The role of Participatory Hydrological Monitoring in Groundwater Governance: Towards Evolving Informed Adaptative Mechanisms

R. Ravindranath[1] and Varun Sharma[2]

Abstract

Groundwater issues have become prominent since last three decades due to the erratic rainfall pattern, irregular supply of surface water flows and growing demand for agriculture, industries and for other domestic requirements. Alongside many basins are already closed or on the verge of closure. With increasing scarcity of water, Groundwater has become all the more important for the agriculture and for the livelihoods of the people. Consequently, the stress on groundwater has been increasing tremendously and it has been over exploited in the last couple of decades, which lead to the deterioration of the water table at an alarming rate and causing environmental hazards in some places. Semi arid regions are the worst affected due to the deepening of water levels in wells.

Many localized initiatives have been launched to address water scarcity; however, these developmental programmers are improving situation at local level without the perspective of basin flows at a larger level, thus leading to upstream and downstream conflicts sometime within a village or community due to the slag in supply and demand status of the resource. The problem of course, is that groundwater has been not treated as a common pool resource. This is compounded by the fact that there is also a lack of knowledge on base flows, which depend on the aquifer properties rather than on the administrative divisions, and some times the flows could be across villages, tehsils, districts and even countries like surface water.

In order to address these issues much technological advancement happened in the last two decades in understanding the hydrological aspects of the resources. However, it would have no value unless these innovations are practiced. Community could only adopt these technologies only if these are robust and user friendly. Government and non-government organizations have initiated a few attempts. At the outset, the participatory hydrological monitoring is a good solution to curb the groundwater depletion and managing the resources in a sustainable manner.

This paper talks about the management of groundwater resources by communities adopting various regulatory mechanisms and assessing the status of the resources with robust methods and utilizing the resources more sustainable across community.

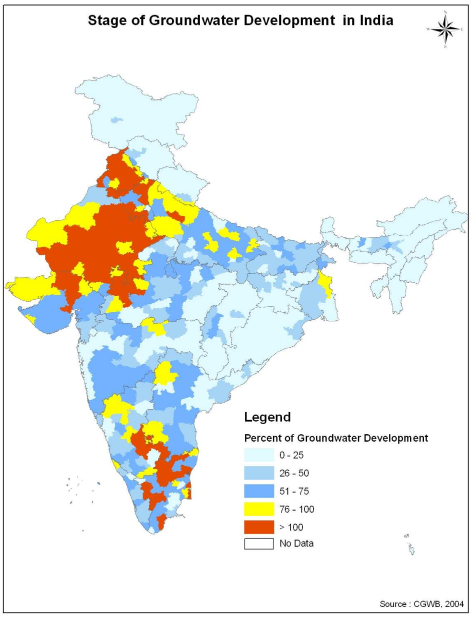
Key words: *Groundwater governance, participatory hydrological Monitoring, Community*

[1] Manager, GIS Cell, Foundation for Ecological Security (FES), Anand
[2] Project Officer, Project Support Group, Foundation for Ecological Security (FES), Anand

1. Introduction: Groundwater Scenario

Aquifer exploitation and groundwater mining is being reported from all parts of the world today. Despite the broad acceptance of Bruntdland Report (1987) and its recognition on various important meetings we are witnessing the exercise and operation of water management practices that have little concern for rapidly depleting groundwater reserves [Stavric 2004]. This is not surprising since groundwater has become an indispensable resource for meeting both rural and urban needs [Kumar 2007, Kulkarni 2008]. Dependence on groundwater has greatly increased owing to the improper management of surface water, faulty conservation practices and rapid growth of population. The Kyoto protocol attributes the wide spread degradation of aquifers to "excessive resource development, uncontrollable urban and industrial discharge, and agricultural intensification".

In India as well, there has been an exponential increase in the number of structures used for groundwater extraction. Agriculture is by far the largest user followed by industrial purposes and then domestic utilities. Groundwater provides 80 percent of water for domestic use in rural areas and about 50 percent of water for urban and industrial areas. There are more than 17 million wells all over the country that are providing irrigation water to more than 50% of the irrigated area. The GoI estimates that out of 5723 numbers of administrative units (blocks/ taluks/ mandals of districts) assessed, 839 units are over exploited, 226 are critical, 550 units are semi critical and 30 units are saline. Excessive withdrawal of groundwater from deep aquifers has resulted in issues such as the drying up of open wells, accentuation of drought like conditions, diminished water quality, social inequities and even rural indebtedness.



It is argued that groundwater is an effective means of alleviating poverty; but benefits are in no case absolute and returns from groundwater irrigation have to be weighed against other alternatives. Custodio (2000) is able to explain the accompanied complexities in managing groundwater and assessing aquifer over exploitation. He claims that groundwater exploitation figures in a dynamic matrix comprising of hydrogeological, hydrodynamic, economic, social and ethical elements. Considering both the magnitude and complexity of the problem at hand, the need for a model that is both replicable and practicable is commonly felt. In recent times participatory hydrological monitoring is being looked upon as a suitable alternative. Even though hydrogeology may simplistically be explained as the science of groundwater that helps to build a correct understanding of aquifers [Kulkarni 2008], it is with people's involvement that it becomes adaptable and contextually suited to local conservation efforts. The current paper is an attempt to explain the manner in which the science of hydrogeology can be applied through community-based institutions. The paper presents the theoretical grounding for participatory hydrological monitoring and some basic challenges to be faced in this regard; it also seeks to present local institutional efforts that bear with them the promise of being able to counter the dilemma at hand.

Participatory Hydrological Monitoring in Theory

Participatory hydrological monitoring draws heavily from theories on Participation. Participation is defined as a process through which primary stakeholders influence and share control of the development initiatives, decisions and resources [Tandon and Corderio 1998]. In this regard Paranjape [2008] explains that participative governance in the water sector requires a common agreement on the assessment of a resource and a discussion of how different stakeholders will utilize it. This requires for institutional reforms that can fully incorporate the ideas and indigenous knowledge of local groundwater users. Since local knowledge has the innate capacity to energize collective action for the conservation of groundwater resources [Krishnan, 2007], it is absolutely essential to mainstream local knowledge and centre stage local users as part of monitoring intervention. Local knowledge is no less valuable and the narratives on Dying Wisdom [CSE 2001] shown that the design and principle of several traditional water harvesting structures are based on an innate understanding of local hydrogeology. Similarly Shah [1993] has been able to highlight a case from Junagadh (Gujarat) where farmers had succeeded in conceptualising their local groundwater hydrology through observations made during water pumping. Most of all Participation in hydrological monitoring ensures the articulation of rules and regulations that are contextually apt, and more likely to be followed; it also invigorates collective action in a manner that it becomes possible to influence macro environment factors (policy, market forces etc.) and related externalities.

Participatory hydrological monitoring has just as much to gain from the discourse on Common Property Resources. In theory, there are two aspects that characterize a Common Property resource - the resource stock and the resource units [Ostrom 1976]. While resource units are subject to private ownership and assist in extraction, the resource stock is jointly accessed by all users. This applies in the case of groundwater as well; where the aquifer is clearly the resource stock, and quantity of water withdrawn or the numbers of extraction devices are the resource units. In this sense resource units, which are most often under private ownership (for example pumps), are a more distinguishable, manageable quantity; on the other hand the resource stock or the aquifer is less easily identifiable or manageable – and this is more so in the case of groundwater which often described as being 'fugitive' or 'invisible'. Groundwater is found to be prone to both appropriation and provision problems. Appropriation problems occur when the crowding of tube wells adversely impacts the productivity of units accessing the same aquifer. Appropriation problems are highly local in nature and occur when a CPR is over exploited in a short span of time. On the other hand provision problems are concerned with recovering or rehabilitating the productive capacity of a given CPR. Provision problems basically refer to the hurdles to be encountered in mitigating the adverse affects of groundwater over-exploitation.

The practical utility of the CPR theory lies in providing a conceptual framework for understanding the inherent linkages between both, the resource stock and the units; since the economic efficiency of groundwater abstraction is, in the long run, determined by the extent to which the resource stock is recharged and conserved [3]. In this regard the second design Principle as articulated by Ostrom provides conceptual direction for groundwater governance by stressing the need to correlate appropriation rules with local conditions and provision rules.

Challenges for Participatory Hydrological Monitoring

The difficulty in evolving appropriation and provision rules for effective groundwater governance lies in the fact that the resource, on account of its ubiquitous nature, is not as amenable to farmer-based governance as in the case of surface water sources. Unlike surface water sources, groundwater reserves are not available to mutual monitoring [Rose 2002]. It is not as easy for one farmer to observe the resource related activity of another, just as it is with surface water resources, where the purpose, duration, period and extent of use are more easily ascertainable and available to ocular estimation. Schlager [2007], is able to capture the dilemma by elaborating that:

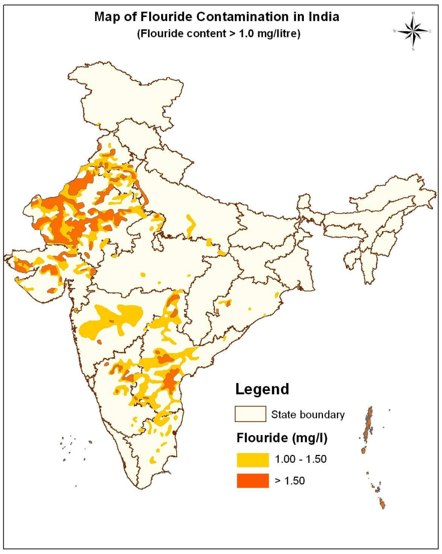
> "Unlike surface irrigation systems in which, through experience, observation and experimentation, the boundaries, capacity and variability of the system may be determined by the irrigators, groundwater pumpers may never grasp the boundaries, structure or capacity of the 'invisible resource' …"

Groundwater development in India is further accompanied with stark inequities. Small and marginal farmers, the landless who have nothing but encroachments to their tally, and even tenants undertaking agriculture on lease basis are unable to benefit as comfortably from groundwater reserves. This is mainly because their landholdings are either too small or fragmented to justify investments in groundwater or they are not able to avail credit assistance. Further, the inequity perpetuated by artificial recharge measures is often overlooked. It is a little hard to believe that artificial recharge will result in equity when undertaken "in the water scarcity hilly areas", as per the National Perspective Plan prepared by the Central Ground Water Board (CGWB) in 1996. It is well known that farmers in the downstream discharge zones reap the benefits of intervention undertaken by marginalized farmers in ridge portions. In such a scenario it remains a challenge for participatory hydrological monitoring to ensure equity in terms of benefits derived and opportunities offered.

[3] Inability to perceive and respect the inter relationship between resource stock (aquifer conditions/quantities) and units (abstraction devices/ draft) results in 'open access' regimes [Hardin 1968]. Research indicates that aquifers, which are commonly perceived as open access regimes, are over exploited and quantities withdrawn are far greater than the optimum economic level [Dasgupta *et al* 1979].

Unintelligible measures undertaken by both government and non-government agencies fail to acknowledge the political nature of groundwater exploitation. Though promises of "free power" are instrumental in deciding the fate of elections, the emergent patterns of groundwater are ruinous [Narendranath et al 2005]. The politics of big dams impinges upon groundwater use patterns as well. Small and marginal farmers who are unable to benefit from Major and Medium sized Irrigation Projects are rarely left with any other alternative but to explore groundwater options. Similarly farmers who have succeeded in establishing access to deep aquifers within the command area (of a project or village tank) are found to care less for socio-institutional arrangements aiming to optimize surface water irrigation. Without giving the political and social character of the groundwater crisis a place in the analysis, it is nearly impossible to ensure the success of participative governance of groundwater.

Closely associated is the economic dimension. Here it is found that the cost of groundwater abstraction is not a simplistic function of depth to water table alone, as often perceived [Kumar 2007]. Among a host of other factors, technology and information availability play a key role in determining the economics of groundwater production. Rural groundwater markets can no longer be ignored and are said to have increased the capacity utilization and economic efficiency of private tube wells [Shah and Raju, 1988]. Cases are reported where groundwater markets have benefited small and marginal farmers, who otherwise have been unable to invest in tube wells of their own account. Nevertheless the role of groundwater markets in deciding relations of power; the prospect of market arrangements terminating in usurious patron-client relations and possibilities for over exploitation in each circumstance requires context specific considerations.



Similarly no institutional mechanisms prevail for regulating and managing groundwater, especially with regard to preventing the pollution of groundwater. This is a fact of much concern considering the radical decline in groundwater quality that is being witnessed in many parts of the country. Pollution of aquifers on account of over application of fertilizers and pesticides, disposal of industrial wastes and expulsion of urban sewage wastes into percolation bodies are sited as some of the common causes. High levels of arsenic and fluoride have been found in groundwater in a number of locations. As per the Manual on Artificial Recharge prepared by CGWB in 2007 an effort is required to determine the migration of pollution and measures for control of groundwater pollution (pp. 10). But the operation of such propositions and their longevity requires political will as much as institutional templates, which are both missing.

Accurate information for decision-making is rarely available. The theoretical criterion, in it self, adopted by official agencies, primarily the Ground water Estimation Committee (GEC 84) and the Ground water Resource Estimation Committee (GEC 97), for the assessment of groundwater development are inadequate for complex aquifer conditions. Despite improvements, owing to which flows and lateral flows are given due importance as part of applied methodologies, a number of regions that are suffering from well failures, drastic drops in water table levels, and reduction in well command are indicated as safe [Kumar, 2007]. But, whatever methods prevail it is found that they remain well beyond the grasp of local communities who are centre-staged for namesake as key stakeholders in pressing debates. It is found that most research is technocratic in nature with community members having little or no role to play.

Hydrological Monitoring and Collective Action

As elaborated above participatory hydrological monitoring does not only have deal with the invisible nature of groundwater, but also tackle social, economic and political realities. The greatest challenge however remains in being able to cohere community-based indigenous forms of knowledge with scientific quantitative analysis. The evolution of institutional frameworks requires community mobilization, framing of rules and norms and action on the basis of information generated using participatory methods

Localized initiatives in this regard deserve a mention. The Social Regulation of Groundwater at Community Level Project, initiated in 2004 in three villages of Andhra Pradesh by the Centre for World Solidarity (CWS) in noteworthy. The project covers 665 families in 3 villages in 3 districts of Andhra Pradesh. Farmers over here had started drilling bore wells in the early 1990s. As a result shallow open wells gradually began to dry up due to falling groundwater levels. Competition between neighbouring farmers often lea them to drill bore wells as close as 2 meters to one another. For instance, in Madirepally [v], Anantapur [Dist.] 3 neighbouring farmers were found to have undertaken 13 bore wells in an area of 0.5 acres in less than 4 years.

Project interventions began with a participatory assessment of the water resources in the 3 villages. Participatory Rural Appraisal (PRA) methods were used to map the resource status and existing water utilization patterns for different purposes: drinking, domestic, irrigation. Growth of groundwater-based irrigation and trends in groundwater levels were then placed in community level meetings. Groups of farmers were formed in all the project villages comprising of bore well owners and neighbouring farmers who did not own bore wells. Care was taken to include small farmers and those who had lost out as a result of aquifer over exploitation. Group members were encouraged to save water by adopting micro-irrigation kits (sprinklers) and sharing water from the existing wells rather than drilling new ones. Conditions were evolved for the equitable access of groundwater through existing bore wells and farmers were trained to monitor rainfall and groundwater levels of their own accord. Water levels in 10 selected bore wells and cropping patterns under each are still recorded every fortnight. Information related to various surface water structures, cropped area, open wells and bore wells is updated every year in a hydrological database and shared with others in gram sabhas (village meetings) and displayed on boards and village walls. By undertaking a demand and supply analysis farmers undertake cropping decisions with a view to collectively conserve groundwater and ensure its sustained availability. With Project assistance farmers have also undertaken measures to enhance groundwater recharge through appropriate watershed structures.

Results are clearly visible in Madirepally [v]. Measures adopted have ensured water for drinking and livestock purposes. Thirty-one individually owned bore wells (54 % of all functional bore wells) came under the water sharing system providing water access to 35 new farmers. Additionally, 47 farmers, earlier not part of the system, received water on an exceptional basis during the kharif of 2006 and succeeded in saving their crop from the reported drought during the year. Ninety-five acres of rain-fed lands were brought under protected irrigation by sharing water from bore wells using micro-irrigation systems during 2006. This corresponds to 48 % of the total well-irrigated area in the village. In terms of groundwater, extraction reduced from 121 % to 80 % of annual recharge over the three-year project time.

Local Geology and GIS based mapping

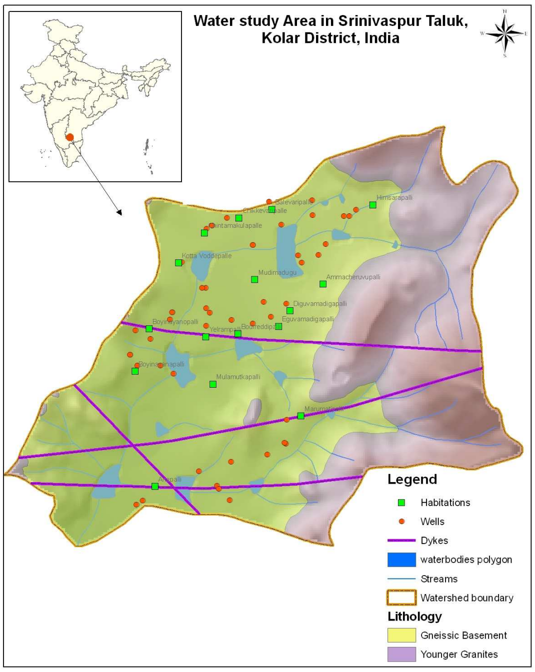
Many localized initiatives have been launched to address water scarcity; however, these developmental programmers are improving situation at local level without the perspective of basin flows at a larger level, thus leading to upstream and downstream conflicts sometime within a village or community due to the slag in supply and demand status of the resource. The problem of course, is that groundwater has been not treated as a common pool resource. This is compounded by the fact that there is also a lack of knowledge on base flows, which depend on the aquifer properties rather than on the administrative divisions, and some times the flows could be across villages, tehsils, districts and even countries like surface water.

In this regard the village tank of Appalammacerhuvu, Chittoor [Dist.], Andhra Pradesh, India forms for a typical case wherein the bund of a traditional village tank lies upon a dyke. The tank's command of 125 acres is crowded with more than 25 tube wells most of which are 400 feet in depth and seasonal in nature. Community members have undertaken small and disparate efforts to enhance groundwater recharge from the water spread (25 acres) to their tube wells. Unfortunately nothing has worked. Community members remain unaware that the standing dyke prevents lateral infiltration of any type from the water spread to the tube wells in the command (aycut). Several such cases persist in the hard rocks of south India, and even though farmers participate in localized initiatives they are not able to fully deduce meteorological and hydrogeological interrelationships.

It was in this direction that the Foundation for Ecological Security (FES) undertook a participatory hydrogeological assessment in two locations of the Papagni river basin in south India: Mudimadugu Panchayat, Kolar [Dist.] in Karnataka and Bandrevu Panchayat, Chittoor [Dist.] in Andhra Pradesh. The river Papagni is found to originate in

Karnataka, from where it traverses across the border to meet river Pennar in Andhra Pradesh. The place has monsoon type of tropical climate and receives an annual average rainfall of about 600mm. Uplands are comprised of the broken ranges of the Eastern Ghats and outcrops of the lower Vindhyan and Cuddapah systems. The Archaean or peninsular gneisses dominate the rock formations and consist of granites, grandiorites and banded gneisses.

With the assistance of local youth it became possible to identify the prominent dykes in the region, which were later mapped with the help of GIS based software. By mapping drainage systems, recharge-discharge zones and underground aquifers it became possible to generate visual material for dissemination at a wider scale. Today water budgeting is undertaken with complete and full information of the zones (sub catchments) created by the presence of dykes; and the specific geological characteristics of each zone. In Mudiamadugu, which has nearly 200 open wells and 20 tube wells, water budgeting reveals a scenario where the local demand exceeds supply by about 4.8 million cum units per anum. On the other hand in Bandrevu Panchayat where there are about 100 open wells and 15 tube wells supply proves to be the greater..



In this scientific rigor and applications have contributed to the development of a community owned database. As part of participatory methods farmers have been able to compare and relate their hydrogeological status with political, economic and social realities. In Mudimadugu farmers are found to be more affluent and willing to experiment with high-risk crops or horticultural varieties that demand a longer gestation period. This is so because the metropolitan town of Bangalore, located in close vicinity, offers good marketing opportunities and handsome prices for such crops. Access to latest technology and higher quality of rural electricity are other drivers. On the other hand Bandrevu Panchayat has relied upon traditional modes of cultivation and till date the village tank (Bandrevu cheruvu) continues to play a central role in supplementary irrigation. Even in the ridge portions farmers are found to rely on percolation bodies and small water harvesting structures for agriculture and livestock maintenance purposes. Quality of electricity is poor and local landlords act as central sanctioning authorities and solitary sources of credit. Since a large portion of lands are found to be under land lease arrangements, farmers are less inclined to make substantial investments in groundwater structures due to the lack of secure tenure. Thus hydrological monitoring has revealed a terrain where aquifer over exploitation is a function of ecological, economic and socio-political factors.

Integration of Local and Modern Scientific Knowledge

Data developed through formal scientific processes can contribute significantly to localized interventions, thereby highlighting those political-ecological elements critical to future intervention. A strategic factor in increasing levels of participation, ensuring the easy adoption of technologies and monitoring methods by communities, is the efficiency with which modern day science and local systems of knowledge can be made to cohere. The act of integrating local knowledge systems with scientific knowledge is appropriately described as a “tight rope walk”. Participative methods lack reasonably validated data and quantification is poor. In contrast scientific methods claim high precision, but are time consuming, require a lot more data than is generally available [Paranjape 2008]. Despite which it is conformed time and again that hydrological monitoring can successfully meet the objective of groundwater conservation only when channelled through communities and grounded in a participation ideologue.

In this regard a study undertaken by Sundarrajan Krishnan, Care Water INREM Foundation, Anand in Thoriyali Village of Jasdan Taluka in Rajkot district of Saurashtra, offers for a case where the local conceptualisation of prevailing hydrogeology nearly corresponds with the actual reality deciphered using modern scientific methods. By relying on information from an ingeniously selected sample comprising of well owners, well diggers, water diviners, drillers, blasters and rig owners, Krishnan has been able to present local understanding of different types of surface lineaments. In local parlance different aspects of the prevailing geology are referred to as Kahn, Adawan and Pad. Dykes and surface lineaments, that which are referred to as Kahns, were mapped with the participation of community representatives; and when maps developed using participatory techniques were overlaid on GIS based thematic maps provided by NRSA on 1:250,000 scale, stark similarities were rendered visible [Krishnan 2007].

Interactions in other pockets of basaltic Saurashtra (Gujarat) revealed collqual and wide spread familiarity with the concepts of Kahn, Adawan and Pad. On the basis of such observations Krishnan has been able to determine the decision making of local farmers to policy changes, cost of extraction, technology availability; and surmise that:

> “ Perhaps, this apparent duality between formal science and people’s science is just an illusion a product of our point of observation, and possibly both of these belong to the same process of societies’ program of knowledge generation”.

The integration of local knowledge with peoples’ knowledge requires for institutional platforms, that are so designed to mainstream indigenous sources of knowledge, to draw from scientific inputs where required and provide the primary stake holders with the opportunity to act independently on the basis of the understanding thus evolved.

Conclusion

This is not that simply accomplished. At times participation appears but a utopian concept, especially considering that relations of power, sociological stratification across castes are traditionally rooted and historically reinforced. Participation in an idealistic sense requires long durations of time, by when resources could already be exhausted. The challenge also remains to look beyond the confines of popular theory while acknowledging the common property nature of groundwater. It is required to move beyond a simplistic assumption of single use and care has to be exercised while relying on the assumption that collective management outcomes are determined by pre-defined (design) principles, thereby diverting attention from stake holder's imagination of collective resource management and the influence of contextual factors [Steins et al, 2000]. Also that in a global milieu that repeatedly affirms the virtues of private property and ownership, it less probable for communities, both urban and rural, to reflect upon the common property nature of groundwater resources.

But wherever such models have been applied it has ensured the longevity of institutions and implementation of norms since they are evolved by the very people who accept and/or enforce them. It makes research people friendly, helps synchronize modern scientific findings with local knowledge systems, negotiate groundwater rights and conflicting interests by attending to ecological issues alongside social and political aspects. In a time when most national and state level regulations are found to succumb to the existing trends in groundwater extraction, grass root mobilization through the agency of participative governance on groundwater provides for the required foundations for a more genuine policy advocacy.

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