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A Survey on Ground Water on Business Economics

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Abstract

Stagnating agriculture and consequent failure of rapid economic growth to bring about poverty reduction as envisaged have been major constraints for India's economic growth. Contrary to the view that slow-down in public investment for irrigation development is mainly responsible for the deceleration of agricultural growth, the paper argues that in spite of the Government initiatives and substantial investments in irrigation development, the area irrigated by public irrigation systems in India has stagnated or even declined. India's irrigation economy has been undergoing a dramatic transformation with the control of irrigation shifting from the government to the individual farmers through millions of wells owned and operated by them. Though the booming tube well irrigation has generated substantial socio-ecological dividends in terms of flood mitigation and reduction in water logging and soil Stalinization, it has also been responsible for resource depletion and contamination of ground water in some parts of the country, leading to various adverse environmental and socio-economic consequences. There is need for achieving the right balance between supply and demand side measures for forging a sustainable ground water governance regime. Problems of groundwater overexploitation in India are bound to become more acute and widespread in the years to come unless corrective mechanisms are put in place before the problem becomes insolvable or not worth solving. Lack of information and absence of systematic monitoring of availability and withdrawal of ground water is a major barrier that prevents the transition from groundwater development to management mode. Further, unlike in the case of surface water irrigation systems, public agencies have only an indirect *role to play in the national ground water sector due to its development mostly in the private, 'informal' sector and the quality and amount of application of science and management to this sector has been much less when compared to the former.*

Keywords:*Ground Water, Business Economics, Agriculture, Consequent Failure, Economic Growth*

INTRODUCTION

Stagnating agriculture has emerged, during recent years, as a speed breaker in India's otherwise splendid and enviable growth story. The failure of rapid economic growth to bring about poverty reduction in commensurate manner is also another major concern linked with stagnant agriculture. It has been widely thought that the slowdown in public investment in agriculture, mainly irrigation development, is the main culprit behind the deceleration in agricultural growth. Government of India's Accelerated Irrigation Benefits Programme (AIBP) was conceived of as a response to the plea for increased public investment in irrigation. In recent budgets, the Union Finance Minister has been laying great stress on completing the "last mile irrigation projects" to step up the pace of irrigation development. Despite these initiatives, the area irrigated by public irrigation systems in India has stagnated, even declined (Shah 2009) . In this paper, I want to argue that irrigation in India is in the throes of a major transition. The irrigation business model that India has followed since early decades of 19thcentury has rapidly changed in recent years, and public policies based on colonial model of irrigation development are no longer in sync with new developments in Indian agriculture, which has come to depend heavily on groundwater irrigation by boreholes and pumps. Neither the goals of India's irrigation policy nor our irrigation development strategy jives with the reality of our irrigation economy today. This transition has created a wholly new challenge of balancing food security and agrarian livelihoods on one hand and sustaining groundwater aquifers under stress. It brings into play a new socio-ecological dynamic that is best understood in the environmental economics framework. Irrigation statistics compiled by the Government of India underestimate the scale of India's irrigation economy which is booming like never before. Official estimates of the net irrigated area in India based on land use surveys is 57 M ha and the gross irrigated area is around 90 M ha. Other sources, however, suggest that there is great deal more irrigation going on in India. The most striking have been new estimates of global irrigated area based on remote sensing data published recently by the International Water Management Institute (IWMI). Based on the analysis of high resolution satellite imagery backed by extensive ground-truthing work, IWMI's estimate suggests that in 2004, India had 99 M ha of net irrigated area and 132 M ha of gross irrigated area. Both these estimates are over 50 percent higher than the official estimates. In fact, IWMI's estimates of irrigated area of today are nearest to what the government of India would like to achieve by 2020. Incredible as these new estimates may sound, recent rounds of national sample survey also suggests that India's irrigation economy may be considerably larger than reflected in the official estimates.

GROUNDWATER REVOLUTION

At the heart of the transformation that India's irrigation economy has been undergoing is the wresting, by millions of small farmers, of the initiative for irrigation development from the hands of the State. Under the model of irrigation development that India followed since the 1830's, the State has been the architect, entrepreneur, engineer and manager of irrigation systems. 'Command area' and 'duty' were the mantra of irrigation planning and management. The Government was the provider of irrigation and the farmer a passive recipient. In this model of unbalanced irrigation development, command areas were created near hydraulically opportune sites where reservoirs or weirs could be built and downstream areas could be 'commanded' by gravity flow. Farmers in the rest of the country were left to fend for themselves. Post-Independence, India followed much the same strategy for irrigation development that created pockets of prosperous command areas, leaving other parts to rain fed farming. By 1970, the population pressure on farm lands in many parts of India had become so inexorable that farmers everywhere felt compelled to work their small farm holdings twice, or even thrice every year. Population pressure on farm lands then flagged off India's tube well revolution. India—especially, in western and north-western parts-- had a centuries old tradition of irrigating with wells. Even in 1900, India had some 4 M ha under groundwater irrigation. At the time of independence, the areas irrigated by groundwater and surface water were evenly balanced. However, it was hardly expected by anybody that India would witness massive spread of tube well irrigation in the surface-water-abundant Ganga Brahmaputra basin or hard rock peninsular India. Such a pattern of irrigation development appeared wholly inconsistent with the country's hydro-geology. Equally inconsistent seemed to be large-scale groundwater irrigation in peninsular India with hard-rock aquifers that have poor infiltration and low storage; tanks have been considered ideal for capturing and storing rainwater for irrigation in these areas that comprise 65 percent of India's land-mass. At the onset of the 20th century, RC Dutt articulated the prevailing thinking about how irrigation should develop in different parts of India:"Every province in India has its distinct irrigation requirements. In the alluvial basins of the Ganges and the Indus the most suitable irrigation works are canals from these rivers; while away from the rivers, wells are the most suitable. In Bengal with its copious rainfall, shallow ponds are the most suitable works and these were the numerous in the olden times, sometimes of very large dimensions. In Madras and Southern India, where the soil is undulating and the underlying rock retains the water, the most suitable irrigation works are reservoirs made by putting up large embankments and thus impounding the water descending from hill slopes. Such were the old reservoirs of Madras." (Dutt 1989, vol. II, p 119, footnote 1). This thinking was endorsed 70 years later by the second Irrigation Commission. For millennia, irrigation in India had remained largely faithful to this dictum. Adaptive, minimalist, unobtrusive irrigation in India of 1800 was a reflection of this hydro-geologic make up of the sub-continental terrain. Constructive imperialism pioneered by Arthur Cotton in the south and ProbyCautley in the north took liberties with this ideal scheme. However, come 1970's, and this age-old wisdom lay in tatters as a new era of atomistic irrigation unfolded and engulfed India nay, all of South Asia-- with small-pump irrigation spreading everywhere like wildfire in canal commands and outside, in arid, semi-arid and humid areas, upstream and downstream of river basins, in excellent alluvial aquifers as well as in poor, hard rock peninsular aquifers with limited storage potential. If the era of 'constructive imperialism' began tinkering with the hydrology of river basins, the recent era of atomistic irrigation with small wells and tube wells went about reconfiguring it totally. The rise of groundwater irrigation also transformed the organization of irrigation at the local level. In pre-Colonial India, co-operation at the community level was the dominant irrigation institution. Under the colonial rule, collaboration between the State and the engineering profession was at the centre-stage of centralized, bureaucratic irrigation development and management. In this new era of atomistic irrigation, the State as well as science became onlookers in a ballgame whose rules and logic they did not understand, much less dictate. In an incipient atomistic irrigation economy of the 1980's and later, neither the State nor the community was the entrepreneur, builder, or the manager of irrigation; it was the multitude of small-holders--Marx's 'millions of disconnected production units'--each with his tiny, captive irrigation system, ostensibly unconnected with the rest. Until now, crops had to wait for water to be released and flow through a network of canals before getting irrigated; now, water was scavenged on-demand and applied just-in-time when crops needed it most. Between 1960 and 1985, India invested in irrigation projects many times more capital in real terms than the British had invested during the entire 110 year period between 1830 and 1940. Yet, even according to the government of India's figures, over 60 percent of irrigated areas are today served by groundwater. Other indicators suggest even this may be a serious underestimate. Remote sensing data as well as national sample survey suggest that as much as 75-80 percent of India's irrigated area today is served by groundwater wells. Until 1960, Indian farmers owned just a few tens of thousands of mechanical pumps using diesel or electricity to pump water; today India has over 20 million modern water extraction structures. Every fourth cultivator household has a tube well; and two of the remaining three use purchased irrigation service supplied by tube well owners (Shah 2008, forthcoming).

SOCIO ECONOMIC SIGNIFICANCE AND IMPACTS OF THE GROUNDWATER BOOM

The groundwater boom is a sub-continental phenomenon that has encompassed, besides India, arid regions of Pakistan Punjab and Sind which boast of the world's largest continuous surface irrigation system and the humid Bangladesh and terai areas of Nepal. In these predominantly agrarian regions, the booming groundwater economies have assumed growing significance from Viewpoints of livelihoods and food security; however, their significance as engines of rural and regional economic growth has remained under studied. There are several ways to consider the scale of the groundwater economy; but one practical measure is the economic value of the groundwater production. An unpublished report for USAID in the early 1990's placed the contribution of groundwater irrigation to India's GDP at around 10 percent (Daines and Pawar, 1987); if that proportion held now, the size of the groundwater irrigation economy of India would be some US $ 75-80 billion. In table 1 below, we attempt a rough estimation of the market value of groundwater use in the Indian sub-continent. India, Pakistan, Bangladesh have active markets in pump irrigation service in which tube well owners sell groundwater irrigation to their neighbours at a price that exceeds their marginal cost of pumping. This price offers a market valuation of groundwater use in irrigation. We use available estimates of the number of irrigation wells and estimates from sample surveys on average yield of wells and annual hours of operation of irrigation tube wells in the countries covered. In India, for instance, a large number of farmers paid their neighbouring bore well owners US $ 0.04/m3 for purchased groundwater irrigation around 20003; applying this price to the annual groundwater use of say 200 billion m3 gives us US $ 8 billion as the economic value of groundwater used in Indian agriculture/year. For the Indian sub continent, the corresponding estimate is around 10 billion US dollars. In many parts of water-scarce India, water buyers commonly enter into pump irrigation contracts offering as much as 1/3rd crop share to irrigation service provider; in water abundant areas, in contrast, purchased pump irrigation cost amounts generally to 15-18 percent of the gross value of output it supports. This can be used to draw the general inference that the agricultural output that groundwater irrigation supports is 4-5 times its market value.

Table 1 - Proximate size of the Agricultural Groundwater Economy of South Asia (c. 2001-02)

		India	Pakistan Punjab	Bangla-desh	Nepal Terai
A	# of wells (million)	21	0.5	0.8	0.06
B	Average output/well (m3/hr)	25-27	100	30	30
C	Average hours of operation / well / year	360	1090	1300	205
D	Price of pump irrigation (US $/hr)	1-1.1	2	1.5	1.5
E	Groundwater used (km3)	189-204	54.5	31.2	0.37
F	Value of groundwater used/year in billion US $	7.6-8.3	1.1	1.6	0.02

Explosive growth in shallow tube wells and small pumps has democratized Indian irrigation much like personal computers have democratized computing globally. By the same token, large canal irrigation systems are heading towards the future that mainframe computers are facing. Boreholes and small pumps took irrigation away from command areas to the nook and corner of the country.

SUSTAINING THE GROUNDWATER BOOM

Nothing is an unmixed blessing; and this is true about South Asia's pump irrigation revolution since 1970's which has been a prominent target of doomsday prophecies about an impending socio-ecological disaster (see, e.g., Seckleret al.1999; Postel 1999; Vaidyanathan 1996). There is much truth in this concern; however, tube well irrigation has generated substantial socio-ecological dividends as well. In flood prone eastern India, it has helped mitigate the rapacity of floods and water logging by reducing 'rejected recharge' by creating more storage in the aquifers. In the Indus basin too, tube well irrigation has reduced water logging and salinization, a task which would have taken hundreds of million dollars of investments in drainage.

Groundwater horror stories of India are however becoming increasingly frightening in arid alluvial and hard-rock aquifers. In some coastal plains along with arid alluvial plains facing overdraft, the central resource governance challenge is coping with salinization and depletion which, in a chronic form already visible in some parts, may seal the fate of agriculture, and of human settlement itself. Then, in hard rock areas of peninsular India, where tube well irrigation expansion is way out of proportion to the limited storage offered by aquifers, resource depletion is a serious issue in itself but has also aided growing concentration of fluoride and other salts in groundwater which is the main source of drinking water supply for rural as well as urban populations. Problems of geogenic contamination of groundwater such as with arsenic in eastern Ganga basin and fluoride in much western and peninsular India are large and serious. The causal role of pump irrigation in mobilizing fluoride and other salts in groundwater is clearer than in arsenic contamination whose chemistry is still tenuous and disputed.

A few years ago, David Seckler wrote alarmingly that a quarter of India's food harvest is at risk if she fails to manage her groundwater properly. Many people today think that Seckler's may well have been an underestimate; and that if India does not take charge of her groundwater, its agricultural economy may crash. Sandra Postel (1999) has suggested that some 10 percent of the world's food production depends on overdraft of groundwater to the extent of 200 km3; most likely, 100 km3 out of this occurs in Western India. Conditions in North China plains they are no better. In the lower Indus basin in Pakistan and the Bhakra system in Northern India, groundwater depletion is not a problem but soil and groundwater salinization is. IWMI's past research to understand the dynamics of groundwater socio-ecologies indicates some recurring patterns.

ENVIRONMENTAL ECONOMICS OF AQUIFERS AND INSTITUTIONAL RESPONSE

Groundwater modeling is the playing field for hydro-geologists. These have developed a rather formidable repertoire of models that analyze the complex behavior of aquifers in response to development. However, in a region like South Asia where millions of smallholders directly interfere with the aquifer processes without let or hindrance, we have little understanding of how users respond to its development, and in due course, its depletion or deterioration. Developing such understanding is an important area of work for environmental economists. How do India's groundwater users relate to aquifer development? How do they respond, as individuals and as a collectivity sharing a portion of an aquifer, to groundwater depletion or quality deterioration? When do they choose to cooperate and when to compete? Do they actually choose? Or are they impelled to behave in a certain way by natural processes they are confronted with? Are there situations in which they find it easier than in others to co-operate for the greater common good? These, and many other such questions, are crucial for us to explore but require a marriage of hydro-geology and social sciences such as economics, political science, and sociology. Much hydro-geology is about the impact of human intervention on aquifer behavior. But environmental economics also needs to explore the impact of aquifer conditions on human behavior, especially, the behavioral response of people living off it. By institutional response, I mean the central behavioral tendencies of groundwater irrigators and the social dynamic that results from different aquifer conditions. In keeping with Veblen (1934), the original institution a list, I treat institutions as 'settled habits of thought common to the generality of men'. An average groundwater user in India has little or no formal knowledge of hydro-geology. Buts/he certainly has ideas and even theories about how it all works underneath the earth's crust (Rosin 1993; Shah 2000). A lot of these popular theories will not withstand scientific scrutiny; yet, farmers' decisions and actions are guided by their theories more than by formal science. One way to think about how farmers form their theories is by referring to what economist John Muth (1961) called rational expectations which help people formulate their view of the future state of things. Rational expectations are to be distinguished from adaptive expectations, which see the future as little more than a mechanical reproduction of the past. The rational expectations model suggests that people take into account all the information available to them including the expectations of others they regard highly to arrive at an expectation which differs from the actual only by a random error (Muth 1961; Sargent 20025). When the behavior of most or all agents is shaped by such rational expectations, self-fulfilling prophecies abound. If majority customers expect a bank to fail, and begin a run on it, a small bank may actually fail. If most traders expect stock prices to rise, and start buying in that expectation, the market will actually skyrocket even when fundamentals suggest no reason for it to. Likewise, the expectations people living on or off an aquifer have about where it is headed in response to development or conservation shape their individual or collective behavior towards it and towards the 'aquifer community'.

IN SEARCH OF SUSTAINABILITY

In thinking about forging a sustainable groundwater governance regime, the emerging global consensus is for achieving the right balance between supply and demand side measures. Governments can meet groundwater depletion in a locale by investing in recharge and/or water imports. However, without effective demand-side measures, increased supply will quickly invite increased abstraction, leaving the resource depleted. In creating demand management regimes, four sets of ideas have been tried worldwide: direct regulation, economic instruments, tradable property rights, community resource management. These are reviewed briefly; but the interesting upshot of this discussion is that throughout the world, groundwater governance is still work in progress.

i. Direct regulation through administrative action-

State claiming eminent domain and using the administrative apparatus of the government to regulate groundwater abstraction dominates the GwG regime in many countries, notably the Sultanate of Oman, Iran, Saudi Arabia, Israel and of course the western United States. In South Asia too, groundwater departments in most Indian states as well as Bangladesh have norms for siting irrigation wells and the minimum spacing to be maintained to minimize well-interference externalities. India has a draft groundwater law tossing around now for over 30 years; several state governments have passed groundwater laws providing regulatory powers (Planning Commission 2007). The regulatory effectiveness of these however has remained limited for a variety of reasons, the chief being the lack of popular support, political will and enforcement capacity commensurate with the enforcement challenge.

ii. Economic Instruments-

Economic instruments are attractive because they can influence the behavior of numerous economic agents without having to coerce or invoke eminent domain. Using a price or a Pigovian tax or cess is basic economic instrument to signal scarcity value. The problem in pricing groundwater is often the high transaction costs of metering, monitoring and charge collection; as a result, pricing is effectively used when it can be levied on bulk users or service providers who can transmit the 'price signals' onward to users. In Western United States, 'pump tax', generally higher for industries than for agricultural users, was widely used to control groundwater overdraft (Turral 1998). In China, water pricing for cost recovery as well as demand management in Cities has worked because municipalities collect them from a handful of water service providing companies; however, collecting water withdrawal fees, provided by the 1995 Water Law, from millions of scattered agricultural tube well owners has proved far more challenging (Shah et al. 2004a). In her new Law of the Nation's Waters, Mexico, like China, has provided water resource Fees besides service charges to be levied on all users including irrigators.. However, like with China, Mexico too has found its implementation difficult (Shah et al. 2004b).The best known case of water pricing for agricultural use is Israel where all irrigation diversion and delivery points are metered and closely monitored (Feitelson 2006). Jordan has introduced a groundwater abstraction charge for industrial users; but its extension to agriculture invited much resistance.Jordan had to use force in installing meters on deep tube wells and create'quasi water police' to enforce pumping quotas (World Bank and the Swiss Agency for Development Co-operation 2000).

iii. Tradable Property Rights-

The conceptual foundation of the tradable property right discussion rests on the premise that under open access, groundwater resource would always be open to depletion and degradation. One road to sustainable resource management is of creating enforceable private property rights, preferably tradable. Tradable water rights modify the outlook of the users as well as third-parties about externalities, leading to more efficient allocation though not necessarily conservation of the resource. The historical foundation of tradable rights, however, rests in the history of European settlements in the New World, where secure property rights were essential to attract settlers to make private investments in land and water development. The idea of the groundwater governance regimes in the US and Australia then rests on the worldview that users can evolve mechanisms for self-governance of the resource with the state providing an overarching regulatory and facilitative framework. The actual experience with such collective self-governance is a matter of much debate even within these countries; however, their experience has given birth to a growth industry for promoting tradable water rights as a one-stop solution to groundwater mal-governance. Virtues of tradable property rights are widely advertised and commended (Rosegrant and Gazmuri 1994). The outcome of an innovative project of introducing tradable water rights in Chile has been vigorously lauded (ibid) as well as roundly criticized (Bauer 2004; Boelens and Bustamante 2005; GWP, 2006).

iv. Community Aquifer Management-

In evolving their groundwater governance regimes, Mexico and Spain have adapted the US experience of tradable water rights and Groundwater Management Districts. The underlying premise somewhat along the Coasean logic is that if groundwater users are organized around aquifers for self-governance, they will internalize third-party externalities through bargaining and negotiation, collectively monitor the behaviour of groundwater as well as its abstracters, and ensure the long term sustainability of both. A more practical consideration was to use groundwater associations as agents in monitoring and enforcement of government policies and laws. The idea of groundwater organizations has a wide appeal; it was advocated to India by a British Geological Survey study (BGS 2004). And in south India, the FAO supported Andhra Pradesh Farmer Managed Groundwater Systems Project has organized groundwater users in

650 habitations in 66 hydrological units (Knegt and Vincent. 2001). Spain and Mexico have however embraced groundwater organizations as key element of their official national water governance strategy.

TRANSITION NEEDED: FROM RESOURCE DEVELOPMENT TO MANAGEMENT MODE

In the business-as-usual scenario, problems of groundwater over-exploitation in India will only become more acute, widespread, serious and visible in the years to come. The frontline challenge is not just supply-side innovations but to put in to operation a range of corrective mechanisms before the problem becomes either insolvable or not worth solving. This involves a transition from resource 'development' to resource 'management' mode (Moench 1994). Throughout Asia where symptoms of over-exploitation are all too clear groundwater administration still operates in the 'development' mode, treating water availability to be unlimited, and directing their energies on enhancing groundwater production. A major barrier that prevents transition from the groundwater development to management mode is lack of information. Many countries with severe groundwater depletion problems do not have any idea of how much groundwater occurs, and who withdraws how much groundwater and where. Indeed, even in European countries where groundwater is important in all uses, there is no systematic monitoring of groundwater occurrence and draft (Hernandez-Mora et al. 1999). Moreover, compared to reservoirs and canal systems, the amount and quality of application of science and management to national groundwater sectors has been far less primarily because unlike the former, groundwater is in the private, 'informal' sector, with public agencies playing only an indirect role.

CONCLUSION

As demand for water increases, water managers and planners need to look widely for ways to improve water management and augment water supplies. The Committee on Ground Water Recharge concludes that artificial recharge can be one option in an integrated strategy to optimize total water resource management, and it believes that with pretreatment, soil-aquifer treatment, and post treatment as appropriate for the source and site, impaired-quality water can be used as a source for artificial recharge of ground water aquifers. Artificial recharge using source waters of impaired quality is a sound option where recharge in intended to control saltwater intrusion, reduce land subsidence, maintain stream base flows, or similar in-ground functions. It is particularly well suited for non potable purposes, such as landscape irrigation, because health risks are minimal and public acceptance is high. Where the recharged water is to be used for potable purposes, the health risks and uncertainties are greater. In the past, the development of potable supplies has been guided by the principle that water supply should be taken from the most desirable source feasible, and the rationale for this dictate remains valid. Thus, although indirect potable reuse occurs throughout the nation and world wherever treated wastewater is discharged into a water course or underground and withdrawn downstream or down gradient for potable purposes, such sources are in general less desirable than using a higher quality source for potable purposes. However, when higher-quality, economically feasible sources are unavailable or insufficient, artificially recharged ground water may be an alternative for potable use.

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