Creating Synergy Between Groundwater Research and Management in South and South East Asia

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Abstract

Groundwater is under increasing threat from over-development, over-extraction and pollution, due to increasing population pressure, increasing living standards, industrialization, and a lack of proper management to match the demands and use patterns with the natural resource base. This is a global trend, and though regional differences exist this is no exception in South Asia and South East Asia. This introductory chapter gives a brief summary of the chapters included in this volume. It sets out by highlighting the major issues and challenges related to groundwater research and management followed by specific issues faced by five Asian countries with relatively high rates of groundwater development and associated environmental and socio-economic implications during recent history (India, China, Pakistan, Bangladesh and Nepal). Then more specific cases and approaches to groundwater assessment and management in the region are briefly described, giving broad indications of the situation in particular areas and how challenges are being approached from various sides. Though many trends and circumstances are similar across the countries, some particular problem areas are more pronounced and need special attention in the different parts. It is also clear that the complexities involved are many and diverse and solutions cannot be found without a multi-disciplinary approach, involving the triangle of stakeholders: the groundwater and land users, the scientists and the managers.

Introduction

Groundwater has been developed in the South and South East Asia primarily during the last 40 years (Table 1). The rate and scale at which this has, and still is, occurring is so intense that it is causing concerns, not only within the countries themselves, but also at an international level. This is because unsustainable groundwater use potentially influences livelihoods and food security for huge numbers of people dependent on groundwater for subsistence or commercial farming in these regions (many millions of people) as well as potentially influencing international food trade and associated policies.

Groundwater problems emerge slowly and incrementally, as the cumulative effect of many individual impacts of abstractions and contamination sources manifest themselves. The impacts are also delayed as the 'transmission time' of any impacts (lowering of groundwater tables and pollution spreading) to surrounding and downstream areas are long. Conversely, the timescales for remediation are also long, and impacts noticed today will persist for some time, even after the reversal of the original stresses. Hence, emerging problems, which are indeed evident in many parts of these countries today, need to be taken seriously and confronted with a degree of priority (Burke and Moench, 2000). Without going into detail, but referring to the following chapters for details, the impacts manifesting themselves are:

- Continuously dropping groundwater tables with ramifications on economic pumping feasibility, inequity in access to the resource by different population segments, and drying out of significant associated groundwater-dependent water bodies and ecosystems.
- Saltwater entry into wells, from various courses and sources, like seawater intrusion in coastal areas, geo-genic[1] saltwater from geological formations, and salinization from reentry of saline drainage waters or mismanagement of irrigation systems in arid areas.
- Contamination of wells from human activities, like agriculture, waste disposal and wastewater discharge.
- Contamination of wells from geo-genic toxic or unwanted elements, like arsenic, fluoride, and iron.

As groundwater availability is less dependent on recent rainfall due to its longer-term storage capacity, groundwater plays a key role in drought protection and drought resilience. However, if groundwater is being overexploited leading to drawdown of groundwater levels there is a limit to this drought buffer capacity, and in fact droughts become the periods where problems of groundwater over-exploitation become more evident and felt among its users.

The International Workshop on "Creating Synergy between Groundwater Research and Management in South and Southeast Asia" held during February 8-9, 2005 at the campus of National Institute of Hydrology, Roorkee, India conducted its deliberations through paper presentations and plenary discussions to highlight the major issues concerning groundwater assessment, development and augmentation, utilization and contamination and above all the management and governance of the resource in the Asian context. This was followed by state of the art country papers from Bangladesh, China, India, Nepal and Pakistan. An overview of the important issues deliberated during the workshop and a summary of the issues raised under the country papers is given below. Sincere thanks are extended to the authors and session rapporteurs, from whose reports we borrowed heavily in drafting these sections.

Global Groundwater Use

Global groundwater use is about 1000 km^3/year, which is around 8.2 per cent of annually renewable groundwater resources (Shah, 2000), but its contribution to human welfare is huge. India, China and Pakistan alone account for one-third of global groundwater use.

[2]Deriving internally from the aquifer material.

Globally, growth in groundwater irrigation has had little to do with the occurrence of the resource, as its intensive development has tended to occur in arid and semi-arid regions with relatively poor groundwater endowments. There appears to be a good correlation between high population densities and high tubewell densities in India, Pakistan, Bangladesh and China. India alone is adding about 1 million new tubewells every year since the last 15 years and there is no sign of deceleration (Shah et. al., 2003). In poor developing countries, protection and conservation of groundwater resources is often in direct and immediate conflict with livelihood support to rural poor and in meeting domestic needs of towns and cities and thus presents the most complex resource governance challenges facing the world's water professionals.

Summary of Country Chapters

The country reports (Chapter 3-9) describe the current groundwater situation in India, China, Pakistan, Bangladesh and Nepal along with significant trends over the past half century. They also point to important challenges and responses emerging as well as recommendations for further efforts.

From looking at the figures of these chapters, of which the most salient ones are summarized in Table 1, it appears that the groundwater dependence, in terms of numbers of people dependent on groundwater, primarily for agriculture, and in terms of amounts of water extracted for irrigation decrease in the order: India, China, Pakistan, Bangladesh and Nepal. This order is only meant to give a sense of the relative scales involved, but of course groundwater use and associated problems are more pronounced in some parts of these countries than in others.

Even higher numbers of people are dependent on groundwater in these countries than apparent from Table 1, namely for their drinking water and other domestic uses. However, the amounts of water required to satisfy these demands are relatively small compared to water requirements within agriculture and hence the water use within agriculture and how it is being managed is crucial to the overall sustainability of groundwater, which justifies the focus on agriculture. Nevertheless, groundwater use for domestic purposes has overriding importance in public health and well-being and should not be overlooked. And in fact, there is often a disregard of the close links between domestic (ground) water use and the use for agriculture. Groundwater developed for agriculture is often used in the households, and impacts due to mismanagement of water and land use within agriculture often has direct consequences for the availability, reliability and quality of domestic water sources and hence the prosperity of farming communities.

Significant Similarities

The stories of the five countries are to a large extent similar and parallel. Significant groundwater development started in the 1970's, with the introduction of tube well and pumping technology, rural electrification and demand for increasing crop production due to population increases, both for sustaining growing cities but also for a growing rural population. Groundwater development has occupied an important place in poverty alleviation policies because of its role in stabilizing the agriculture and ensuring food supplies and livelihoods for farmers of which many are in the lower brackets of household income. Groundwater scarcity translates directly into lack of secure food supplies and livelihoods for many rural farmers with previous easy access to groundwater. So, on one hand groundwater is (or has) created wealth and poverty reduction in rural areas.

Table 1. Key figures for groundwater use in agriculture in five major groundwater using nations in South and South East Asia[3]

Parameter	India	China	Pakistan	Bangladesh	Nepal
Percentage of population whose livelihood depend on agriculture	70%	59%		about 85%	86%
Percentage of population dependent on GW for irrigation	55-60%	20-25%	60-65%	about 64%	
No. of people dependent on GW for irrigation, million	586-639	257-321	89-96	85	
No. of GW structures, million, recent data (year)	20 (2005)		0.60 (2005)	0.95 (2001)	0.86 (2005)
No. of GW structures, million, previous data (year)	4 (1951)			0.15 (1985)	
No. of GW structures used in agriculture, million			0.68	0.9	0.06
Percentage of GW structures used in agriculture			97%	30-35%	7%
Percent of total water withdrawal derived from GW		20%	33%	75%	
Percent of GW withdrawal used for agriculture			46%	70-90%	6%
Percent of irrigation water from GW	70%		35%	75%	
Cultivated land, M ha		123.4	16		2.4
Irrigated area, M ha		49.1	14.3	4	0.92
Percentage of cultivated land irrigated		39.8	89.4		38.1
Irrigated area, irrigated by GW, m ha	45.7		3.45	3	0.21
Irrigated area, percentage served by GW	70%		73%	75%	23%
Start of GW irrigation boom	1970's	1980's	1970's	1970's	1970's
Total annual GW recharge, BCM	432	884	83		8.8
Net annual GW availability, BCM	361	353	70		
Total annual GW draft, BCM, recent data	150	112	68		1.1
Total annual GW draft, BCM, previous data		57	10		

[3] The table includes primarily data derived from the chapters of this volume. Missing data does not imply that information does not exist but rather that it was not reported in these chapters.

On the other hand, and increasingly, groundwater problems hit disproportionably hard on the poor people. This generates an obvious impasse for politicians and managers, creating inertia towards actively addressing the groundwater problems. It is only within the last decades that researchers have analyzed the trends and warned against the lack of commitment to emerging groundwater issues and politicians and managers have become sensitive and started reacting.

This development in groundwater exploitation has been termed a ‘groundwater boom’ or ‘groundwater rush’, implying that it is not sustainable and that eventually the rates of exploitation will have to level off and/or decrease. The problems are manifesting themselves to various extents in all of the five countries, but it should be kept in mind that the problems are not always directly associated with the groundwater use itself.

Groundwater level declines are of course most often associated with the direct over-use of groundwater but contamination of groundwater is often not an effect immediately associated with the use of groundwater. As an example, much groundwater is being contaminated due to the agricultural practices followed in intensive agriculture be it irrigated with groundwater or not. Also, the increasing production of wastewater, especially from large cities in these countries is posing severe problems for the overall ambient water quality, both in surface waters and groundwater due to the limited treatment capacity of many cities. Dumpsites and other types of waste disposal on the land is another source that increasingly has to be attended to in order to alleviate groundwater problems of these areas.

In general, there is an increasing concern over the deteriorating quality of groundwater in many parts of these countries, though the trends are not always quite well documented, and it is progressively being realized that without proper attention to the groundwater quality aspects we will not be able to solve long term threats.

Significant Differences

Before the groundwater boom, groundwater was lifted by simple mechanical or manual methods. However, for modern groundwater irrigation, a source of energy for lifting water is essential, either fossil fuel (diesel or petrol) or electricity. Hence, the linkage between the energy for lifting groundwater and irrigation economics is very important and this link is increasingly being realized as a potential mechanism for controlling the rates of groundwater extraction in agriculture. In parts of the Nepal terai and parts of India (North eastern parts), the lack of rural electrification is an impediment for efficient utilization of groundwater (Chapters 8 and 15) . In other regions, the limit to pumping is given by the number of daily hours of electricity supply, and basically farmers pump continuously if they have the possibility. Subsidies to irrigation through free or cheap energy have been a tool for enhancing groundwater irrigation development. Still only little actual and pro-active efforts have been put into suspending some of these benefits, in favor of saving on groundwater resources though India is playing with various models at the pilot scale (Chapter 18). In China, electricity is controlled better (in terms of supply and revenue collection) and here more concrete attempts of limiting groundwater pumping through supply and economic incentives have been implemented (Chapter 4).

In general, it appears that India and China may be addressing their groundwater problems quite differently. India has invested huge sums in watershed development programs in which components of groundwater recharge are very significant. Also, many activities to recharge groundwater at local scales are of private or collective nature and have in places turned into almost spiritual movements trying to 'quench the thirst of mother earth'. In China, the trend has been more towards privatization of irrigation and wells and trying to implement more bureaucratic measures for groundwater control. Large efforts and hope for water saving irrigation have been raised, but whether these technologies are relieving stress on groundwater is far from clear. China is facing increasing groundwater demands from growing cities and the conciliation of water use in agriculture vs. a growing industrial society is a major challenge.

Pakistan is mainly struggling with the optimal and conjunctive use of its surface water and groundwater resources, the ever-lurking salinity problems and a number of large cities outgrowing the present supply of water (Chapter 9). Since these cities are far upstream in the Indus river basin wastewater flows that cannot be treated with the present capacity poses major threats on surface and groundwater.

Bangladesh also faces the challenge of optimizing surface and groundwater, with huge seasonal differences in surface water availability and limited infrastructure and institutions for storing water and developing and maintaining irrigation (Chapter 3). The one overriding problem of groundwater in most of Bangladesh is the natural presence of high levels of arsenic in shallow groundwater. This is increasingly limiting the sustainable use of shallow aquifers for drinking and even for agriculture.

Nepal is the country in which groundwater is least developed, and still presents a huge potential for lifting the rural population, mainly in the *terai*, out of poverty if properly managed (Chapter 8). Arsenic maybe a black joker in these aquifers, but the picture is still not clear. In the Kathmandu Valley, groundwater development has already reached its potential and signs of over-exploitation are evident.

Groundwater Modeling and Optimization

The issues related to development, protection, restoration, and remediation of groundwater resources are very complex. Proper understanding of aquifer behavior in response to imposed or anticipated stresses is required for designing and implementation of management decisions. Groundwater management strategies should be directed towards balancing the demand with the fortune of supply. Groundwater modeling is one of the management tools being used in the hydrogeological sciences for the assessment of the resource potential and prediction of future impact under different stresses/strains. There are numerous codes of groundwater models available worldwide dealing with a variety of problems related to flow and contaminants/pollutants transport, rates and location of pumping, natural and artificial recharge and changes in groundwater quality. Each model has its own merits and limitations and hence no single model may be universally applied. Management of a system means making decisions aiming at accomplishing the system's goal without violating the specified technical and non-technical constraints imposed on it. A complete groundwater management model thus is the combination of a groundwater simulation model and a resource optimization scheme. It is through simulation models that one can integrate groundwater science into the management options to understand and evaluate the potentiality and the fate of the resource for different options and constrained situations. These models thus help the resource managers and decision makers to transform or mediate a supply driven groundwater development into an integrated groundwater resource management through integration of supply-side management with the demand-side constraints.

Application of such simulation models and optimization studies for the aquifers of northwest India has been quite helpful (Kaushal and Khepar,1992). High yielding intensive irrigated agriculture (mainly rice and wheat) based on indiscriminate exploitation of groundwater has led to continuous decline of the water table in freshwater areas, with deterioration of water quality, water logging and soil salinity in the saline groundwater bearing areas. Such a scenario of falling/rising water table is threatening the sustainability of irrigated agriculture in the these areas, the food bowl of the country. Simulation modeling and optimization studies indicated that if the present trend of excessive pumping of groundwater through installation of various structures continue, it will not be possible to pump groundwater by centrifugal pumping system because of a continuous fall in groundwater table. The farmers will have to install submersible pumps at a very high cost. An available management option was to decrease the area under paddy or reduce the pumping in that area and meet the remaining irrigation demand by transfer of canal water from rising water table areas to the declining water table area. In case of rising water table areas, the adoption of conjunctive use practice of surface and poor quality groundwater coupled with efficient irrigation application systems can help in managing the water table conditions and sustaining agricultural production in these regions

Safe Use of Saline Groundwater Resources

Future reductions in freshwater supplies to agriculture will induce farmers to look for non-conventional water sources, e.g make greater use of saline groundwater resources. Saline groundwater occurs extensively (32-84% of the underlying shallow groundwater resources) in the arid and semi-arid environments of India and Pakistan and other countries (Sharma and Minhas, 2005; Qadir et. al., 2006). Persistent research efforts have demonstrated the possibilities of using such waters through selection of salinity resistant crops, crop varieties and cropping patterns while maintaining low levels of salts in the active rhizosphere through appropriate irrigation schedules, application methods and conjunctive use of groundwater, canal and rainwater and optimal use of chemical amendments and land configurations to mitigate harmful impacts (Minhas, 1996).

Decisions regarding conjunctive use of saline and freshwater resources and allocation of water based on economic returns and tolerance to salinity is a complicated process and is best attempted through numerical modeling. Such a model shall maximize net benefits from use of waters of varying salinities through allocations to different crops and determine the optimal groundwater pumping for irrigation and drainage water disposal. The allocation of poor quality water essentially centers on crop-water-salinity production functions, which are non-linear in nature. For economic optimization of the conjunctive use, salinity resistant cash crops (cotton, mustard, horticultural crops) may find favor over traditional cereal crops. Conjunctive use of saline groundwater with canal water on sustained basis will also require disposal of some part of saline water through evaporation ponds and regional drains.

Establishment of water quality monitoring networks, modification in canal water delivery schedules, and suitable water and energy pricing and promotion of micro-irrigation systems are required to better use the saline groundwater resources (Tyagi et. al., 1995). Efforts are needed both at farmers' level as well as at government level to realize potential gains of conjunctive water management.

Groundwater Augmentation

Watershed based development has been accepted as a key strategy for ensuring sustainable management of land, water, vegetation and human resources for improved productivity in rainfed areas. Water harvesting and groundwater recharge are principal components of most of such development interventions. In many parts of hard-rock regions of India, groundwater depletion has invoked widespread community-based mass movement for rainwater harvesting and recharge, e.g. in eastern Rajasthan, Gujarat, Madhya Pradesh and Andhra Pradesh states of India (Sharma et. al., 2005). Protagonists think that with better planning of recharge structures and extensive coverage, the decentralized recharge movement can be a major response to India's groundwater depletion because it can ensure that water tables in pockets of intensive use rebound close to pre-development levels at the end of monsoon. India's Central Groundwater Board has developed a national blueprint for groundwater recharge in the country which aims at recharging surplus runoff of about 36.4 billion cubic meters in an area of about 450,000 sq km identified in various parts of the country experiencing a sharp decline in groundwater levels (CGWB, 1996). Using this opportunity would require investing in creating scientific capability and infrastructure for groundwater recharge as a top priority for regions with excessive pumpage and significant renewable water resources.

Institutional Credit for Groundwater Development

In India alone, farmers have installed about 20 million groundwater abstraction structures by government support through institutional credit and subsidies to electricity and diesel to run the pumps. Institutional credit of about USD 5.2 billion/annum is made available for both private (individual) and community owned dugwells, tubewells, irrigation pump sets, energization, river lift irrigation schemes and associated infrastructure such as pipelines, irrigation systems and tanks. This credit is duly supported by subsidy provided by central and state governments to promote and popularize minor irrigation investments amongst farmers. However, there are large regional variations in implementation of the programs as certain areas in the northwest and south overexploited the resource and institutional credit has to be stopped in 'dark' and 'critical' blocks, whereas there were few takers for the credit in the eastern region due to small and scattered holdings and very weak governance and infrastructure systems. Sizeable numbers of small and marginal farmers also do not have access to institutional credit because of fragmented land holdings, cumbersome procedures and documentation and delays in subsidy and loan disbursement. Several evaluation studies have found that institutional credit and private investments become attractive only when farmers opt for diversified agriculture based on high value crops. Inadequate and unreliable energy supplies in rural areas coupled with populist schemes of free/subsidized energy seriously affects the equitable distribution of benefits of groundwater and poor and small farmers get marginalized. Uneconomic pricing of energy has also resulted in unwarranted, exaggerated and sub-optimal use of groundwater leading to adverse environmental impacts and low productivity in agriculture.

Groundwater-Energy-Agriculture Policies Nexus

Energy and water are key inputs to agricultural production and their inter-linkages pose significant management challenges. Lack of appropriate energy policy and policy to deal with management of groundwater has not only contributed to over-exploitation of groundwater, it has also resulted into a nexus (Shah et. al.,2003). Perverse incentives provided as part of the energy policies have lead to inefficiency and almost financial bankruptcy of the energy utilities. However, further and deeper analysis of the nexus shows that growth in use of groundwater and energy for pumping coincides with the overall development policy of attaining food security. Agricultural policies, especially those dealing with gaps in market linkages for agricultural products and role of minimum assured support price for certain crops by the government, have great influence on farmers' choice of cropping pattern and hence excessive groundwater use.

The Indian Punjab has become one of the most important regions for cultivation of paddy in the country where the state government gives free electricity to the farmers for running their tubewells. Due to large-scale cultivation of paddy, and low recharge of groundwater, the water table has been declining steeply; in certain regions by about 1 m per annum. The water table in large parts of the region has gone down by 30 m during the last four decades (Hira and Khera, 2000) and original shallow tubewells have gradually been replaced with high powered submersible pumps. Efforts to convert a part of the area from paddy to some other crops have met with little success as paddy is more profitable than any other crop and it enjoys a regime of assured procurement at the pre-announced price. The combined effect of these policies has resulted in the hydrological unsustainable over-exploitation of groundwater. Policies governing agriculture and energy (and thus groundwater) are apparently dictated more by political populism rather than sound management strategies for sustainable resource development and utilization. Procurement policy and pricing mechanisms need to be revamped, not just from reducing fiscal burden on the exchequer and from equity perspective, but for long term environmental benefits and livelihood security that can be achieved from efficient utilization of groundwater. Indirect policies of the energy and agriculture sector need to be concurrently approached to bring diversification into agriculture and therefore arresting groundwater depletion, and safeguarding livelihoods and food security.

Integrating Groundwater Science and Management

The inherent characteristics of groundwater, its prevalence and reliability in supply and quality, which lead to its widespread use by millions of small farmers also give rise to major challenges faced by groundwater managers. Effective groundwater resource management requires an optimum balancing of the increasing demands of water and land users with the long-term maintenance of the complex natural resource. Groundwater science helps us to have an accurate assessment of the resource, understand specific susceptibilities of the aquifers to abstraction and contamination and the interactions between groundwater and surface water resources. Management of the resource in addition requires the groundwater managers to appreciate the policies which strongly influence water use and food production, regulatory provisions and their limits for conserving the resource, role of stakeholders at different levels in decision making and the need for development of integrated approaches that balance the needs of the poor and the environment with economic development goals. There appears to be a general disconnect between the technical specialists of groundwater resources and the decision makers challenged with its sustainable use and management. Proper groundwater management requires the integration of science into management decisions. Groundwater scientists and mangers need to have a better and common understanding of some of the routinely used terms like 'safe or sustainable yield', 'groundwater over-exploitation', and the actual role and scope of water saving technologies for resource augmentation. As groundwater resources come under increasing pressure, allocation between various users, including the environment, becomes increasingly complex and the need for sound approaches based on natural, economic and social sciences becomes progressively more evident. There is a strong need to close the gap in perceptions and understanding between groundwater managers and scientists to soften up the traditional roles and to improve the appreciation of communication and mutual understanding of diverse roles. The overall goal should be to form a partnership that ensures that decisions, though pragmatic, are made based on the best available multi-disciplinary scientific knowledge.

Recommendations

Each country paper gives a list of recommendations for improved development and management of groundwater in their context. Summarizing these, and using the framework suggested by Zahid (Bangladesh), they can be classified into the following groups:

i. Monitoring/Data Management

- Strengthen appropriate organizations and frameworks for monitoring the quantity and quality of groundwater on a continuous basis.
- Prepare databases to compile, store and retrieve vital data on groundwater properties and variables necessary to detect significant trends.

ii. Investigation/Implementation

- Perform detailed and precise studies using modern tools to generate relevant and accurate data, which shall ultimately result in a more accurate assessment of groundwater resources.
- Encourage and implement artificial recharge, conservation, water-saving irrigation, conjunctive use of surface water and groundwater, fresh and brackish water, treatment and reuse of wastewater, and land use planning and land zoning as per the availability of water and taking appropriate measures to avoid pollution.

iii. Capacity Building/Awareness Raising

- Enhance public awareness and knowledge of groundwater.
- Enhance capacity building of groundwater centers/institutes and create work environments for better communication, co-ordination, and collaboration among water managers, planners, decision-makers, scientists, water users, etc.
- Present results of investigations and evaluations of groundwater and regional hydro-geological mapping in formats workable enough for examining and approving permits to groundwater abstraction and practical schemes of groundwater exploitation.
- Develop a state of knowledge and capability that will enable the countries to design future water resource management plans by themselves addressing economic efficiency, gender equity, social justice and environmental awareness in order to facilitate achievement of the water management objectives through broad public participation.

iv. Management/Policies/Economic Instruments

- Establish legal and regulatory framework regarding development and use of groundwater.
- Revise policies on subsidized power in the agricultural sector. Suitable cost and charging systems of electricity is to be decided to ensure recovery of operation and management and capital cost and avoid misuse/overuse of power.
- Encourage and involve community organizations to prescribe irrigation charges and to become responsible for collection and imposition of penalties for non-payment.
- In the case of industrial effluent disposal, follow the principle of "polluter pays".

Ways Forward

Though it is realized that priorities may differ depending on individual pressing problems, the historical perspective of groundwater use and management, cultural values and political realities, it is also clear that awareness raising and capacity building is an overriding requirement at all levels in society to enhance the understanding, sensitivity and commitment towards improving the use of groundwater in Asia and other regions.

Furthermore, it is important to make decisions on an informed and qualified basis. To that end, there has to be an increased dialogue and collaboration between managers/decision makers and the researchers. Providing the incentives for both parts to contribute to such a dialogue is crucial and it is humbly hoped that providing forums like this workshop contributes towards this goal. The last, but not least partner in such a triangle (Figure 1) is of course the groundwater users. Informing them and involving them actively in this dialogue is also a key to obtaining sustainable and acceptable solutions to groundwater management challenges.

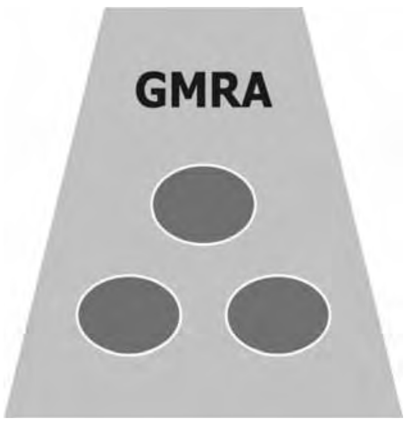

Figure 1. The triangle for a Groundwater Management Research Alliance (GMRA). The dots represent the three parts: groundwater users, groundwater scientists and managers

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