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Towards a Managed Aquifer Recharge strategy for Gujarat, India: An economist's dialogue with hydro-geologists

Tushaar Shah *

International Water Management Institute, C/o INREM Foundation, Near Smruti Apartment, Anand, Gujarat 388001, India

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SUMMARY

Gujarat state in Western India exemplifies all challenges of an agrarian economy founded on groundwater overexploitation sustained over decades by perverse energy subsidies. Major consequences are: secular decline in groundwater levels, deterioration of groundwater quality, rising energy cost of pumping, soaring carbon footprint of agriculture and growing financial burden of energy subsidies. In 2009, Government of Gujarat asked the present author, an economist, to chair a Taskforce of senior hydro-geologists and civil engineers to develop and recommend a Managed Aquifer Recharge (MAR) strategy for the state. This paper summarizes the recommended strategy and its underlying logic. It also describes the imperfect fusion of socio-economic and hydro-geologic perspectives that occurred in course of the working of the Taskforce and highlights the need for trans-disciplinary perspectives on groundwater governance.

1. Gujarat's groundwater governance challenge

Besides its age-old dynamism in maritime trade and commerce, during recent decades, Gujarat has become increasingly known for its crisis of groundwater. During the Colonial era, while the British concentrated public irrigation investments in the Indo-Gangetic plains in the north and on Godavari, Krishna, Cauvery basins in the south, much of the Bombay Presidency, of which Gujarat was a part, remained left out. Here, supplemental irrigation using bullocks and leather buckets to lift water from shallow open wells remained a widespread tradition (Shah, 2009a). Use of Persian wheels was common too. At the turn of the 20th century, Gujarati farmers were among the first to import Lister–Petter engines from England, and press them into irrigation service. Around 1910, many owners of diesel engines in central Gujarat began laying buried cement pipelines to sell well-irrigation service to other farmers. Shah (1993) interviewed an old farmer who supplied, as far back as in 1935, irrigation water to farmers in four neighbouring hamlets using his own buried pipelines. So productive was well irrigation considered that the Colonial government imposed a groundwater cess which generated much controversy in Bombay newspapers (Hardiman, 1998). Localized, informal groundwater markets using buried cement pipeline networks existed in large parts of central, south and north Gujarat by 1950 (Shah, 1993). With the availability of electricity and electric pumps, these markets became central to Gujarat's agriculture. With rapid expansion in well irrigation, groundwater depletion emerged as a major challenge especially in dry north Gujarat, Saurashtra and Kutch. With declining groundwater levels, bullock-bailers became history by the early 1980s; demand for electric pumps soared and a complex political economy emerged around the nexus between electricity supply and groundwater irrigation. The Electricity Board found the transaction costs of metering far-flung tubewells scattered over a vast countryside prohibitive; and farmers complained of the tyranny of meter readers and their extortionary demands from them. In 1987, yielding to a long and strident farmer agitation, Gujarat Electricity Board changed from metered pricing of agricultural electricity consumption to flat tariff based on connected horse-power of irrigation pumps (Shah, 1993). This had the multi-pronged effect of increasing the demand for electric pumps, raising the operating factor[1] of electric tubewells and enhancing the depth and breadth of local water markets (Shah, 1993). At the same time, the new formula also deepened further Gujarat's groundwater depletion crisis.

Situated in the western-most part of India, the state of Gujarat with a population of over 60 million is enclosed on three sides by a 1600 km Arabian sea coastline (Fig. 1). Geographically, the eastern mainland of Gujarat is humid in the south and semi-arid in the north. In the west, the Saurashtra peninsula is divided from the mainland by the Gulf of Kutch, which is separated from the mainland Gujarat to the east and Pakistan to the north by the low-lying desert called the Rann of Kutch. The state can be conveniently divided into four hydro-geological zones: (a) humid south

* Tel.: +91 2692 263816x817.
E-mail address: t.shah@cgiar.org

[1] Operating factor is the number of hours of actual operation of a tubewell/year as a % of hours of possible operation/year.

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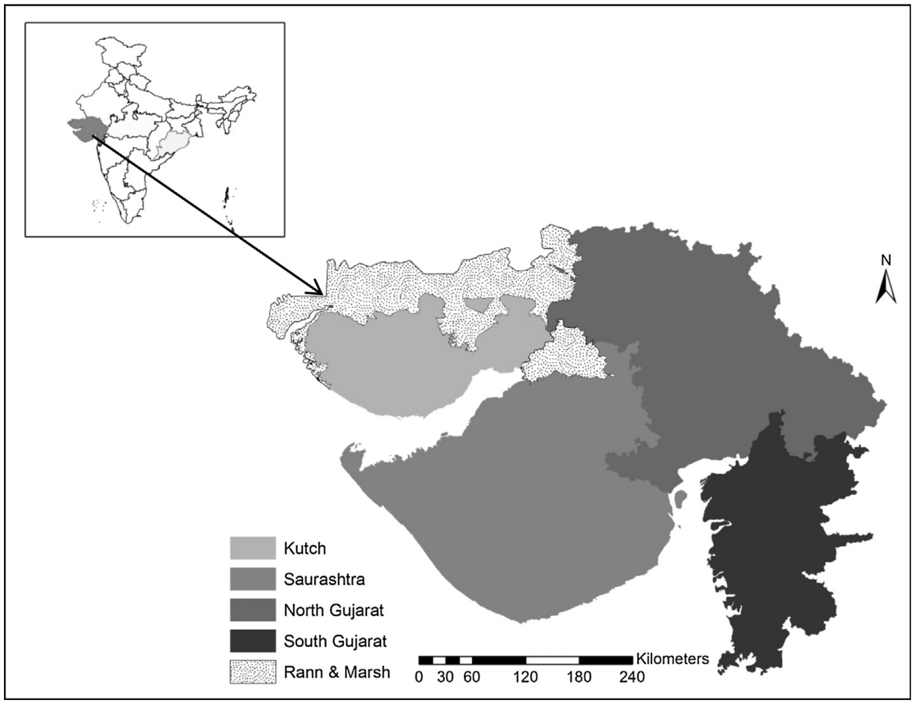

Fig. 1. Map of Gujarat and its four major regions.

Gujarat with alluvial aquifers; (b) semi-arid central and eastern Gujarat with alluvial aquifers in some parts and hard-rock aquifers in others; (c) arid north-Gujarat and Kutch with mostly alluvial aquifers, and (d) semi-arid Saurashtra with mostly hard-rock aquifers.

The state displays great variability in its agro-meteorological and climatic conditions. Most of Gujarat, except some southern districts, represents one of the most water-stressed regions of India. The hydrology of the state is characterized by wide spatial variations in rainfall (377 mm in Kutch to 1875 mm in the Dangs), and high year-to-year fluctuations in rainfall with the coefficient of variation ranging from 25% in Dangs to 80% in Kutch (IRMA-UNICEF, 2001). The state has unconsolidated, semi-consolidated and fissured geological formations (Fig. 2). The state has a history of frequent droughts and famines. A famine Gujarat suffered in 1900 was so severe that a third of the population and most of the livestock perished (Yagnik and Sheth, 2005). Today, Gujarat is one of India's most rapidly growing states in industrial and economic terms. Yet, some 57% of the state's population is rural and more than 45% depends on agriculture for its livelihood. Even as the share of agriculture in the state's domestic product has declined to about 15%, the number of workers employed in agriculture has not declined as rapidly. As a result, the performance of the agrarian economy affects large sections of the population. Through the 1980s and 1990s, Gujarat's agricultural economy recorded a negative trend rate of growth, which has been a matter of great concern for the state's planners (Bagchi et al., 2005).

After 2000, thanks to a clutch of imaginative policies by the state government (Shah et al., 2009), Gujarat's agricultural economy has experienced a dramatic turnaround, with annual agricultural growth rates approaching an unprecedented 10%. This has eased somewhat the concerns for agrarian livelihoods. However, the state's groundwater situation has continued to remain precarious. At the turn of the Millennium, groundwater depletion had assumed the proportions of a crisis in semi-arid alluvial North Gujarat and Kutch, and in hard-rock areas of Saurashtra. India's Central Ground Water Board (CGWB) assessed that out of Gujarat's 184 talukas,[2] 31 were already withdrawing every year more groundwater than the long-term annual recharge creating a negative groundwater balance. Twelve more talukas were on the border-line, drafting 90% of the estimated 'safe yield'. Of the remaining, 69 talukas were drafting 65% of the 'safe yield' but experiencing rapid development of the resource. Fig. 3 shows the differing levels of groundwater development in the districts of Gujarat.

High fluoride concentrations and salinity levels in groundwater, the main source of drinking water supply, were detected in 16 of Gujarat's 25 districts in the early 2000s.[3] In parts of North Gujarat, groundwater tables had dropped so low that 'tubewell companies' of farmers replaced numerous individual-owned tubewells to share the large investment—and the risk of failure—associated with installing deep tubewells, fitted with 90 horsepower to 120 horsepower submersible pumps and buried pipeline networks for water distribution (Shah and Bhattacharya, 1993).

Gujarat has been by far the most proactive and advanced among Indian states to take cognizance of the groundwater depletion challenge. Recognizing that perverse subsidies to agricultural electricity supply is a major cause for groundwater depletion, Government first tried to correct these perverse incentives by metering tubewells. However, when farmer opposition to this proposal proved too strident, it implemented *Jyotigram Yojana* for rewiring the countryside separating tubewells from other rural electricity consumers and imposed a strict ration on farm power supply (Shah and Verma, 2008; Shah et al., 2008). The government also actively supported farmer movement for decentralized water harvesting and groundwater recharge (Shah, 2000, 2008). All these helped somewhat to alleviate groundwater depletion in some parts of the state, notably the hard-rock districts of Saurashtra where recharge efforts by local individuals and communities developed into a veritable mass movement that arguably helped to turn around the region's agriculture (Shah et al., 2009). Thanks partly to this

[2] A taluka is a sub-district administrative unit covering roughly 100–120 villages.
[3] <http://cgwb.gov.in/gw_profiles/st_Gujarat.htm> visited on September 25, 2007.