the policy and organisational framework that prevails in the state.

2.1 Statewide

The Sahyadri Mountain ranges running parallel to the Arabian Sea, divide the State of Maharashtra into the coastal region (Konkan) and the Deccan Plateau. The physiography of Maharashtra is quite variable, ranging from barren hills and wastelands to highly productive valley regions.

The Government of Maharashtra (GOM) Groundwater Survey and Development Agency (GSDA, 1983) has divided the state into five geological regions (listed in order of occurrence):

1.	Deccan trap volcanic multi-layered rock	81.2%
2.	Archaean and Dharwar metamorphic complex igneous rock	10.5%
3.	Alluvial unconsolidated sedimentary rock	4.7%
4.	Pre-cambrian consolidated and compact sedimentary rock	2.0%
5.	Gondawana consolidated sedimentary rock	1.6%

Clearly, igneous and metamorphic ('hard rock') predominate. The condition of these rocks varies with depth, beginning at the surface with a thin (0.5 to 2 metres) soil layer. Below the soil layer is a zone of weathered rock, known locally as 'murum', which varies in thickness from 2 to 10 metres. Below the murum lies a 3 to 20 metre thick zone of semi-weathered rocks characterised by multiple fractures. Below this zone exists a non-weathered and non-fractured massive basement.

When saturated, the weathered and fractured zones constitute a hard-rock aquifer. Groundwater storage and yield, however, are impaired by poor permeability and shallow depths. Exploitation of these aquifers by tube wells is therefore limited, but large diameter dug wells are widely-used to tap groundwater in these formations. The Deccan trap, formed primarily from lava flows, is the major groundwater province in the state.

Well yields in these rocks commonly vary from 45 to 90 m^3/day, but wells located in suitable sites have been reported (Agashe, 1989) to yield 100 to 240 m^3/day. The Archaean and Dharwar metamorphic complex igneous rocks are found in the Konkan and Vidarbha regions. The yield of dug wells in these rocks varies from 45 to 50 m^3/day. By comparison, tube wells in alluvial aquifers are generally more than 2000 m^3/day. For the entire state of Maharashtra, the average area irrigated per well is 1.23 hectares (Government of Maharashtra, 1977). The number of wells in the state is dramatically increasing as shown in figure 1 (data from Dhavan [1987], and Dhokarikar [1989]). GSDA (1983) estimates the number of wells to reach ultimate potential exploitation would be 2,740,000.

The hard-rock aquifers are primarily recharged by the monsoon rains that fall from June through September. A very close relationship between this rainfall and groundwater levels is reported by Sawant (1989) and Agashe (1989). Groundwater levels show large fluctuations, attaining their highest position at the end of the monsoon season (October) and their lowest in summer (May). A very wet monsoon season may raise the groundwater level by 8 to 10 metres from its summer low; consecutive lean monsoon seasons may drop the groundwater level low enough to leave wells dry. These monthly groundwater level fluctuations can greatly affect water availability from dug wells.

In irrigation project command areas, additional groundwater recharge occurs due to seepage from the tank, canals, and field channels, and due to deep percolation of irrigation water. In a theme paper presented by Kulkarni

(1989), recharge from canal water was estimated to vary from 15 to 34% of the water released at the canal heads of the major irrigation projects studied. The paper also reported an increase in the number of wells in command areas after commencement of irrigation projects by a factor as high as 10 in some commands.

2.2 Minor Irrigation Command Areas

Minor Irrigation Command Areas are those less than 2000 hectares in area. They are typically found in the higher watersheds of the state. Due to the steep slopes in these areas, drainage is good and waterlogging from high water tables is generally not a problem. Farms in these commands are small, usually less than 2 hectares. During kharif season, common crops include sorghum, millet, groundnut, chilies, and mung beans. Irrigation for these crops may be given during any extended dry period in the monsoon. Common rabi season crops include wheat, sorghum, and gram and receive most of their water from irrigation.

Wells provide the farmer with groundwater for additional irrigation. As described above, these wells are usually of the dug well variety more suited to the hydraulics of hard-rock aquifers.

Groundwater is popular with the farmers since they have more choice over when it is used, how much is used, and what types of crops they may irrigate with it, as compared to canal water. Daines and Pawar (1987) found that the economic rate of return for hardrock dug wells in irrigated areas is between 50 and 87% compared to a rate of 10 to 16% for canal irrigation.

2.3 Current Irrigation Policy

The current irrigation policy for Maharashtra is the result of numerous legislative acts dating back to 1887. Among these acts are the 1934 Bombay Canal Rules, in 1976 Maharashtra Irrigation Act, and the 1987 Bombay Irrigation Act. Groundwater in India is considered to be private property and not subject to control by the government. Therefore, these acts mainly govern the use of surface water.

Nevertheless, the interrelationship of ground and surface water has been recognised by the law-makers and current policy does, in fact, indirectly regulate conjunctive use. Some of these policies are:

1. In command areas, irrigated land is designated as either groundwater-irrigated or canal-irrigated. Areas irrigated with canal water may also receive groundwater if canal supplies become short. The farmer must report this use to the appropriate executive engineer within 8 days. The water charge in this case is 50% of the regular canal charge (Rule 18, Bombay Canal Rules, 1934). In contrast, groundwater-irrigated areas may at no time be irrigated using canal water;

2. Well water transported via surface channels constructed for canal water is charged at the full canal rate (Rule 19, Bombay Canal Rules, 1934);

3. With the permission of canal authorities, a farmer may divert or pump water from natural surface drainage that originates from percolation or leakage of canal water (return flow). The water charges for such use are at par with the direct canal water supply (Rule 55a, Maharashtra Irrigation Act, 1976);

4. Irrigation water from wells located within the irrigable command of a canal or within 35 metres on either side of a canal is charged at 50% of the normal canal water charge (Rule 55b, Maharashtra Irrigation Act, 1976);

5. Any person planning to construct a well in an irrigation command is required to inform the canal authorities of his intentions, or he may be penalised (Rule 105, Maharashtra Irrigation Act, 1976);

6. The irrigation of perennial crops with canal water is restricted as follows:

   (a) In major irrigation systems, the area planted in sugarcane, a heavy water-consuming crop, is limited to 1/4 to 1/3 of the total command area. This restriction, popularly known as the 'X Limit', does not apply to sugarcane grown exclusively with well irrigation (Form III, Condition 1, Bombay Canal Rules, 1934);

   (b) In minor irrigation projects it is not feasible to irrigate perennial crops with canal water since water cannot be assured on a year-round basis.

In actuality, adherence to the rule requiring a farmer to inform the irrigation authorities of his plans to construct a well in the command area depends on other financial factors. If a farmer is using his own money to construct a well, he often does so without seeking anyone's permission. However, if the farmer approaches the Maharashtra Cooperative Land Development Bank (LDB) for a loan to construct the well, the bank, with the help of GSDA, must first do a hydrologic feasibility study of the well site. Depending on the results of this study, the well may or may not be financed (see section 2.4.7). LDB loans are special long-term, low-interest loans. A farmer has the choice of obtaining a higher cost loan from another bank in which case the well may not need to meet any hydrologic guidelines.

Furthermore, while the irrigation of perennial crops with canal water is restricted, a farmer is free to grow any crop he chooses if he irrigates that crop with his groundwater. Use of return flow canal water in natural drainage is also available for any crop albeit at the full canal charge.

2.4 Organisations Involved in Conjunctive Use

Due to the existing policy constraints outlined above, there is presently no organisation in Maharashtra directly responsible for conjunctive use management in irrigation projects. However, discussions with officials from various organisations revealed that many of these organisations carry out activities related to conjunctive use, or at least to the use of groundwater. Furthermore, some officials had studied conjunctive use problems in the past and expressed an interest in being further involved in the activity, including possible computer model development. Highlights of groundwater related activities of various organisations follow.

2.4.1 Directorate of Irrigation Research and Development (DIRD)

The DIRD, a wing of the GOM Irrigation Development (ID), records groundwater levels in some 84,000 wells in 24 major irrigation projects around the state. Levels are monitored twice a year, before and after the monsoon. The purpose of this activity is to watch for drainage problems in the commands caused by waterlogging. Additionally, the organisation has carried out some water balance studies in a few of the major irrigation projects (Kulkarni, 1989).

2.4.2 Management Wing of ID

The Management Wing of the Irrigation Department manages day-to-day operations and maintenance of irrigation systems. It collects seasonal data regarding the crops grown and the area irrigated in the commands for the purpose of levying appropriate water charges. Discussions with project managers revealed that they too realise the importance of conjunctive use and have studied the problem (see Ralegaonkar, 1983, and Chavan, 1984). They would welcome any further research in this area.

2.4.3 Groundwater Survey and Development Agency (GSDA)

The GSDA was set up by GOM to explore for and develop groundwater in the State and provide technical assistance to various other agencies. It is actively engaged in hydrogeological reconnaissance and mapping (at a scale of 1:800) and monitors groundwater levels in a large number of observation wells.

In 1973 GSDA began periodic evaluations of the groundwater potential of the state's watersheds. One use of this information is to make decisions concerning financing the wells. The watersheds are classified as 'white', 'grey', or 'dark' according to their degree of groundwater exploitation. A white watershed is one in which the total groundwater potential is less than 65% exploited. Grey watersheds fall between 65 and 85% total exploitation and watersheds over 85% exploited area classified as dark. Of a total 1481 watersheds in the state, 1367 are classified as white, 80 as grey, and 34 as dark (Dhokarikar, 1989). GSDA provides this information as a general guide for groundwater development in Maharashtra.

2.4.4 Central Groundwater Board of the Government of India (GOI/CGWB)

The Central Ground Water Board, under the Ministry of Water Resources, Government of India, is the national apex body for groundwater activities. Its responsibilities include the preparation of regional hydrological survey maps (at a scale of 1:50,000), and the exploration, development, and management of country's groundwater resources. GOI/CGWB is preparing a computerised data bank of hydrogeologic data. There is some overlap in the activities of GOI/CGWB and GSDA in the state of Maharashtra.

2.4.5 Financial Institutions

Bankers come into the picture as providers of loans to farmers for well construction. NABARD is the controlling agency in this respect, setting technical guidelines and monitoring rural financing at the national level. NABARD finances the Maharashtra State Cooperative Land Development Bank (LDB) and other national banks at an 80:20 ratio respectively. These banks, in turn, do the actual financing of the farmers.

In approving the financing of well construction, LDB uses guidelines and other information from GSDA. If the proposed well site is in a watershed classified as white, financing for the well is approved if it is not within 150 metres of another well to prevent interference in hard-rock aquifers. If the well site is in a grey watershed, the well must meet the GSDA hydrologic feasibility requirements regardless of its proximity to other wells. If the well site is in a dark watershed, financing is not approved.

3. CONJUNCTIVE USE STRATEGIES

Surface and groundwater could be managed conjunctively for minor irrigation command areas using a variety of approaches as examined below. Through our discussions the following strategies were identified:

1. Periodically skip certain canal rotations to induce farmers to use well water during these periods;

2. Pump groundwater from wells in the command area into the canal system to increase its water supply;

3. Exclude areas irrigated with groundwater from the command area and expand the surface irrigated command area accordingly;

4. Allow the farmer to manage the available groundwater resource.

Strategy 1 was attempted experimentally in the Nira command but was found to be a failure. The approach is infeasible because not all farmers necessarily have a well and dug wells in hard-rock aquifers often cannot yield sufficient quantities of water to make up for the skipped rotation.

Strategy 2 is practised in the alluvial aquifers of the Western Jumana Canal System in Haryana (Michael, 1978) where a battery of tube wells along the canal is pumped to supplement the canal's supplies. The advantage here is two fold: to augment the canal water and to lower the water table to prevent waterlogging problems. This option has yet to be tried in Maharashtra but its success in the state is doubtful. The alluvial aquifers in the Haryana area are quite high-yielding compared to the shallow, hard-rock aquifers in Maharashtra. A variation of this approach is to pump groundwater into the canal system from a network of private wells. This probably has even less chance of success since additional distribution structures would have to be built and because individual farmers would be reluctant to share their private well water.

Strategy 3 has not yet been attempted in Maharashtra minor irrigation commands. It presents difficulties because it is hard to determine exactly how much the command area could be safely expanded. It cannot simply be expanded by one hectare for every hectare under well irrigation. This is due to two reasons. First, the efficiency of well irrigation is higher than that of surface irrigation. Second, distributing more of a given amount of canal water to new command areas means that less water will be applied to the old command area. This will consequently reduce the seepage that recharges the groundwater in the old command area, undermining the original reason for expanding the command area. In addition to these reasons, extending the command area eliminates any safety buffer provided by groundwater during periods of canal water shortage. For Strategy 3 to be successful, some rigorous methodology for estimating the water balance of a command area would need to be developed and applied.

Strategy 4 is, in fact, the present practice in Maharashtra. If canal water is in short supply during the kharif and rabi irrigation season, farmers will not hesitate to make up the difference with well water, if permitted. Moreover, during the summer when the canal system is not operated, it is common for farmers to grow cash crops using groundwater. The strategy is quite flexible. At one extreme (e.g. the Satana Minor Irrigation Project in the Godawari System), a farmer may opt for a more dependable 'on demand' groundwater resource over the less dependable (in both quantity and timeliness), government-controlled canal water. This allows him to cultivate more profitable crops, tilting farm economics against the use of canal irrigation. At the other extreme, where the groundwater potential is low, cash crops are unattractive, or the canal system is dependable, the farmer may choose to rely completely on canal water.

4. ASSESSMENT

The present government policy and institutional framework allows farmers a high degree of management control over their groundwater resources. The Irrigation Department plays an active role in managing surface water and, by allowing farmers to manage groundwater use, the Department has also been effective in conjunctive use administration in command areas. A more direct role by the government may adversely affect irrigation performance. Strategies for improvement of conjunctive use should encourage and facilitate the private control of groundwater use.

Of the four strategies for conjunctive use management on minor irrigation systems, the present policy (Strategy 4), has the most potential for success because it allows farmers to manage their own resource. It should be recognised that the present government policies and management practices contribute to the success in the utilisation of the groundwater resource. However, the irrigation department does not give itself due credit, because measurements of irrigation performance are restricted to surface water alone.

While the present policies allow for a high degree of farmer control of on-farm irrigation water from wells, the farmer has no control over the supply of groundwater. Provision of surface water infrastructure leads to an increase in groundwater potential due to leakage from dams and canals. The means of operating and maintaining surface water affects the supply and timing of groundwater supplies. By indirectly controlling a source of groundwater, the government may have a means of assisting farmers and improving conjunctive use performance.

To measure the benefits of conjunctive use, irrigation performance standards are required that consider both groundwater and surface water. Measures of performance relative to the standards and system objectives need to be identified and defined. Performance should be measured relative to economic, water use efficiency, and equity objectives. With conjunctive use performance measures it is possible to assess the baseline status of conjunctive use and to assess strategies for improving conjunctive use.

Given the current water policy and institutional constraints, there remains the question of what can be done to improve irrigation performance by considering conjunctive use. Possible options are:

1. Obtain a better understanding of the water balance in minor irrigation command areas. A water balance study would assist in understanding this complex system and may give indications on how to improve the system;

2. Develop a means of assessing irrigation performance that considers both surface and groundwater. Performance measures can be used to assess the present status of irrigation performance and compare alternative conjunctive use strategies;

3. Take physical, operational, and maintenance steps on the surface water system which would enhance the conjunctive use of groundwater and surface water strategy for enhancing conjunctive use should evaluated and compared to other strategies using performance measures;

4. Give farmers advice on technical, agronomic, and economic inputs to assist in their management of groundwater.

5. SUMMARY AND CONCLUSIONS

The outstanding physical feature in Maharashtra is the domination of low-yielding hard-rock aquifers. Recharged by monsoon rains and surface irrigation losses, these aquifers provide a reliable source of water for many small farmers. The fact that the aquifers are low-yielding limits possibilities for large scale pumping projects like those found in alluvial aquifers.

The Government of Maharashtra has set up laws and policies that separate surface and groundwater uses. The Irrigation Department constructs and manages surface irrigation systems while farmers control their own use of groundwater. Given this policy setting, the Irrigation Department does not have an agency for managing conjunctive use. The Government of Maharashtra does have several institutions indirectly involved in groundwater use whose functions are to observe groundwater levels, monitor the number of wells, and provide financial assistance to farmers.

An advantage of the policy allowing farmers to manage their own groundwater is that farmers have control over the timing and amount of groundwater used for irrigation. In spite of the capital and operation expenses, many farmers have constructed their own wells to use

independently or to augment surface water sources. The government, through its financing system, regulates the spacing of wells to prevent groundwater mining and removal of water from canals. While there may be some options where the irrigation department can take a more active role in conjunctive use, we currently feel that the policies and management style of the Government of Maharashtra with respect to groundwater use is appropriate for the setting.

There does remain room for improvement within the present policy and system of management. A means of measuring performance considering ground and surface water should be developed to give the government due credit for its policies, and to evaluate the effect of various surface water strategies on conjunctive use. Focus could also be placed on the farmers, assisting them in improving their use of groundwater.

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