

Applications of Remote Sensing and GIS Technologies in Groundwater Hydrology: Past, Present and Future. Madan Kumar Jha and Stefan Peiffer. BayCEER Publisher, Bayreuth, Germany. 2006. 201 pp. Price: Euro 20.00.

Groundwater is one of the most valuable resources on earth, which supports socio-economic development and ecological diversity. However, overuse and unabated pollution of groundwater are threatening human life and various ecosystems. The sustainable management of freshwater in general and groundwater in particular, is a major challenge of the 21st century. Use of conventional techniques/tools is often severely limited by the lack of adequate data, particularly in developing nations. As a result, innovative technologies like remote sensing (RS) and geographic information system (GIS) have a big role to play. As we know, the role of RS and GIS techniques in surface water hydrology is well demonstrated and a plethora of research papers have been published in different journals, coupled with several conference proceedings. However, the applications of these promising techniques in groundwater hydrology have received only cursory treatment, mostly focusing on a specific aspect only, and are less documented as rightly pointed out by the authors.

The editors of a reputed international journal on groundwater, namely *Hydrogeology Journal* published by Springer, have published a special issue in 2007 on RS and GIS applications in hydrogeology, which reflects the global importance of the subject. However, in the era of information technology, a suitable book solely dedicated to the applications of RS and GIS techniques in groundwater hydrology or hydrogeology is lacking. The present book by Jha and Peiffer fulfils this gap. The book is indeed a timely and important contribution to the field of groundwater hydrology (or hydrogeology).

At the outset, the consequences of imprudent exploitation of the scarce groundwater sources are brought out. The usefulness of RS and GIS technologies for a succinct study of the problem is explained. The basic concepts, working principles and applicability of the two technologies to groundwater studies are elucidated with a detailed review of the relevant literature. Based on the literature study, the authors have identified six major groups for conducting the study, namely assessment and exploration of groundwater resources, selection of sites for artificial recharge and water harvesting, GIS based

sub-surface flow modelling, assessment of pollution, natural recharge distribution and data analysis. Under each of these groups, the pertinent studies are explained.

Two chapters (5 and 6) are contributed by different German authors. Chapter 5 presents the capability of RS technology in the field of hydrogeology with suitable examples. Some perspectives on future applications of satellite data are added. Chapter 6 presents the 'Hoelting method' for evaluating groundwater vulnerability with a case study. However, a comparative analysis of the salient methods for assessing the vulnerability is not provided. The presentation of this chapter does not match with that of the other chapters.

In the subsequent chapters, the authors present the current status of application of RS and GIS technologies in groundwater hydrology in collection of data using RS and processing by GIS, explaining the advantages as well as drawbacks, constraints and challenges presently faced. On-field examples of the constraints would have added to the value of the presentation. The authors have rightly given a 'wake-up-call' to planners in developing nations to tackle pollution, before it gets out of hand. I would suggest inclusion of some relevant case studies in the next edition. In my opinion, the book brings together, uniquely and lucidly, the various aspects of application of RS and GIS technologies in groundwater hydrology. This book would prove to be equally useful to students, researchers and on-field planners. The figures and tables are of good quality and useful to the readers. The book uniquely covers the past, present and future of these technologies in hydrogeology and is written in a lucid style with straightforward explanations.

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Groundwater Governance: Ownership of Groundwater and its Pricing. S. Romani *et al.* (eds). Capital Publishing Company, New Delhi. 2006. 514 pp. Price: Rs 1500.

Much is talked about groundwater governance or groundwater management. However, except for a few knowledgeable people, others can hardly guess the dimensions or nuances of governance, leave aside their roles in the resolution of con-

flicts. Since independence, the uncontrolled pace of groundwater development has resulted in over 1600 blocks in the country being categorized as overdeveloped, critical or semi-critical. This leaves a host of formidable environmental, ecological, economical and social fallouts like declining water levels, drying up of wells, increasing cost of water lifting, sea-water ingress, drinking water scarcity, degrading water quality, fall in agricultural output and income, unemployment of farm labourers, debt traps, etc. Only a paradigm shift from groundwater development to management holds the key to its equity and sustainability. To address the hazards of overexploitation, the administrative, technical and limited legislative measures adopted so far, including restrictions on well energization or control of lending facilities from financial institutions for well-drilling, have been rather ineffective. This book, the first of its kind, contains articles by experts from all over the country with valuable contributions on the theme. It embodies the Proceedings of the 12th National Symposium on Hydrology held at New Delhi in December 2006. The authors attempt to address almost all aspects of groundwater governance, starting from optimal utilization, overexploitation, and pollution of the resource to institutional and legal reforms, water rights, water pricing and sectoral allocation. The editors have divided the book into five parts devoted to these interrelated themes.

The first part of the book, which is in effect a preamble to the other sections, is devoted to the theme of groundwater management and its emerging challenges. There are eighteen articles in this section. In his lead paper, S. Romani underlines specific strategies in varied hydrogeological terrains for optimal groundwater development and management, and for ensuring equity and sustainability of the resource. According to Stephen Foster and Hector Garduno, management options in hard-rock areas, often hit by over-exploitation, involve cross-sector approaches, including agriculture, energy and trade-policy interventions. They advocate dry land agriculture, development of alternate livelihoods, crop-water planning to maximize farmer's income and minimize groundwater use, conservation of drinking water sources and groundwater augmentation. In sedimentary tracts, shared utilization and protection of large, inter-state aquifers are of prime concern. Authors have presented interesting case studies like groundwater abstraction systems in varied hydrogeological environs,

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groundwater management in the Andaman and Nicobar Islands in the aftermath of the tsunami, strategy for mitigating effects of global warming on groundwater resources of Rajasthan, and evaluation of augmentation tubewells project in western Yamuna canal command. Several articles highlight the role of sophisticated tools in management decisions, like the use of remote sensing studies in artificial recharge in Uttar Pradesh, isotopic studies on recharge in the Himalayan hilly terrain, and mathematical modelling of groundwater flow and optimizing pumping schedules in Palla well field, Delhi. In short, this chapter presents a survey of the hydrogeological problems in the country and integrated multidisciplinary approaches towards groundwater management.

Part 2 contains thirteen articles dealing with the institutional and legal framework in groundwater governance. Governance means ensuring equity, efficiency and sustainability of the resource. Groundwater management entails information gathering and resource planning, groundwater monitoring and undertaking research on ways of augmenting and managing the resource, educating the general public and participatory approach in the process. This needs institutional mechanism and capacity building at the grass roots level, with legal support. However, existing regulatory measures are not properly empowered and in no way increase water-use efficiency. In the overexploited areas, the regulations cannot deter the affluent from digging or deepening wells, but deny the economically weaker sections bank financing for well-drilling, thus creating inequity in the sharing of resource. K. S. Takshi points out many infirmities in the Model Bill circulated by the Union Government. He suggests combining on the demand side, measures to control, protect and conserve water resources, as also measures to augment the resources on the supply side, along with inter-departmental coordination and community participation to implement the schemes. R. K. Khullar cites the example of Haryana, where a massive awareness campaign succeeded in collective solution of declining water levels through conservation of water by weaning away farmers from summer paddy, rainwater harvesting and conjunctive use. K. D. Sharma rightly feels that groundwater management should be a part of the integrated water-resources planning. N. C. Ghosh and Anupama Sharma in an in-depth study, focus on the need for long-term policies of demand and supply manage-

ment of groundwater in the country, based on the projected per capita availability and requirement of water over the next two decades, and the scope of groundwater augmentation. Groundwater quality management is also a crucial aspect. N. C. Nayak *et al.* uphold the importance of groundwater databases in its management in the mining and industrial belt of Orissa. Feasible management approaches depend heavily upon both databases and institutional capacities for regulation and scientific research.

In parts 3 and 4, there are thirteen articles devoted to inter-related themes of water rights, water pricing and sectoral allocation of groundwater. In the Rome Declaration of 10 December 2003, the UN recognized access to water as a human, social, individual and collective right. However, under the Easement Act (1982) of the land, the owner has absolute right to water beneath his land and unbridled authority of groundwater extraction, leading to overexploitation. In the opinion of M. S. Rathore, water rights should be defined in such a way that the use rights are held by the community rather than the individual. He suggests water rights-based, but dispersed governance with rights and responsibilities shared among the states, local communities and resource-using institutions. River basins should be the basis for planning in groundwater management. J. A. Thambe favours treating water as common world heritage.

Although the National Water Policy broadly outlines the priorities of water allocation, lack of well-defined allotment leads to conflicts of competitive demands from various sectors and court litigations. Also, it is unanimously agreed that groundwater should be treated as economic good. However, absence of clear pricing policy coupled with various subsidies, has been an incentive to overuse this economic resource. Rational water pricing may be an effective deterrent to groundwater overdraft, if other economic policy instruments strive to achieve the same objective. Water markets may thrive in a resource regime of clear entitlements and allocation and dependable access system. John Kurien and A. K. Sinha moot a minimum entitlement to all citizens for domestic consumption, an additional entitlement for traditional water users according to current usage, and the balance owned by the states, and auctioned – the entitlements being tradeable. Market trading of entitlements and private sector competition will ensure efficiency, the equity being taken care of by entitlements,

and sustainability by the state/community and a regulator (institution). A. K. Rastogi suggests a slab system pricing structure, with the economically weaker section of society charged at subsidized rate. V. V. Damle is of the view that groundwater pricing should reflect service costs as well as social opportunity costs. K. Md. Najeer *et al.* have given examples of groundwater pricing in terms of investments towards watershed treatment or recharge structures, and extraction of recharged water in overexploited watersheds.

Majority of the groundwater consumers use their own resources for construction, operation and maintenance of wells. It is only through community participation in governance that equity and sustainability of the resource is possible. Srinivas Mudrakartha advocates the formation of multi stake holders participation forums for triggering participation at various levels and providing linkages with concerned institutions, as successfully experimented in Sabarmati stakeholders forums in Gujarat. The story of construction of 5600 johads and water management in Alwar District, Rajasthan, is an example of community participation (Rajendra Singh).

In the quagmire of bureaucratic inaction, political unwillingness, intellectual paucity, planning ineptitude, unimaginative handling by the administration and hydrogeological complexity, it is the vast majority of the groundwater users who are left to suffer. A relook may be necessary at the Model bill or legislations as enacted in some states. This is the only book so far published on the various facets of groundwater governance in India, which focuses on a plethora of case studies and views of experts with utmost lucidity and clarity. Interactions foster new concepts or innovative ideas. This book will surely be held as a valuable reference for all groundwater scientists, economists, legal experts, and serve as an eye-opener for all who matter. The articles are incisive in analysis, and firm in assertion that everything is not lost as yet. There is light at the end of the tunnel. The editors have done a good job in bringing out this book, unusual in many respects.

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