Parameters of Doubt: Prospects for Groundwater Assessment to Help Farmers in Hard Rock Areas of South India

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INTRODUCTION

THIS PAPER EXAMINES the policy dilemmas in increasing farmer participation in both the management of groundwater-based irrigation technology, and also in groundwater resource management, and to see how the farmers' role in both can be better integrated. The paper looks first at the conceptual issues in developing frameworks to study groundwater irrigation management needs. It then looks at the issues and opportunities for improved groundwater management by farmers in the hard rock areas of South India, and the data initiatives this will require. "Hard rock" is a general term used to describe the metamorphic and volcanic rocks found across Central and Southern India, to distinguish them from the sedimentary formations also found in these regions (in which water yields are usually higher), and the alluvial deposits of the flood plains.

In India, extensive groundwater development is a relatively recent phenomenon associated with development and dissemination of lift technologies, and the power sources to operate them. Groundwater development and the organizations in charge of it, are embedded in an institutional framework designed to stimulate agriculture production and transform agrarian structures through new technologies, and not to manage groundwater resources in an equitable and stable way. More effective management of groundwater resources thus requires a major institutional shift which gives greater importance to development and support of water rights and negotiation over abstractions, and gives farmers clear benefits from the technology installed. This shift will be difficult because the technical innovation program has been very successful in some areas and advantageous to existing organizations. Nevertheless, in the hard rock areas, the technology delivery system has been poor, with poor selection and installation of well casings, pumps and motors. The technology available is not always relevant to the agrarian structure of small farms, nor to the groundwater hydrology of low yields with a high variability across the year.

Current attempts at groundwater management through controls on the siting of new wells, and increasingly sophisticated hydrological modeling, are ineffective for equitable and sustainable use. Sustainable use is more likely to be achieved by controls or incentives that restrict the quantities of water mobilized, and programs that provide more easily accessible information and forums for negotiation. Controls or incentives to prevent usage of certain types of pumps and motors might also be more relevant.

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MANAGEMENT ISSUES AND ORGANIZATIONS IN GROUND-WATER FARMER-MANAGED IRRIGATION SYSTEMS (FMIS)

The dilemmas in promoting greater farmer management in groundwater irrigation can be illustrated through some standard frameworks for irrigation management. Management tasks and resulting activities are influenced by the following:

i) Availability of water under existing technologies.

ii) Competition for available water resources.

iii) Capital, labor and skills needed for water acquisition.

iv) Operational complexity in water distribution, both in regular conditions and under periodic scarcity.

Where a clear social mandate for irrigation management exists, the resulting institutions reflect three other social controls as follows:

i) The objectives of investors in irrigation technology.

ii) The property rights that control access to the benefits of this technology and its management organizations.

iii) The legal and jural structures that enforce these property rights.

Research on indigenous surface water FMIS has usually found organizations for irrigation management carefully nested within an overall framework to minimize conflicts and maximize benefits from irrigation, with structures for technology management and resource management quite congruent. This is not the case in groundwater management in many countries, where there is no clear institutional focus on either groundwater irrigation management or groundwater resource management, and where groundwater development is implemented through a range of technology and credit organizations. The problems of poor definition between controlling institutions and performance of management tasks occurs with gravity schemes as well as groundwater, and many initiatives to increase farmer participation have been constrained by lack of broader change in controlling institutions. However, the problems have been severe for groundwater in the water-scarce regions of India. The technology focus of the prevailing groundwater institutions has resulted in poor installation of technology, that will be very expensive to correct and provide very little chance of increased water yields to levels desired by farmers. Thus there are major constraints to encouraging farmers into greater management responsibilities. The uncertain property rights, and lack of respected legal and jural systems encourage competition and direct appropriation rather than collaboration. There are no indigenous management institutions and principles on which to build.

As activities develop to increase the farmers' role in groundwater irrigation management, it is important to understand the constraints that the existing technology focus has left in converting farmers and groundwater development organizations more toward farmer management. Are farmers being encouraged to determine objectives for new institutions, and to get involved in their operation, or are they merely being encouraged to perform certain management tasks?

This framework can certainly be used to identify many ways in which groundwater resources will require different management structures as compared to surface FMIS. It also facilitates the discussion of problems faced by a "system" of well users across one aquifer, as well as the more conventional concept of a community benefitting from a single source. However, it also highlights the importance of hydrological information to groundwater irrigation management, as well as information on technology costs in capital and labor. For groundwater irrigators, collaboration and sharing of information on water availability is often very important in consolidating farmer interaction. There is less stimulus from mobilizing communal supply of labor and funds than is found in surface FMIS.

There will also be quite important differences in management needs between different groundwater areas. In the hard rock aquifers of South India, where water resources are generally poor, water yields are heavily dependent on annual recharge, and show a fair degree of fluctuation in their water levels and well yields across the year. In these areas, public borewells are rare as there are few yield advantages to borewell development. Such communal borewells and dugwell developments that exist have often been developed for welfare reasons, and may be sited in locations where water resources are poor. It is open (hand-dug) wells which dominate over most of the hard rock areas, often operating only for one household.

THE PROPERTY REGIMES OF GROUNDWATER RESOURCES IN INDIA

Understanding the bias of institutions controlling groundwater development helps in identifying many of the current confusions over groundwater rights, and the inadequacy of legal and jural systems to protect them. As the current groundwater institutions are focused on technology dissemination, the property regimes on rights of access to benefits tend to follow the interests of the controllers of these institutions. It is not surprising then, that most of the controls are directed at benefitting and protecting the holders of private property.

The main dissemination has been to private farmers (usually with land as collateral) who can repay a loan with interest. Banks and private industrial companies have been leading actors in technology dissemination, despite the appearance of control by various state agencies. Thus, although siting restrictions were one of the earliest controls investigated by Indian authorities to reduce overdevelopment, the banking institutions have no incentives to support such restrictions to private farmers.

Even though there are public borewells mobilizing water initially within a "state property regime," increasingly, ownership and use is vested in a local association or corporation with rights directly comparable to private ownership. Although groundwater is often referred to as an "open access" resource, the controlling influence is private property as a means to acquiring and installing technology. Thus groundwater resources are best identified as a private property regime where there are no restrictions on the externalities caused in the use of that resource by the owner. This certainly helps in understanding the resistance to changes in legal and jural structures to provide better groundwater management.

The dilemma for groundwater development (as with surface water) has not so much been about the right to develop an abstraction point but about the volume of water that can be taken from that site. However, whereas surface water is highly visible and catchment principles can fairly easily be understood by communities and superintending institutions, this is not the case for groundwater, which is largely invisible and unpredictable. The hard rock aquifers are particularly poorly understood by both farmers and superintending authorities.

Where the incentives to mobilize irrigation technology are largely subsistence based, and the technology commanded within village resources, irrigation management has *de facto* been directed at sustainability (although it may not be cited as a specific management objective). Rights to extractions are seen more as group access within common property regimes, with cooperation between groups encouraged, rather than enforced, by a superintending agency that itself gains direct benefits from the subsistence economy and from fostering collaboration. Indeed the dependence of the "supra-group" on the system it legislates upon encourages its relative impartiality and determination to avoid disputes.

Where the incentives are production of a surplus, profit or returns to capital invested, as is true for much groundwater investment, and the technology need not (or cannot) be developed on a community base, then the incentives to collaborate over equitable property rights and legal institutions become profoundly different.

Incentives to improve (or even initiate) groundwater resource management systems are limited in India for several reasons. First, existing controls are weak, and naturally, powerful vested interests are often able to circumvent them. Superintending groundwater organizations have no legislative function. They gain little from working with local groups, and much from the continued distribution of technology. The organizations involved in groundwater development are diverse, and interests are not concurrent. Many groundwater organizations are now starved of funds, and are increasingly involved with urban water supplies and pollution problems.

Most seriously, however, data are not available as information that can be easily understood, and can be agreed by farmers and superintending institutions as a basis for action. Much effort has gone into diffusing or inducing technical change. Rather less has gone into helping farmers determine what technology they need and can pay for from irrigated crops. Almost no effort has gone into systems to disseminate information and support negotiation.

Although the key credit and technology agencies have known the problem of competition between wells and over-pumping, little action has been taken to define further controls. This is partly because it is difficult to construct pump technology with very strong controls on flow, unlike surface water. The technology itself is "lumpy," and actual volumes abstracted depend on efficiencies, on pumping time, and even energy supply, not simply the structure itself.

Although principles like riparian rights and prior appropriation have been used to determine access rights for surface water, these are very difficult to apply in groundwater, especially in India where pump technology has changed so rapidly. The direction of groundwater flow is too poorly understood to be able to use the principle of riparian rights. If a farmer wishes to claim prior appropriation rights, should this be done on a volume per year, or a sum per month? Should it be done in relation to the existence of a well or the time of ownership of particular technology? It is not surprising that beleaguered local authorities take refuge in spacing rules, as they are the only guidelines for which procedures exist, even though they are recognized as unreliable and are flouted with impunity.

Control of volumetric extraction has been avoided because it is so difficult to set up technology to do this. However, the dominant institutions have also had little concern for the smaller farmers who are most commonly the first affected by declining resources, since they have often tried to avoid assisting these farmers (indeed, prevailing trends in agricultural modernization may support their disappearance). Their key supporters in the development agencies and local officials have few powers to preserve the opportunities of small farmers once groundwater resources become oversubscribed.

Following these dilemmas logically, it could soon become necessary to distinguish rights to install technology at a site, and rights to extract certain volumes from that site, as opposed to rights to use the water after it has been mobilized by lift technologies, and set up legal and jural systems that can control powerful private interests. However, since the hydrological calculations are almost impossible, and the legal controls unlikely, then it is the rates of abstraction that require controlling. This can be done directly, or through removing subsidies and financial incentives on pump technology and the goods it produces.

Increasing the sustainability of groundwater use by restricting site access to technology is not a helpful strategy; it disadvantages groups which need government help in acquiring capital and skills for the technology. Moves to greater sustainability are more effectively initiated by helping farmers to understand the potential of the groundwater resources in their neighborhood, and developing forums where the rights of use can be discussed and agreements negotiated. Helping farmers to understand the adequacy of groundwater for preferred cropping schedules, and the consequences of over-pumping and inefficient use, is also critical.

DATA COLLECTION FOR GROUNDWATER DEVELOPMENT AND MANAGEMENT

The wealth of organizations involved in groundwater development in India suggests that there should also be a wealth of information. There is indeed a wealth of figures, but the majority is derived from highly empirical calculations, and is still based on relatively crude groundwater analyses, with limited studies on key aquifer parameters for modeling recharge and flow. These comments are in no way meant to criticize Indian field workers, who perform the tasks set to a very high standard. The problems are in the techniques they are required to use and the data they are able to collect. First, this reflects the heavy orientation of data collection toward the needs of technology dissemination. Second, it reflects the limited options of many groundwater agencies, which often do not have sophisticated drilling equipment, and whose available rigs are heavily in demand for practical drilling rather than research purposes. Usually research agencies do the specialized reconnaissance and pumping tests. This is expensive, slow, and the information often does not return to the local staff.

As a result many of the techniques used to estimate aquifer behavior and water yields are now widely criticized. They make heavy use of data which are easily accessible—such as climate and water levels—but make very little use of conventional aquifer parameters. The figures in use for aquifer parameters like transmissivity and storativity have often been derived through quite inventive (but unconventional) procedures.

Most of the hydrological data for groundwater management come from the following sources:

i) Procedures in the "norms for assessment" which are used to estimate the potential number of well developments in an area, for credit funding purposes.

ii) Procedures to help field staff and farmers select small agricultural pumpsets and well diameters, usually in relation to "design flows" for particular cropping patterns.

iii) Hydrological data from the drilling of borewells, often furnished by contractors.

iv) Data from remote sensing.

v) Geophysical logging data for the siting of wells.

The known weaknesses of calculation procedures (i) and (ii), and the difficulties of obtaining more accurate estimates of parameters through conventional pumping tests, are some of the reasons why remote sensing and geophysical logging are increasing in popularity with groundwater data organizations. These techniques allow the compilation of maps and local groundwater profiles which permit local staff to respond more quickly to administrators and the public. Maps can be compiled relatively easily from satellite data and existing hydrological data, and local hydrological conditions are "ground truthed" by studies from available pumping data rather than specialized tests. The measurement known as the "specific capacity" of a well[12] has

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12 Liters per second that can be pumped per meter of water level drawdown in a well; not to be confused with the aquifer parameter known as "specific yield."

been uniquely important in the mapping of Indian groundwater resources, and the techniques for its calculation have helped determine many of the current "spacing norms" on well development. However, the technique is only in existence because of the pressures to disseminate pumps, and the lack of options for more sophisticated and detailed measurements.

While some additional data collection will be needed for improved planning, the real issue is to raise public debate and understanding, and put pressure on the production of useable results, both from existing and new data. Extensive collection of new data will not necessarily overcome these data gaps, nor will such work necessarily return to the public domain where it can be accessed by farmers and local administrators. Thus, although the weaknesses of existing techniques are known, it may be more relevant to do some serious overhaul and study on existing data bases, especially as this would help to explain some of the mistakes that have been made in borewell installations and pump recommendations. Such studies would also bring new understanding into circulation quite quickly, whereas extensive development of new pumping tests will be expensive and time consuming.

Local staff are the best people for such work, as they know the local areas, the foibles of local equipment and something of the history of pumping tests and calculations performed by their colleagues. Centralizing information for more complicated modeling may produce some additional information on resource availability, but it will not provide information easily understandable by farmers and local government officials, nor to the local geohydrologists who have to face the farmers. Ironically, information in regional centers is sometimes more easily accessed by powerful interests, whereas the direction of flow of information is much more open in local offices.

While farmers do want to know if there are options for their region to develop more groundwater, they really want to know about the security of their existing well investments, and their likelihood of attaining adequate water yields to cover their costs from crop production. Data mobilization initiatives to support farmers are likely to have a different organizational framework between tubewells and dugwells, with differing impact on broader FMIS initiatives in improving performance and cost recovery, and turning over projects to farmers.

For public borewells, the quality of information on groundwater yields and its variability has strong implications for initiatives to improve performance. However, the participation procedures in design and implementation now widely practiced in surface FMIS may be difficult to use in the hard rock areas, because of the extent of technical problems and shortfall of water required. The current systems of drilling and logging, often provided by contractors, means that little reliable information is available to estimate the number of beneficiaries from a well and the pumping regimes which will be possible. The actual areas that can be served may often fail to encompass entire communities.

Time lapses of two years or more may take place before the well is energized, leaving villagers uncertain of developments. Subsequent additional pumping tests to estimate equipment needs are common. As engineers still use quite crude estimates of "design flows" for various crops, their guidelines to farmers on crop options are still weak. They can rarely predict the variability in water yields across the year which is almost invariably present in sedimentary and metamorphic rocks in South India. Most seriously, there are often problems in the installation of well-casing and pumps, reducing yields and creating operational difficulties. However, in improving procedures of technology delivery, additional thought must be given to manpower and transport for dissemination, as existing resources are overstretched in many state agencies. Any social organizers and trainers to promote groundwater FMIS face more technical challenges in reforming groundwater delivery than with gravity schemes.

The large community of farmers dependent on individual dugwells and borewells equally face some special data needs, and need new initiatives to provide this data. In South India, field officers in data collection organizations are a more appropriate base for advisory services.

However, there has to be much more effective liaison between these field officers and rural development officials, as well as farmers. Farmers want to know where to locate a well, the type of wells and in-well bores it is worth developing, the likelihood of finding good quality water, and the right kind of pumps to install. This can improve their dialogue with contractors and bank officials. They do not need detailed guidelines, but ideas on the problems likely when excavating wells and installing and operating pumps. They need to know what information is available from public agencies, what can come from contractors, and what they can simply get from other farmers. They also need help and advice on the likely water regime across the year, on the effects of heavy pumping both on their own well sites and on their neighbors, and perhaps a study initiative to promote exchange of information.

It is also necessary to examine the pumps and motors available on the market, to see if these exacerbate overpumping on small holdings, and are really suited to prevailing hydrology. The range of capacities of pumps and motors is quite limited, and in the past has been strongly influenced by the state agro-industry corporations who manufactured and distributed pumps in some states, and also by credit and subsidy policies which were based on certain types of pumps and motors.

Equally, more relevant information should flow regularly to local administrators involved with approving and assisting groundwater development. This includes information on the pattern and extent of well development and pump usage, and the effects of subsidized electricity consumption. Unfortunately, such information is unlikely to be exchanged if farmers think their developments will be seen as illegal and stopped (or taxed), and some thought has to be given on how to make information flow better between different groups.

What is really necessary, however, is a framework of controls or incentives for groundwater management that is both understood and seen as equitable, both by different kinds of farmers and well owners, and between different water users. This requires recognition that not only are current controls unworkable and based on dubious assumptions, but they are actually inappropriate to improved groundwater management. Institutional objectives must change in order to achieve sustainable groundwater use. Allowing farmers to participate in prioritizing institutional objectives for groundwater development as well as in the design of structures to undertake management tasks will be the first step in the right direction.