Towards a Participatory Approach for Groundwater Management

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I. Background

At the 13th Biennial conference of the International Association for the Study of the Commons (IASC) hosted by the Foundation for Ecological Security (FES), a workshop was conducted on "*Participatory Groundwater Management*" (PGWM) with the support of the *Arghyam Foundation*. As part of preparation for this workshop, a detailed review was carried out of participatory approaches to groundwater management with a special focus on experiences in India.

This report presents the review of literature and summarizes the discussions held at the conference around participatory approaches to groundwater management. Section II presents the common pool resources theory in the context of groundwater; section III briefly reviews international experiences in participatory groundwater management with cases from Australia and Spain; section IV outlines the need for an aquifer-based participatory approach to groundwater management in the Indian context; section V discusses the experience of Andhra Pradesh on PGWM; section VI summarizes the deliberations at the conference session on PGWM; and section VII presents the policy discussions and discusses potential ways ahead.

II. Common Pool Resources Theory for Groundwater

The theory of common pool resources (CPR) has been applied to a variety of natural resources over the past few decades. Development of the theory has helped form a language for articulating experiences in the form of case studies on forests, surface water, fisheries and other resources. On groundwater too, there has been pioneering work by CPR theorists in the United States; but the application of concepts to developing countries has been few and far between. This is also because of the differences in conditions in these countries and the resultant need for extension of the concepts and relaxation of some of the implicit assumptions. There is therefore a need to elucidate CPR theory for groundwater, comparing it with surface water and other natural resource commons, and provide a template for understanding the groundwater commons context in India. This

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section attempts a step in this direction. We briefly summarize CPR theory for natural resources and specifically look at its application to groundwater[3].

Costly *exclusion* and *subtractability* characterize common pool resources (Ostrom and Ostrom 1977). CPRs may also experience *assignment problems*, *technological externalities* (Ostrom et. al. 1994) as well as *appropriation* and *provision problems* (Schlager 2007). In Table 1, we try to understand how these characteristics of CPRs apply to groundwater.

Table 1: Groundwater as a Common Pool Resource

CPR Characteristic	Description	Groundwater as CPR
Non-Excludability	Inability to define or restrict resource access to a limited number of users	Provision relatively inexpensive; access also possible through groundwater markets; exclusion prohibitively costly, if not impossible.
Subtractability	Each unit of a resource harvested by a user is not available for use by others	Rivalrous consumption; groundwater extracted by one user not available for other users in the same time and place
Assignment Problems	Users competing for more productive resource areas and/or interfering with others' harvesting	Groundwater availability not evenly spread; well interference common especially in hard rock areas
Technological Externalities	Abstraction technology of a resource user interferes with that of others	Deeper tube wells affect shallow wells; higher capacity pumps might run lower capacity pumps dry
Appropriation and Provision problems	Potential and tendency for over-exploitation of a resource	Groundwater is an 'invisible resource'; difficult for individual users to know boundary, structure and capacity of aquifers.

Surface irrigation requires massive upfront production and transaction costs to begin with. As compared to this, this initial cost and requirements for organization are much lesser for groundwater for which access to the resource is easy and initial development of infrastructure is relatively inexpensive. Even when users cannot or do not develop their own groundwater access infrastructure, access to groundwater is possible via groundwater markets (Shah 1993; Dubash 2002). Easy accessibility to the resource prevents exclusion (thereby letting open access to the resource) and poor information of the resource makes it difficult to have reliable indicators of performance and predictability. Both these create appropriation and provision problems.

Closely placed wells, variable depths and pump capacities cause assignment problems within the same aquifer. Technological externalities may occur as a result of a cone of depression which creates interference between two wells. The standard solutions advocated for these problems are regulation of well spacing, limits to pump capacities and cap on well depths.These appropriation problems are local in time and space; therefore they require localized information to act on. But graver than theseare provision problems.

[3] For a comprehensive review of literature on the application of CPR theory to groundwater, see Schlager (2007).

Secular long term decline of water tables, salinity and water logging caused by rise in water tables happen on a large scale and cannot be solved by acting on individual users. They require cooperation among a large number of users and information on a large scale. Provision problems are especially difficult to address as they appear gradually and by that time resource users get adjusted to a non-sustainable level of resource use. Further, any potential recovery from depletion and over-exploitation takes a long time. Good quality detailed information and a strong legal system are requisites to act on provision problems, both of which have been found to be difficult even in groundwater basins where decades of action has taken place (Schlager 2007).

Ostrom (2001) has argued that users will design and adopt rules for sustainable CPR management if the perceived benefits exceed the rule making, monitoring and enforcement costs; and if they perceive that they will be able to enjoy the benefits of improved management. For this two happen, Ostrom has defined four resource characteristics and six user characteristics which can facilitate self-governance. In Table 2, we look at these characteristics in the context of groundwater.

Table 2: Self-governance in Groundwater

Characteristics	Description	The Case of Groundwater
Resource Characteristics		
Feasible improvement	Improvement in resource availability through user action should be feasible	Feasible in most cases although recovery is very slow
Indicators	Reliable and valid indicators of the condition of the resource should be available at relatively low costs	Unlikely and difficult to obtain given the *invisible* nature of the resource. Users develop thumb-rules on how their groundwater system works but these are not always accurate
Predictability	The flow of resource units should be predictable	
Spatial Extent	The resource system should be sufficiently small such that users can develop accurate knowledge of external boundaries and internal microenvironments	
User Characteristics		
Salience	Dependence of the user community on the resource is high	Usually true in the case of groundwater, even within canal command areas
Shared Understanding	Users have a good understanding of how the resource system operates and how their actions influence it	Unlikely and difficult to obtain given the *invisible* nature of the resource.
Low Discount Rate	Appropriators use a sufficiently low discount rate in relation to future benefits from the resource	Variable
Trust and Reciprocity	Users trust each other to follow mutually determined rules and relate to each other with reciprocity	
Autonomy	Users are able to define rules autonomously without being over-ruled by	

	external authorities	
Prior Experience	The user community has prior organizational experience and local leadership	

Thus we may conclude that, groundwater systems are highly dynamic and one-size-fit-all solutions are unlikely to work. They need to be implemented, observed and adapted to the changing situation and specificities of groundwater basins (Schlager 2007).

III. International Experiences in PGWM: Australia and Spain

Approaches to groundwater governance are being debated worldwide within which Australia and Spain present contrasting approaches. Whereas Australia has formed a strategy in which shares and entitlements for groundwater are implemented through a collaborative process of engagement with users, Spain relies more on water user associations and self-regulation by users. Whereas Australia relies on a more private individual market oriented approach, Spain advocates a more community managed process. Which of these has been more effective? What lessons do they present to the rest of the world, especially the south Asian context where the groundwater conundrum is ever more threatening?

Ross and Martinez (2008) analysed four cases, two each from Australia and Spain on local groundwater governance. In Australia it covers the Namoi and Murray NSW basins within the Murray Darling basin and in Spain it covers the Mancha Occidental and Campo Montiel regions within the Upper Guadiana basin. The authors examine the robustness and relevance of design principles proposed by Ostrom for sustainable local self-governance.

In the Australian example, Groundwater users have long term entitlements to harvest groundwater. The NSW authorities define institutional rules and arrangements to manage the resource, issue harvesting rights and determine the share of the resource that is available to water users in specific periods. Water is distributed by private water supply companies who work closely with irrigators. In the Spanish examples the resource boundaries and hydrological yields are well defined but these yields do not have socio-political acceptance. Resource users have long term rights to use the resource and no service providers exist to regulate the supply of water which is still pumped privately. River basin authorities are empowered to define the sustainable yield and the amount of water that may be used in a specific period but, especially in the Mancha Occidental, many users have ignored directions from authorities.

The development of groundwater management plans in over-allocated resources, and collaboration between the government, irrigators and environmental groups has been difficult, but the difficulties have been reduced by the relatively small number of irrigators involved in the Australian examples as compared to the Spanish ones especially the Mancha Occidental aquifer.

In Spain, water user communities have been unable to prevent illegal pumpers i.e. prevent free-riding. This has been a major obstacle towards implementing aquifer level pumping use restrictions. There is also a lack of trust between the user communities and the basin level authorities. In some cases, the user communities have also acted as a platform for individual users to put forward their case and play a lobbying role for illegal pumping. In short, the basin level agreement has failed to convince local user groups, and also does not have enough legal authority to implement the goals. Unless there is a strong leadership at the basin level and the user group levels, the local user groups adopt a more defensive approach.

A number of users play an important role in implementation. In Australia, with just a few hundred users, it was possible to meet each farmer individuals and address local concerns. However, in the Spanish case with around 15,000 farmers, it has been difficult to implement a fully collaborative process and obtain feedback on scientific assessment from farmers. This has led to a mismatch between farmer's concerns and sustainability based thinking. Within Spain itself, smaller aquifers with less number of farmers, strong local leadership and relatively less exploited aquifers to begin with have shown a better functioning system of local groundwater governance as given by the Campo Montiel example.

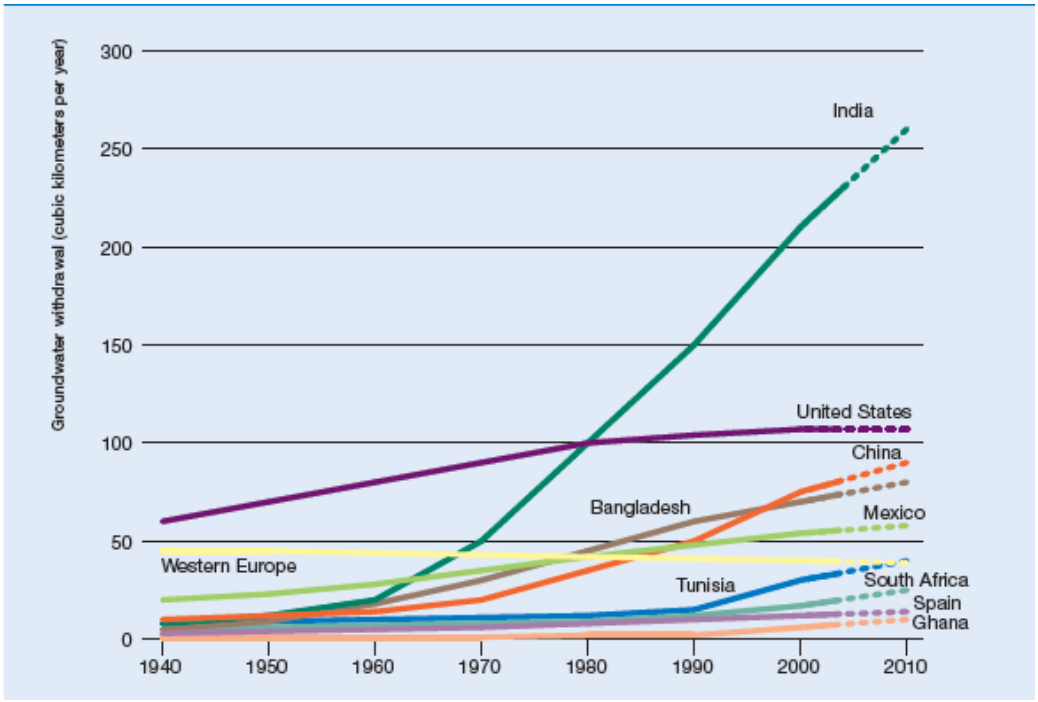
In all cases, overexploitation has occurred and water authorities have attempted to limit pumping rights there has been strong resistance from users who have made considerable investments in the expectation of a reliable, continuing source of supply. Robust regimes have only been achieved where authorities and water users have been able to collaborate. Participative processes have been introduced in all the aquifers studied, but these have been complicated by a lack of shared perceptions and trust between participants.

The studies confirm difficulties for aquifers which have large number of users, high local variability in physical conditions, lesser options for farmers to diversify to less water intensive possibilities. These compounded by an less-participatory government less amenable to collaborative decision making processes will make it tougher to act on groundwater management in the south Asian context. The generic approaches need some re-thinking surely for this region.

IV. The Indian Context of Groundwater: Need for an Aquifer-based Participatory Approach

Globally, around 900 km^3 of groundwater is used in agriculture and this supports livelihoods and food security for more than a billion rural households via an economy in excess of US$ 200 billion. Much of this use is concentrated in India, United States, China, Bangladesh, Iran and Pakistan which together account for more than 80% of the global groundwater use (Figure 1; Shah et. al. 2007).India is the largest user of groundwater in the world and this use is critical since it sustains about 61% of irrigation in a predominantly agrarian economy and also supports nearly 90% of the rural water supply.

Figure 1: Growth in groundwater use in selected countries



Source: Shah (2005)

There are many factors which make groundwater management in India tricky:

- Groundwater has high economic value and is critical to millions of livelihoods
- Common pool access which is relatively inexpensive to establish and hard to restrict
- Fugitive nature of the resource with tens of millions of scattered users simultaneously drawing on the resources largely through self-provision
- Differential capabilities of appropriators causing negative technological externalities
- Difficulty in enforcing property rights
- Disparity between scales of information and action
- Conflicts between its different users and uses (domestic, agricultural, industrial) are increasing as groundwater use continues to expand.

In Kulkarni et. al. (2011) – one of the papers presented at the IASC conference – the authors share their experiences pertaining to the governance of groundwater resources in the common property framework. The authors explain the relationship between availability, demand and supply of groundwater; present alternate (conceptual) trajectories resulting from supply-augmentation and demand-management approaches. They compare two alternative approaches to groundwater governance – command and control (C&C); and decentralized governance through communities. They argue that C&C approach lacks acceptability at the local level and is therefore difficult to implement; while purely community driven efforts suffer from mismatches between community and resource boundaries.

The authors present frameworks for action for scenarios of groundwater over-use and deteriorating groundwater quality; the focus is on intensive information generation and dissemination as a precursor to regulation and community action at various scales. Finally, the authors suggest a process-driven approach to arriving at appropriate institutional arrangements for groundwater governance. These include capacity building activities, collaborative processes between academia and governance institutions, and an overarching legal framework that facilitates and encourages decentralized management while moving away from the traditional C&C approach.

The authors identify the following factors for managing groundwater resources and piloting PGWM in India:

- To understand groundwater resources in all their dynamics
- To understand the present state of groundwater resources and reasons for depletion
- To understand the status of groundwater quality and its impact on living beings
- To study the availability, demand and supply
- To facilitate the community in the process of decision making for the sustainable and equitable management of groundwater resources

Moench et. al. (2005) conducted four case studies in different parts of India – Tamil Nadu, Gujarat, Rajasthan and Maharashtra. This was combined with a wide review of available literature. In addition, reconnaissance case studies were conducted at locations where some form of groundwater management was observed. There were several workshops conducted to discuss the findings of this study and these contributed to this paper. Within all the menu-list of possible solutions being advocated for addressing groundwater problems in India, one approach commonly cited is that of community involvement in self-regulation. Conventional approaches to community based management of groundwater require an in-depth understanding of hydrogeology and robust institutions which can implement suggested regulations on groundwater supported by appropriate legal structures. However, it is not clear if such approaches can be adopted on a large scale in countries such as India due to lack of scientific support to undertake such wide-scale mapping and also weak institutions un-empowered to implement such regulations. So, what approaches need to be undertaken for addressing groundwater problems in India?

The level of scientific understanding of groundwater in India is very poor in spite of efforts from government and non-governmental organizations. Even with much greater expansion of current monitoring efforts, it seems unlikely that information will be available on a micro-watershed scale. This massive gap between what is needed and the current availability of information is one strong impediment to devising locally based groundwater management approaches. The current approach in India of taking abstraction and recharge volumes as a basis for approach to aquifer management is highly data intensive. Instead, the authors argue that management should be based on simple key indicators of changes such as water levels, water quality etc. This can reduce the dependence on high quality expertise and data. One avenue for increasing the information currently available is to involve users directly in

monitoring of hydrologic variables. Generating data through communities could be a potentially powerful tool for solving the scale issue in groundwater data.

In terms of institutional capacities to implement traditional groundwater management regulations, the authors see it difficult in a democracy such as India for such decision makers to take decisions which can be potentially unwise politically. But they see two avenues where there is some potential for conventional approaches to work: (1)Areas with less number of users where the hydrologic units and community or administration units match each other; and (2)Aquifers that are of strategic importance would probably incur greater involvement from politically influential populations, thereby increasing chances of success. But the authors admit that these situations are few and far between.

It is proposed that the solution may lie in re-defining groundwater management appropriately. They propose to move beyond the conventional approaches which require meeting the basic technical requirements of data and institutions. Instead they suggest that technical limitations facing groundwater management are as much a product of how management objectives are defined. They suggest that livelihood focused interventions may have as much, if not more, ability to mitigate the impact of emerging groundwater problems than conventional forms of groundwater management.

Another interesting proposal by Moench et. al. (2005) is of looking at groundwater in Indian context as not a water issue but as a livelihood issue. Such a manner of thinking will open solutions at livelihood transition which do not involve any direct action on groundwater, but could potentially affect the condition of the aquifer. For thinking on policy related to groundwater, the authors conclude that instead on conventional approaches which advocate direct action on groundwater thereby require intensive data and robust institutions, we need to rather focus on livelihoods, food production and food security, which are ultimately of more fundamental concern to decision makers. Working on these objectives and relating them to groundwater could provide us with more workable solutions for the future.

V. Andhra Pradesh Experiences in Participatory Groundwater Management

Worldwide, Western US, Spain, Australia, Mexico are the often cited examples of attempts at groundwater management. Various approaches for community based regulation have been tried in these countries and lessons have been learnt. However, in India, such experiences are lacking. The reasons for absence of such efforts in India have been the unsupportive legal regime, water sector focus on surface water, power subsidies, and often-daunting task for civil society organizations to engage directly on an invisible common pool resource. The southern Indian state of Andhra Pradesh has taken a lead in the direction of piloting groundwater management ideas. Not just one, but there are now at least three different approaches in that state itself on strategies for countering exploitation, equity and utilization related concerns on groundwater. These on-going pilots by civil society

organizations, by the government and as sub-activities within existing government programs are bringing out a lot of learning and providing pointers to a developing national effort on groundwater.

Van Steenbergen (2010) analyses experiences of a) APWELL, b) Andhra Pradesh Farmer Managed Groundwater Systems Projects (APFAMGS), c) Andhra Pradesh Drought Adaptation Initiative (APDAI) and d) Centre for World Solidarity (CWS). Example of approaches and village cases of each of these efforts are taken. They are categorized into 3 main domains, i.e. i) Coordinated crop planning, ii) Social regulation on groundwater, iii) Sharing access to groundwater. Data collected from these pilots have been analysed to look at achievement of goals, impacts of efforts, lessons for future endeavours.

The emphasis of these four pilots on each of the focus domains is different. Whereas APFAMGS has emphasis on coordinated crop planning, CWS has more emphasis on sharing access. The APDAI also has focus on sharing access, but with some experiments on the other two domains also. The APFAMGS follows a method of demystifying groundwater science and involving farmers to perform a crop planning which is agreed informally by the well owning community. It however excludes non-well owners in this process. The observation here was that quite encouragingly, areas which had a groundwater exploitation problem (in terms of negative water balances), were more receptive to crop planning than those which had a relatively comfortable groundwater situation. This responsiveness however, went slightly down during the three year period of observation. To be noted is that in this APFAMGS approach, there is no collectivization of access or social regulation. Contrastingly, CWS and APDAI have tried more on community action, shared access for wells and also attempted a pipeline based water transport system for providing access to the hitherto deprived. There have been variable results with these experiments. Overall, a few villages have been model examples in which the rules have been followed strictly, water extraction has decreased and access increased to the have-nots. But on a larger level, there have been difficulties in continuing initial enthusiasm. Some examples such as Chellapur village show that fine tuning of local regulations will result in greater acceptance – by providing water for dry-land crops in later seasons, combination of technologies such as sprinklers and pipelines can result in water savings and more incentives for cooperation, the solutions need to be acceptable to all farmers in a village and not just bore-well owners since finally all farmers have a stake in groundwater.

These pilots have exploded certain myths and confirmed expectation also. They have shown that:

- Community participation in hydrologic knowledge generation and science demystification can go a long way in making decisions on water usage
- It is crucial to involve all farmers in a village in groundwater management process since eventually everybody is affected
- Group formation in access to groundwater is very difficult to sustain, but incentives such as pipeline networks, sprinklers and market access to dry-land crops can act as reasons for binding such groups

- Groundwater exploitation should not be the only focus of interventions, but very importantly equity concerns in access to groundwater and protection of crop yield need to be paid attention also.
- In some cases, community action is aided by previously related social capital e.g. Joint ownership of power transformer which naturally aids joint access to groundwater
- Normative rules for self-regulation in common pool resource hold true with these cases e.g. Advantage of homogenous community, definition of boundaries, prevention of free-riding; but best practices such as knowledge demystification, incentives to group formation can solve some of these problems
- Up-scaling and sustainability of these experiments is possible further with help from larger policy support in terms of regulations, energy policy, support to decentralization and support to successful initiatives.

VI. Conference Session: Approached to PGWM

The following papers were presented during the Session on "Participatory Groundwater Management" held during the IASC Conference on January 12th, 2011.

Authors	Title
1. Himanshu Kulkarni, PS Vijay Shankar and Sunderrajan Krishnan	Groundwater governance: Backing CPR principles with a process-based approach
2. Chandrakanth Mysore	Groundwater conservation and management in India: Application of IoS and Wade frameworks
3. Nagaraj Nareppa and Koichi Fujita	Water crisis in India: Innovative approaches and policy imperatives for sustainable management of groundwater resource
4. Harshvardhan Dhawan, Himanshu Kulkarni, Devdutt Upasani and Amit Upamanyu	Typological approach for groundwater management: Protocols development and Implementation
5. Neha Singh and N C Narayanan	Efficacy of groundwater as 'Commons': An enquiry into the Implementation of Groundwater (Control and Regulation)Bill of 1992 in selected States in India
6. Daniel Matz, Stephen Moysey and Ravindranath Rangoori	Investigation of the impact of the common land protection on water resources in rural India using geo-hydrological methods
7. Himanshu Kulkarni	Groundwater management through the 'commons' lens: Recognizing complexity

Himanshu Kulkarni –the session chair – started the session with a presentation that combined three session papers and focused on the complexity associated with managing groundwater as a CPR (Kulkarni 2011) and elucidated a process-based approach to developing protocols for groundwater management (Harshvardhan et. al. 2011; Kulkarni et. al. 2011). One of the key points discussed was about the scale at which resource availability and development is assessed. Kulkarni mentioned that the Central Groundwater Board

(CGWB) assesses groundwater at the block level – an administrative unit. However, studies in 10 villages in an overdeveloped block showed that while 7 villages did have overexploitation, the other 3 did not qualify as over-developed. In fact, in one of the villages, there was no groundwater use at all. Given the CGWB assessment, there were now restrictions in place which prevented further groundwater development even in this village. Thus, the scale at which such assessments are made become crucial and perhaps need to be re-visited. The groundwater system is heterogeneous and highly dynamic; and this is especially true for hard rock areas (more than 60% of India's land mass); with significant variations sometimes even within villages. Therefore administrative boundaries are inappropriate for groundwater assessment, measurement and regulation.

Chandrakant Mysore presented a paper on the application of IoS and Wade frameworks to groundwater conservation and management in India (Mysore 2011). He observed that only 34% of the pump-sets used to extract groundwater use electricity while the rest depended on diesel; therefore electricity as a lever for managing groundwater has limited applicability. His concluding suggestions included: (1) Installation of water meters; (2) Focus on improved irrigation extension services; and (3) Issuing permits for only one functional bore-well per farmer.

Nareppa and Fujita (2011) discussed the uncontrolled development of groundwater in India via the explosive growth in dug-wells and bore-wells. They discussed key issues leading to the current state of chaos and anarchy in groundwater governance: (1) the lack of a precise information system; (2) poor maintenance of inventory; (3) absence of technical support services; and (4) the daunting task of dealing with a large number of decentralized users. Their concluding suggestions included improvements in irrigation efficiency and pumping technologies as well as economic incentives coupled with supply side interventions.

Neha Singh presented her review of the implementation of the Groundwater (Control and Regulation) Bill of 1992 in the states of Kerala, Maharashtra and Punjab (Singh and Narayanan 2011). The study found that in Kerala, the issue of ownership of groundwater dominated the policy deliberations; they largely revolved around drinking water issues in Maharashtra; and focused on appropriate timing of sowing paddy in Punjab. The study observed that the Bill seems dated and takes a highly regulatory approach to groundwater management without clearly setting out policy priorities. The concluding suggestions included revising the Bill to incorporate the new realities after the 73rd amendment; and weaving-in the Public Trust doctrine.

VII. Policy Discussions and Ways Ahead

One of the key policy makers attending the session was Mr. Ramaswamy Iyer (former head of Central Water Commission). Mr. Iyer has summarized his views on looking at water as commons from the policy perspective in a note titled “Transforming Water policy and law: A water manifesto for the government of India”. Some of the policy recommendations that are relevant to PGWM are highlighted here. Mr. Iyer recommends a National Water Act setting forth certain basic propositions regarding water and providing a framework for legislation, policymaking and executive action at

various levels. He puts forward that there should be explicit declaration of the right to water (including the right of access to water sources), and privileging it over economic use rights. Civil society needs to be empowered to play its role in water management, and moderating the sovereign power of the state for this purpose. Water (in all its forms) is to be regarded as a common pool resource; the state should hold water and other natural resources in public trust for the community. There needs to be a legal basis for institutional arrangements for holistic coordination at the river-basin level. There need to be state-level legislation for principles and institutional arrangements for entitlements, priorities, regulation, dispute resolution, etc.

Very importantly and specifically Mr. Iyer recommends that we need to move away from land-linked private property in groundwater towards (a) treating groundwater as a community resource held in trust by the state and (b) a system of community management of aquifers. Core to this argument is the need for the Public Trust Doctrine. Under this doctrine, the state is perceived of, not as owning the water resources of the country, but as holding them in trust for the people (including future generations). As a trustee, the state will of course have to be empowered to legislate, regulate, allocate, manage, and so on, and all this must involve a degree of control.

Apart from this session on PGWM, another session on a Policy dialogue for water as commons was conducted on January 12th. In this session broader issues including a commons approach to groundwater and water as a whole was discussed. The panelists were Mr. Ramaswamy Iyer, Ms. Sunita Narian and Mr. Daniel Chavez. Mr. Iyer pointed out that since 2002 a key policy shift has been privatization of services in water sector. The civil society has responded and protested against this change in India. In spite of statement from the Prime Minister that "community is a custodian of water resources", there are confusing signals being sent, especially on the Plachimada case which can make clear the government's position on public trust doctrine with regard to water resources. The Supreme Court now has to decide if the Public trust doctrine applies and whether the aquifer is held in trust by the state for the community for the Plachimada case. Ms. Sunita Narian stated that linkage of land with water will be a key issue for the groundwater commons. This is especially coming out in case of the Nirma cement plant in coastal Gujarat. She stated that thinking from policy on groundwater is still very limited and groundwater irrigation is still referred to as minor irrigation as opposed to major irrigation for surface water, even though the recent trend is that of groundwater covering much higher area of irrigation in India vis-à-vis surface water. In the future, she feels that such conflicts will create the space for negotiations. Also, the price of food and milk will drive public interest on the commons. In order to have local participatory governance of groundwater, there needs to be deepening of democratic institutions. The audience mentioned that Canada recently has declared that social burden due to water quality on health is not the responsibility of the individual, but the government.

Finally Dr. Himanshu Kulkarni summarized the thinking on PGWM with the following six points:

1. Science of groundwater: Current approaches to groundwater management in India either do not include the hydrogeology (science of groundwater) at all or use hydrogeology largely from an "exploratory" perspective. The latter involves approaches of "finding" groundwater rather than looking at "judicious, efficient, equitable and sustainable usage of groundwater". In other words,

the science of groundwater finds limited application in projects and programs dealing with groundwater. Education also remains largely exploration-heavy.

2. Ownership/privatization: Whilst dealing with groundwater management, it is becoming increasingly important to understand how multiple users and uses bring in complex perspectives on "ownership" and "privatization" of groundwater resources. Its fugitive nature but potentially easy access makes groundwater relatively easy to use. In agriculture, the large number of users spread across the country implies that groundwater resources are already in the private-access domain. Groundwater use from a typical aquifer is 'fragmented' in many parts of India – hundreds of users tapping into a single, local aquifer. On the other hand, when agricultural lands transition to urban and industrial uses, there is almost a larger 'recapture through consolidation'. This means that fewer users use larger shares of the common resource. These dynamics are likely to play out into different scenarios in terms of the exploitation and quality issues with regard to groundwater.

3. Groundwater as "commons": Considering the fact that a large population depends on groundwater for drinking water supply, recognizing groundwater as "commons" becomes an imperative, particularly for ensuring drinking water security. Recognizing aquifers as units in which groundwater occurs becomes a first step in this direction with the purpose of developing improved understanding of resource boundaries.

4. Protection of groundwater resources: Water supply and sanitation programs still include "source protection" as a priority. Unless and until the perspective of looking at groundwater changes from "sources" (well, springs, tube wells, hand-pumps etc.) to "resources" (aquifers), protecting groundwater resources from the perils of exploitation and water quality deterioration will continue to be challenging. Protecting groundwater will require major reforms in policies as well as in styles of implementing various water-related and rural development programs. Amendments to the Easement Act (1882) with regard to groundwater, is an example, although it will continue to be a major political stumbling block in reforms on water resources in India.

5. Water Policy: Major reforms in the water policy are required to address groundwater problems in the country. Water policy will need to include specifics on groundwater resource and groundwater problems in India; at the moment most references to groundwater in the water policy are too generic to make significant dents in practices of using groundwater, given the diversity regarding resource characteristics and anthropogenic patterns surrounding groundwater in India.

6. Indirect instruments: Indirect instruments of regulation, which today rest solely with electricity supply rationing and metering, will need to include major policy shifts in sectors like agriculture. For instance, promoting, subsidising, incentivising improvements in rain-fed agriculture would also have impacts on groundwater resources. Such shifts are likely to result in increased food productivities and impact peoples' perception of valuing resources like groundwater for low-water, critical requirements like moisture management and protective irrigation.

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