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Impact of land-use change on groundwater in the Punjab-Haryana plains, India

"Mahima" Department of Geography, M.D.U. University Rohtak

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Abstract The changes in Land use have mostly occurred locally, regionally and globally over the last few decades and will carry on in the future as well. The increase in imperviousness has a major impact on groundwater and is of major concern over the past years to those who are involved in groundwater studies. The increase in urbanization results in reduction in infiltration, which affects the groundwater recharge and storage. Thus, land use changes have to be evaluated properly using traditional as well as latest techniques viz. Remote Sensing and Geographical Information System (GIS). The increase in population leads to increase in food, fodder and fuel demands with rapid change in land use patterns. From the time when the human civilization started, mankind interdependence on environ- meant is greater, excess hunt of progress, comfort and security has resulted in augmented stress on the environment. Proper planning and management for development of natural resources without jeopardizing the environment is a vital concern to be sorted out for the world community. Quality inputs on the rate and pattern of land use change is essential for proper planning and management. Land use change pattern reflects the rate of change of groundwater recharge. It is necessary to detect the land use change in the past and present existing land use, and its spatial distribution and potential changes are essential prerequisites for planning and management. Proper land use planning and management is key to socio-economic up-liftmen of a region and country as a whole.

Keywords: Land Use; Groundwater; Infiltration; GIS; Remote Sensing.

INTRODUCTION: Groundwater is a major source of drinking water across the world and plays a vital role in maintaining the ecological value of many areas (IPCC, 2016). However, the quantity and quality of groundwater are changing due to human activity (Gehrels et al., 2016) jeopardizing the suitability of the groundwater system as a source of drinking water and affecting natural reserves. Assessing the impact on the groundwater system and predicting the magnitude of change in the future is therefore a major scientific challenge (Tang, 2015). Land-use and land-cover changes are one of the main human induced activities altering the groundwater system (Calder, 2015). Nevertheless, the impact of future land-use changes in the groundwater system has not been investigated extensively. Throughout the entire history of mankind, intense human utilization of land resources has resulted in significant changes of the land-use and land-cover (Bronstert, 2014). Since the era of industrialization and rapid population growth, land-use change phenomena have strongly accelerated in many regions. A Land-use change directly impact the hydrology of the catchment area (e.g. Bhaduri et al., 2016 Fohrer et al., 2001; Tang et al., 2005). The research on the impact of land-use changes on surface hydrology has therefore received considerable attention from both field observations and model simulations.

About 75-80% of human requirements for water are fulfilled by groundwater. Indecent studies it was observed that of the use of inorganic fertilizers has resulted in increasing nitrate and related pollution in groundwater. The Punjab-Haryana plains (India) are one of the most agriculturally productive regions in the world. The plains are rich in natural resources, including deep productive soils, adequate water supply, and favorable climatic conditions for agriculture resulting in two or more crops per year. Increased production and productivity that characterized the green revolution of the 1970s and 1980s came about due to a combination of factors including expansion of irrigated areas by the development of surface and groundwater resources and increased use of inputs, such as fertilizers, herbicides, and pesticides. Since then, water supply has been threatened due to degradation of water quality. Uncontrolled disposal of urban waste into water bodies, open dumps, and poorly designed landfills cause groundwater contamination (Singh, 1999, 2000). Groundwater pollution has become one of the most important toxicological and environmental issues in India. In January 1994 the Central Pollution Control Board (CPCB), Delhi, undertook the first major groundwater quality monitoring exercise. The report, published in December 1995, identified 22 locations in 16 states of India as "critical" sites of groundwater pollution, and the CPCB found industrial effluents to be the primary reason for groundwater pollution.

Groundwater development and problems in the Punjab-Haryana plains The green revolution in the states of Punjab and Haryana brought prosperity to the region, but problems of soil and water degradation emerged and have become increasingly important because these states make a significant contribution to national food security. The irrigated area in these states more than doubled between 1965 and 1995. Consequently, the major crops, which include rice, wheat and cotton, are totally irrigated in the region. The number of tube wells in the region has increased during the last three decades. Groundwater pumping has resulted in over-exploitation and groundwater table declines of up to 2 m in the last 20 years (Table 1). The groundwater table decline has forced farmers to lower the pumps and further deepen the wells, increasing the costs of pumping and energy use and thus decreasing the profitability and efficiency of agriculture. The government policy of providing a highly subsidized power supply to rural areas further aggravates the problem. The quality of the deep groundwater aquifers in most parts of Haryana is marginal and highly saline. Pumping water from greater depths could, therefore, result in the use of saline water for irrigation. Precaution in the use of groundwater is thus essential for a long-term sustainable agriculture (ICAR, 1998).

Impact of land use on soils and nutrient quality: There has been a marked change in soil fertility caused by changes in agricultural land use and practices during the green revolution (Singh, 2000). For example, 3% of the soil in 1980 had a low P content, and by 1995, 73% of soil had a low P content, whilst the area of soil with a low N content only increased from 89 to 91%o. Soils with a high K content decreased from 9 1% in 1980 to 6 1% in 1995 (ICAR, 1998). The rotation of crops, wheat and rice, is disturbing the balance of available nutrients in the soil and also is causing a deficiency of micronutrients, particularly zinc and copper. This process has a large implication for ground water quality.

Groundwater quality: other challenges and responses: Disposal of untreated mercury-contaminated effluent from caustic manufacturers has contaminated groundwater. Dumping of effluent and hazardous waste is common in industrial areas of India. Industries and factories release untreated effluents directly into the ground, contaminating underground aquifers. The mercury concentration in one sample was more than 270 times higher than the World Health Organization's drinking water standard (0.001 mg l"1). Groundwater in the industrial areas of northern India is unfit for even agricultural use. Groundwater pumped from a tube well bored to a depth of about 61 m by Suruchi Dyeing Udyog, a factory south of the GT Road in Ghaziabad, Uttar Pradesh, was yellow-colored and contained 0.54 mg l"1 paranitrophenol (an organic compound), a concentration much greater than the water quality standard of 0.001 mg l"1. It is likely that a factory in that area pumped untreated effluent into the groundwater. Because 80% of the country's drinking water is supplied by groundwater, the Facility for Ecological and Analytical Testing of the Indian Institute of Technology, Kanpur, conducted a groundwater survey to evaluate the extent of the groundwater contamination. There were traces of the heavy metals iron and zinc in all samples, cadmium in five samples and lead in three samples.

POLICY AND MANAGEMENT DEVELOPMENTS AND FUTURE CONSIDERATIONS: In order to address the issue of long-term policy on water-use, the following strategies are important: (a) technologies or strategies are needed to restore the water table to 1970 levels and to establish an appropriate use of fertilizers; (b) the water supply in areas with groundwater level declines needs to be replenished through artificial groundwater recharge. The rainy season surplus water, which typically is transported as storm flow, may be an appropriate source for the additional recharge; (c) on-farm irrigation water management should be given top priority to enable maximum productivity per unit of water and to avoid the development of water logging and soil salinity. This will require use of surface water in conjunction with groundwater. Between April and June, the recommended cropping pattern should include only crops that have low water consumption, particularly in those agro-climatic irrigation zones where groundwater is over exploited. Regional groundwater resources planning are needed for a 50 horizon. Aquifers may also be recharged by collected rainwater. The continuing change in the water quality status needs to monitored and evaluated and to this end, remote sensing techniques in pollution detection provide a promising new technology that is most effectively used in conjunction with traditional frequent sampling and continuous monitoring.

Conclusions: In the present study, a comprehensive review on the research works in the area of impact of land use change on groundwater has been carried out. The main findings of the study are as follows:

- Hydrologic effects of land change can be substantial and have both positive and negative consequences for humans at a variety of temporal and spatial scales.
- Water demand is forecast to increase world- wide, including in those areas already experiencing high water-stress. Certain land use and land cover changes, some of which are occurring at an accelerating rate, and have distinctly negative impacts on water resources.
- The impact of urbanization on groundwater has a major concern over past few decades, and in particular, for those involved in ground- water quantity and qualitative studies.
- Increment in impervious area due to urbanization results in decreased infiltration, and finally affecting the groundwater storage.

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