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Rising water table: A threat to sustainable agriculture in an irrigated semi-arid region of Haryana, India

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ABSTRACT

The sustainability of the rice–wheat cropping system in an irrigated semi-arid area of Haryana State (India) is under threat due to the continuous rise in the poor quality groundwater table, which is caused by the geo-hydrological condition and poor irrigation water management. About 500,000 ha in the State are waterlogged and unproductive and the size of the waterlogged area is increasing. We analyse the hydrology and estimate seasonal net groundwater recharge in the study area. Rainfall is quite variable, particularly in the monsoon season, and the mean monthly reference evapotranspiration shows a high inter-annual variation, with values between 2.45 and 8.47 mm/day in December and May. Groundwater recharge analysis during the study period (1989–2008) reveals that percolation from irrigated fields is the main recharge component with 57% contribution to the total recharge. An annual groundwater table rise of 0.137 m has been estimated for the study area. As the water table has been rising continuously, suitable water management strategies such as increasing groundwater abstraction by installing more tubewells, using the groundwater conjunctively with good quality canal water, changes in cropping patterns, adoption of salt tolerant crops, changes in water-pricing policy, and matching water supply more closely with demand, are suggested to bring the water table down to a safe limit and to prevent further rising of the water table.

1. Introduction

Water is the major limiting factor in crop production in arid and semi-arid regions (Jalota and Arora, 2002; Li et al., 2004; Ji et al., 2007), as annual rainfall is low and uncertain, crop water requirement is mainly supplied by supplemental irrigation. The large-scale introduction of canal irrigation in these areas has increased water availability (Chowdary et al., 2005). It also has intensified the process of soil salinisation by increasing waterlogging (Kumar and Singh, 2003; Wichelns and Oster, 2006) due to intensive seepage into the ground water. In arid and semi-arid areas, agricultural intensification and specialization have resulted in declining biodiversity and other environmental problems in agro-ecosystems (Krebs et al., 1999; Tilman et al., 2002). The search for self-sustaining agricultural systems is currently of major concern to researchers, farmers, and policy makers worldwide (Foley et al., 2005).

During the last few decades, the threat of soil and groundwater salinisation induced by irrigation has become a major issue in hydrology, agronomy, soil, and irrigation sciences (Tyagi et al., 1993; Kaledhonkar and Keshari, 2006). Because of its importance for food security and environmental conservation, water and salt balance studies have been receiving due attention at various research institutions worldwide (Cartwright et al., 2004; Kitamura et al., 2006; Rejani et al., 2008). Waterlogging and soil salinisation reduce the quality of soils and associated crop productivity (Upadhyaya and Chauhan, 2002; Oster and Wichelns, 2003; Sharma and Tyag, 2004); affect groundwater quality, and furthermore limiting the use of groundwater for agriculture and community supply (Kirchner et al., 1997).

An estimated 8.4 million ha in India are affected by soil salinity and alkalinity, of which about 5.5 million ha are, also waterlogged (Ritzema et al., 2008). Due to the 'Green Revolution' in India during the 1970s, a continuous expansion of farmland (Abrol, 1999; Singh, 1999; Jhorar et al., 2009), and dual cropping on existing farm land occurred in northwest parts of the country, particularly in Haryana and Punjab (Abrol, 1999). This generated the need for more canal water for irrigation, as rainfall in the area is not sufficient to satisfy crop water demands. Here the water table started rising and caused waterlogging and soil salinisation in western and central parts of Haryana State, including Rohtak and Jhajjar districts where groundwater is of poor quality (Boumans et al., 1988; Singh, 1999; Jhorar

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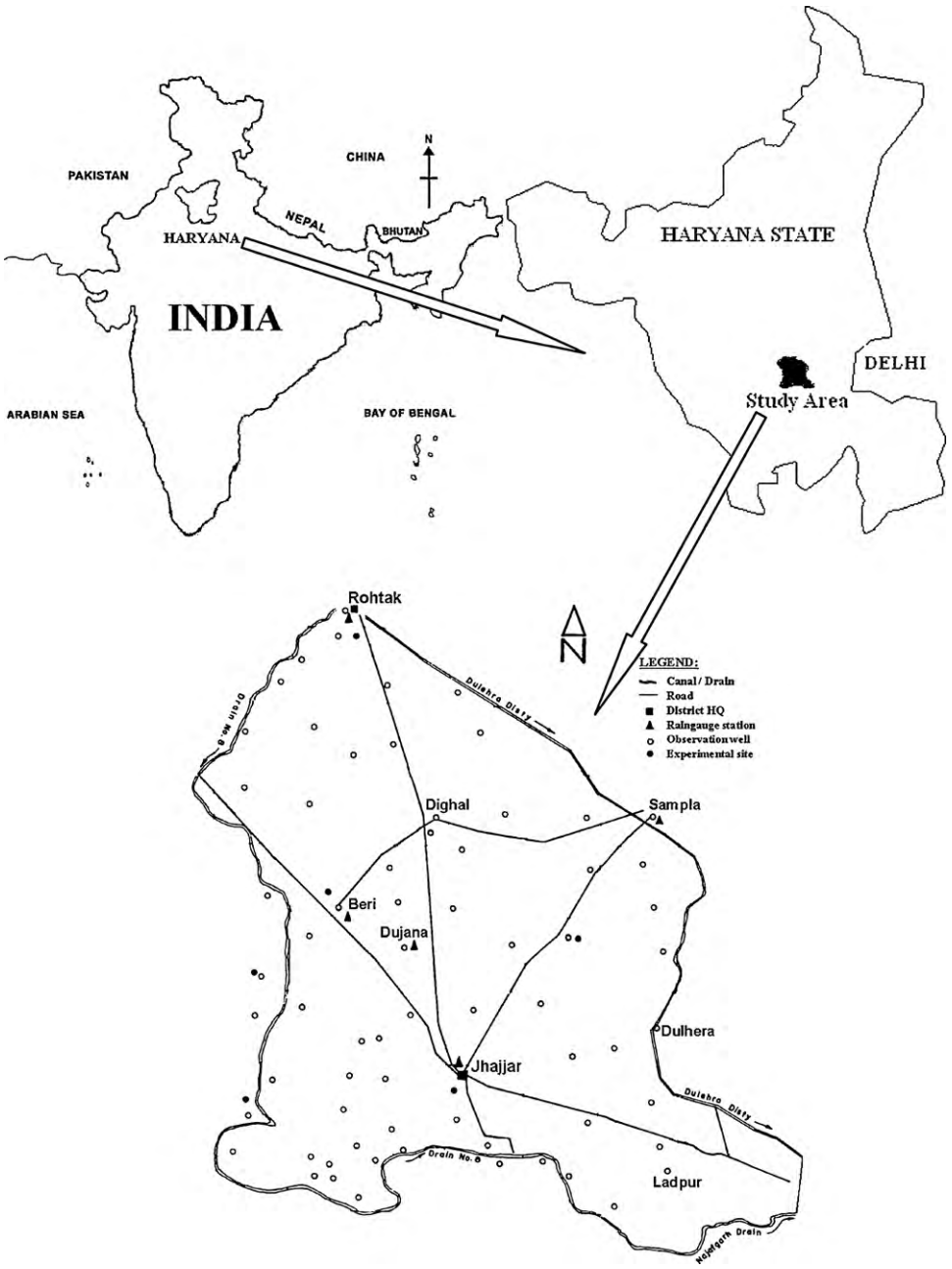

Fig. 1. Location map of study area with rain gauge stations and observation points.

et al., 2009). An estimated 500,000 ha of Haryana are waterlogged. In addition, the problem is spreading in more canal-irrigated areas and creating hydrologic imbalances. Water losses from irrigation systems and non-exploitation of saline ground water are the major factors contributing to this phenomenon.

We analyse the hydro-geological conditions of an area in Rohtak–Jhajjar districts of Haryana State, to provide an overview of the process dynamics that led to imbalance of the system.

2. Description of the study area

2.1. Location and topography

Haryana State is located between the Himalayan Mountains in the northeast and the Thar Desert in the southwest in an alluvial plane between the rivers Ghaggar and Yamuna (Kamra et al., 2002). Nearly all the cultivable land in the state is under rice–wheat cropping system, which requires more water than is available. As a consequence, groundwater development in some districts is more than the replenishable groundwater recharge and a large part of the North, East and South Haryana (except central and western part) is facing the problem of falling water table. However, in the study area, water table is rising, as, it is characterised by a geological and topographical depression in the centre and features mainly inland drainage conditions on an extensive closed basin (CCS Haryana Agril University, 1997). Thus, the State is facing the problem of both falling and rising water table in different locations.

Our study area lies between 28°30′N and 28°54′N latitude and 76°27′E and 76°54′E longitude and covers an area of about 92,000 ha. The area, which lies within the districts of Rohtak (24,783 ha) and Jhajjar (67,217 ha), is bounded by the Diversion Drain No. 8 flowing from North to South, which continues as Najafgarh Drain in a southeastern direction and the Dulehera Distributary bounding the area in an eastern direction (Fig. 1).