

## Groundwater management for food security

K. D. Sharma

*There is a strong nexus among overutilization of groundwater, subsidized power utility, marketing, minimum support price and procurement policies. Improving competitiveness of water-guzzling crops in the groundwater surplus eastern India and less water-requiring commodities in overexploited northwest and south India through technology, marketing, incentives and disincentive interventions could rationalize the groundwater use.*

Over the period 1951–2007, irrigated area from major projects in India has increased to 3.5 times, from tanks 1.9 times and from groundwater 6.3 times. Construction of a large number of major, medium and minor irrigation projects through the Five-Year Plan periods, rural electrification, subsidized power and tube-well revolution in the Indo-Gangetic Plains since 1980s have led to significant development of irrigation potential in the country. This enlarged area coverage coupled with improved technologies, credit and better inputs underpinned the rapid growth in agricultural productivity, production, livelihood, income, employment and rural development. Foodgrain production increased to 4.5 times from 50.82 million tonnes (mt) in 1950–51 to 230.67 mt in 2007–08, thereby imparting food security in the country<sup>1</sup>.

Out of the net irrigated area of 58.5 m ha in India<sup>2</sup>, the area irrigated through groundwater accounts for 35.0 m ha (60%). Over the last quarter century, 89% of the total incremental net irrigated area was contributed using groundwater through private investment; 75% share was of tube-well irrigation only<sup>3</sup>. The groundwater schemes are comprised of dug wells, dug-cum-bore wells, shallow and deep tube-wells and filter points, each having command area between 1 and 5 ha. Even in the several command areas of major irrigation projects, farmers often use groundwater as a matter of routine to supplement canal water to maximize agricultural production. The Third Census of Minor Irrigation Schemes (<http://wrmin.nic.in/micensus/mi3census>) conducted during 2000–01 revealed that about 80% dug wells and 60% tube-wells were constructed investing the farmers' own savings. A few State Governments provided assistance in the form of technical guidance and custom service for boring. Only 4% dug wells and 14% tube-wells were constructed using bank/

other loans and 23% tube-wells were government-funded. Subsidies are also made available for installation of groundwater schemes to the weaker section of farmers. The construction, operation and maintenance of groundwater schemes are done wholly by the farmers themselves. In general, these schemes are labour-intensive with short gestation period and subsidized energy makes them attractive. The groundwater irrigation is under the direct control of the farmers and is amenable to precision agriculture and higher irrigation efficiency of 70–80% compared to 25–45% in the canal irrigated areas<sup>4</sup>. As a part of various development programmes, innumerable such new schemes are being taken up in the states.

### Groundwater utilization for irrigation

In the active recharge zone, the annual replenishable groundwater resource for the entire country is 433 billion cubic metre (bcm). Keeping 34 bcm for natural discharge, the net annual groundwater availability is 399 bcm. The annual groundwater draft is 231 bcm, out of which 213 bcm (92%) is utilized for irrigation and 18 bcm is for domestic and industrial use<sup>5</sup>. There would, therefore, appear to be a little problem on average.

This dangerous complacency is based on an erroneous assumption that there is limitless groundwater. In fact, all water issues are local issues, and overall averages flatter to deceive<sup>6</sup>. At local levels many of the highly productive localities are already under severe stress. The groundwater administration still operates in development mode without managing demand, treating water availability as unlimited, and directing their energies towards enhancing production, despite the fact that symptoms of overexploitation are clear<sup>7</sup>. The major foodgrain-

producing states of Haryana, Punjab and Rajasthan in northwest India are overexploited<sup>5</sup> to the tune of 109–145%. On the other hand, there is a large scope for developing and utilizing groundwater for irrigation in the poverty-ridden eastern states of Assam, Bihar, Chhattisgarh, Jharkhand, Orissa and West Bengal, since 58–82% groundwater remains under developed and unutilized for irrigation. The annual groundwater draft for irrigation is 45–85% in the rest of the eight major foodgrain producing states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and Uttarakhand.

### Foodgrain production

Rapid expansion of groundwater use for irrigation was a key factor in the relatively rapid growth of agriculture between the mid-1960s and late 1980s. Overall, the stage of groundwater development in the country<sup>5</sup> is 58%. However, there is a large variation in the stage of groundwater development across the country. Based upon the level of development of groundwater, the major foodgrain-producing states were divided into three groups (Table 1) to analyse the production scenario in the country during 2006–07, for which data are available<sup>1</sup>. Further, for this analysis the development and utilization of groundwater are considered synonymous.

The utilization of groundwater exceeds 100% in the Group I states. On an average, during the past decade, the Group I states and Uttar Pradesh contributed 97% (range 96–100%) wheat and 51% (range 44–65%) rice to the central pool every year, thereby contributing to the national food security. These states, covering slightly more than one-third net sown area under foodgrains, have the highest productivity of 2.6 t ha<sup>-1</sup> and produce

**Table 1.** Grouping of major foodgrain-producing states according to the level of groundwater development in India

Group	Groundwater development (%)	States
I	>100	Haryana, Punjab and Rajasthan
II	45–85	Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and Uttarakhand
III	18–42	Assam, Bihar, Chhattisgarh, Jharkhand, Orissa and West Bengal

Source: CGWB<sup>5</sup>.

**Table 2.** Area, production, productivity and coverage under irrigation in major foodgrain-producing states

State	Area		Production		Productivity (kg ha <sup>-1</sup> )	Percentage coverage under irrigation
	(10 <sup>6</sup> ha)	Percentage to all-India	(10 <sup>6</sup> t)	Percentage to all-India		
Group I + Uttar Pradesh	43.4	35	95.5	44	2647	70
Group II – Uttar Pradesh	48.7	39	68.7	32	1631	40
Group III	28.3	23	47.0	22	1585	30

Source: Anon.<sup>1</sup>.

44% of the foodgrains in the country since 70% net sown area is irrigated (Table 2), out of which 68% is irrigated through groundwater schemes. A deeper analysis shows that growth in the use of groundwater and energy for pumping in these states coincides with the overall national policy of attaining food security. In the Group II states, the groundwater utilization ranges between 45 and 85% and is able to provide reasonable household food security. Although these states have 39% net sown area under foodgrains, they produce only 32% quantum of foodgrains in the country due to lower productivity of 1.6 t ha<sup>-1</sup>, since 40% (compared to 70% in Group I + Uttar Pradesh) net sown area is irrigated (Table 2); the groundwater schemes irrigate 22% of this. India's future food security will be ensured through the second green revolution in the high productivity potential Group III states, where the groundwater is under-developed and under-utilized to the tune of 58–82% (utilization 18–42%), since small and marginal farmers are not able to afford the cost of sinking and energizing tube-wells due to their poor socio-economic status. Water marketing is prevalent in this region, where affluent farmers having substantial land holdings, monopolize on groundwater extraction for selling to poor farmers. Currently 23% net sown area is under foodgrains in these states producing 22% foodgrains in the country since only 30% net sown area is irrigated (Table 2), out

of which only 10% area is irrigated through groundwater schemes. Therefore, there is a greater scope for groundwater development in the region, which often faces floods during the rainy season, resulting in increased foodgrain production and productivity from an abysmal 1.6 to at least 2.6 t ha<sup>-1</sup> (similar to the Group I states + Uttar Pradesh), i.e. a net gain of 1.0 t ha<sup>-1</sup> (Table 2). Improving productivity of rice in eastern India would ensure food security in the coming years.

In addition to foodgrain production, groundwater contributes significantly to sugar cane, oil seed, cotton, tobacco, fruit, vegetable, medicinal plant and spice production, fodder production for the livestock during summer and coastal aquaculture. In general, all the tropical fruits, medicinal plants and spices are grown using groundwater irrigation in the country. Thus, the utilization of groundwater ensures food security.

### Groundwater management

Groundwater is an invisible and endangered open or common access resource. Overexploitation of groundwater beyond the sustainability limits in several parts of the country has resulted in widespread and progressive depletion of its levels in selected pockets of 370 (61%) out of 603 districts in the country<sup>8</sup>. In 15% of the blocks the annual extraction of ground-

water exceeds the annual recharge and in 4% of the blocks it is more than 90% of recharge<sup>5</sup>. Reduction in groundwater supply, saline water encroachment, drying up of the springs and shallow aquifers, increased cost of pumping by replacing centrifugal pumps with expensive submersible pumps, reduction in free flow, weakening drought protection and even local land subsidence in some places are threatening the sustainability of the aquifers. In many areas this has occurred more or less year-on-year, except for temporary respite following years of exceptional monsoon rainfall when a partial recovery has been observed. The practice of the sale of water, either in cash or on crop-sharing basis has also encouraged the rich farmers to construct deep tube-wells and over pumping the groundwater. Rapid decline in groundwater levels in the drier parts of India is a matter of concern, since demand-driven exploitation without regulatory measures and understanding of area-specific problems lead to crisis not only for the present but may also result in damage to the groundwater system with adverse impact on future water supplies. It has been reported that declining groundwater levels could reduce India's harvest by 25% or more<sup>9</sup>. The 'Country Strategy of India' of the World Bank has identified groundwater mining as a troubling reality on the horizon<sup>10</sup>.

The other important part of the decline in the utility is related to groundwater

quality. Leachates from compost pits, animal refuse, dumping grounds for garbage, synthetic fertilizers and pesticides-enriched irrigation return flows, seepage from septic tanks, seepage of sewage, etc. have adversely affected the groundwater quality in several parts of India. Geogenic contaminants such as unsafe concentration of arsenic, fluoride and iron are related to excessive groundwater pumping. The incidence of groundwater pollution is high in urban areas, where large volumes of domestic and industrial wastewater are discharged into relatively smaller areas as point source. Groundwater contamination, however, could be detected only after the sub-surface contamination begins. Further, steps to ensure sustainable groundwater use will face many hurdles since groundwater has become a market commodity in large areas. The depletion and degradation of groundwater is a major cause for increasing the rural poverty in India.

Groundwater management deals with a complex interaction between human society and physical environment and presents a difficult problem of policy design. Aquifers are exploited by human decisions and overexploitation cannot be always defined in technical terms, but as a failure to design and implement adequate institutional arrangements to manage people who exploit the groundwater resource. Common pool resources such as groundwater have been typically utilized in an open-access framework, within which resource ownership is according to a rule of capture. When no one owns the resources, users have no incentive to conserve for the future, and self-interest of individual users leads them to overexploitation. Groundwater management is a much debated issue, but there are very few examples of effective action on ground.

Figure 1 shows the status of groundwater use in the country<sup>5</sup>. The map shows two challenges: first, how to restrain groundwater use to sustainable levels in overexploited regions and second, how to develop the large untapped groundwater potential in eastern India.

Sustainable groundwater development and management in the overexploited regions needs to be taken up by incorporating artificial recharge to groundwater and rainwater harvesting, management of salinity ingress in coastal aquifers, conjunctive use of surface water and groundwater, management of poor/marginal

quality groundwater, water conservation by increasing water-use efficiency, regulation of groundwater development, etc. Several micro-level studies have concluded that these technologies have been successful. Innovative methods of recharging the groundwater and also storing water in floodplain aquifers along the river banks may enhance the ultimate irrigation potential from groundwater to more than 64 m ha from the present 35 m ha<sup>7</sup>.

In parts of the country where groundwater withdrawal currently exceeds recharge resulting in the declining water levels, the following are essential: (1) There must be regular and accurate assessment of actual groundwater use in

both rural and urban areas to correlate with recharge and extraction. (2) Further expansion should be strictly monitored. (3) Separation of feeders for domestic and agricultural power and its timely but controlled supply for irrigation could help regulate groundwater use. (4) Ways must be explored to empower and entrust village communities with the right and responsibility to collect electricity charges and in overexploited blocks to regulate access through obligation on groundwater users to undertake rainwater harvesting and groundwater recharge.

In eastern India, the priority should be to exploit the abundant availability of groundwater in Assam, Bihar, Chhattisgarh, Orissa and parts of Jharkhand,

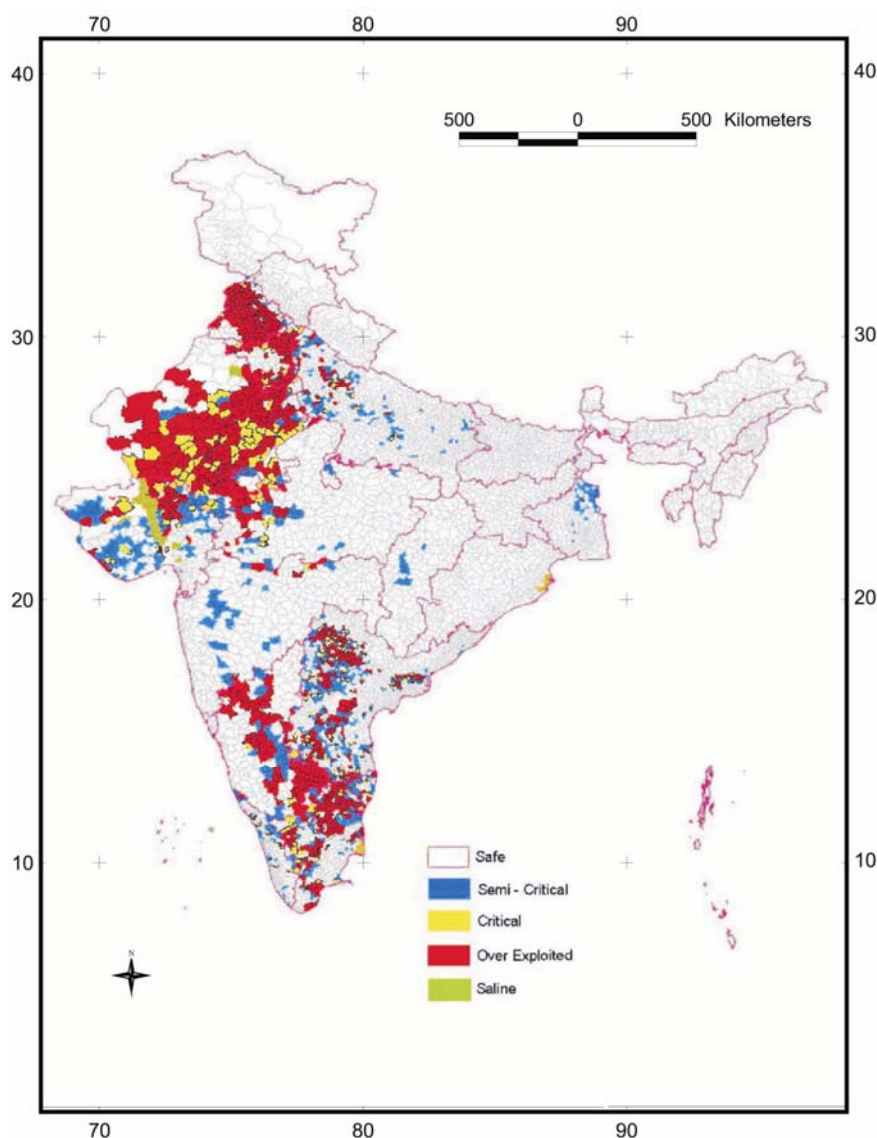


Figure 1. Categorization of blocks/mandals/talukas as on March 2004 (source: CGWB<sup>5</sup>).

eastern Uttar Pradesh and West Bengal. The ongoing programme of rural electrification in the region under the Bharat Nirman Yojana will help. The scope of the Rajiv Gandhi Grameen Viduytikaran Yojana must be expanded to include energization of pump-sets by converging resources for better groundwater utilization. The objective should be to bring large parts of the cultivable area in these states under irrigation through a time-bound programme. This would be the key to the breakthrough in agricultural production and food security. As this is viable, an action plan needs to be drawn up by the states involving provision of (1) adequate power for irrigation, (2) soft credit for farmers to install tube-wells and pump-sets, and (3) subsidized rates for grant of electricity connections. With the implementation of differential pricing for peak and off-peak supply of electricity, it should be possible to have a modest rate for supply of off-peak electricity to agriculture. However, the electricity rates should not be reduced to unsustainable levels reached elsewhere. Further, groundwater development in eastern India would provide plenty of scope for employment of unskilled labour force. It is therefore important to link the National Rural Employment Guarantee Programme with groundwater development.

The concept of virtual water is more relevant to the states in eastern India where groundwater is under-utilized by 58–82%. Water-guzzling crops such as rice and sugarcane could be promoted in these states, including eastern Uttar Pradesh. In this process rice cultivation

in Haryana and Punjab could be discouraged by diversification into low water-requiring crops such as maize, soybean, vegetables, etc. Similarly, cultivation of banana could be shifted from the southern to the eastern states for managing groundwater demand to the safe level. There will be several permutations and combinations in the form of virtual water hidden in the produce. It will also require relocating some agro-industries.

The sustainability of groundwater use is one of the core areas which requires attention for meeting irrigation and drinking water requirements and ensuring food security. In the Ganges–Brahmaputra–Meghna Basin with abundant groundwater resources, holistic planning of groundwater development in the east and north-east and adequate recharge measures in the northwest and south are essential, so that the mistakes of the past are not repeated. In other areas too, judicious planning of groundwater development and artificial recharge could result in maximum productivity without raising environmental concerns. Water-demand management focusing on need-based allocation and pricing, involvement of stakeholders, effective implementation of regulatory mechanisms, capacity building, and fostering a sense of identity are also key for sustainable groundwater utilization and food security in the years to come.

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1. Anon., Agricultural statistics at a glance. Ministry of Agriculture, New Delhi, 2008.

2. CWC, Water resources at a glance, Central Water Commission, New Delhi, 2008.
3. Samra, J. S. and Sharma, K. D., In National Groundwater Congress, Central Ground Water Board, New Delhi, 2009 (in press).
4. Anon., Measures of impact of science and technology in India: Agriculture and rural development. M.S. Swaminathan Research Foundation, Chennai, 2007.
5. CGWB, Dynamic ground water resources of India, Central Ground Water Board, New Delhi, 2006.
6. Shah, T., Deb Roy, A., Qureshi, S. and Wang, J., *Sustaining Asia's Ground Water Boom: An Overview of Issues and Evidence*, Natural Resources Forum, 2003, vol. 27, pp. 130–140.
7. Eleventh Five-Year Plan, Planning Commission, Government of India, 2007.
8. MOWR, 13th National Conference of Water Resources and Irrigation Ministers of State Governments and Union Territories, Ministry of Water Resources, New Delhi, 2005.
9. Singh, D. K. and Singh, A. K., *Int. J. Water Resour. Dev.*, 2002, **18**, 563–580.
10. MOWR, National Workshop on Challenges for Water Development and Management in India and Future Strategies, Ministry of Water Resources, New Delhi, 2005.

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*K. D. Sharma is in the National Rain-fed Area Authority, NASC Complex, New Delhi 110 012, India.  
e-mail: drkdsharma@gmail.com*