Groundwater in the Indo-Gangetic basin: evolution of groundwater typologies

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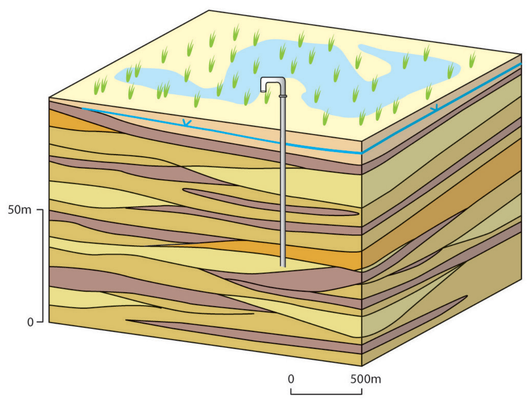
Introduction/Abstract

The Indo-Gangetic Basin comprises one of the world's most important aquifers. The basin is home to approximately 1 billion people and encompasses northern and eastern India, much of Bangladesh, parts of southern Nepal and the most populous areas of Pakistan. Despite the presence of large rivers, much of the basin's population are dependent on groundwater for drinking water, and the groundwater resource is highly exploited through an estimated 20 million boreholes to support a globally important agricultural industry. The security of supply from this aquifer is threatened by environmental change and increased abstraction. In order to help understand the aquifer and characterise its resilience to change we have developed a groundwater typology map for the basin.

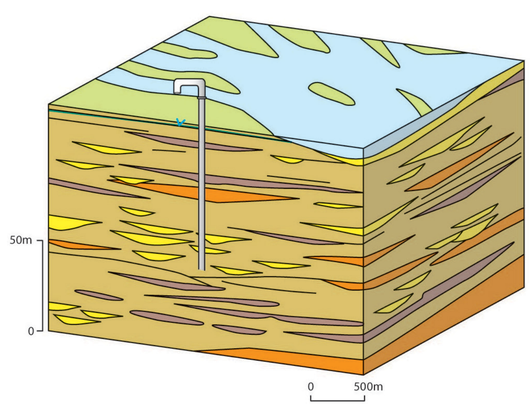
Indo-Gangetic Aquifer

The aquifer is divided into four main typologies based on its aquifer properties.

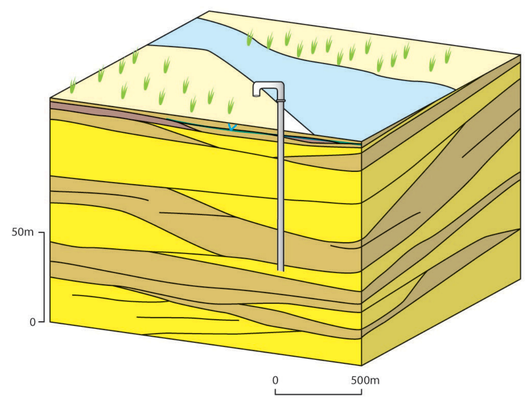
Pleistocene alluvium: a high yielding multilayered aquifer, typically 200–400 m thick, supporting boreholes with yields of 5–40 l/s. Deeper horizons >100 m are confined. Groundwater is often fresh but can become saline with depth, and towards the south, where recharge is lower. Aquifer material is generally well oxidised sediments.

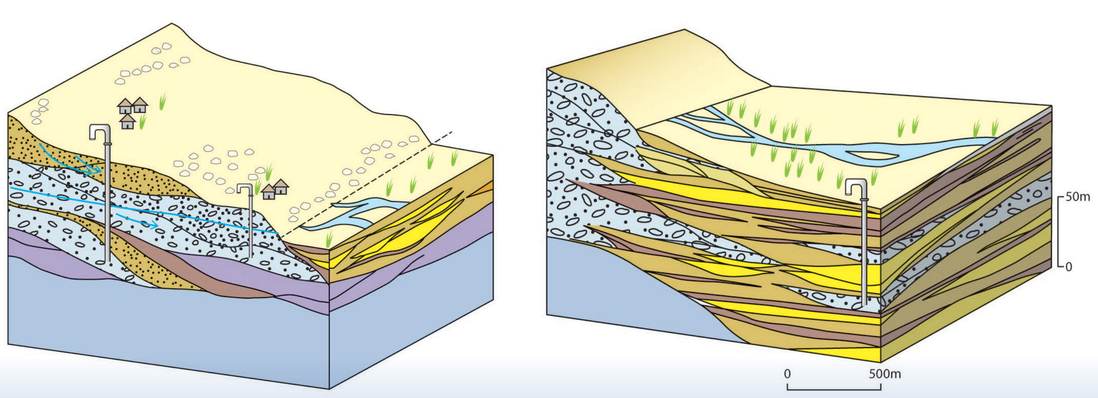


Holocene deltaic and tidal deposits: high to low yielding aquifer, typically 100–300 m thick. Borehole yields vary from 1 l/s–100 l/s. The multilayered aquifer has a high proportion of silts, therefore yields can be variable. Groundwater is often brackish due to saline intrusion and the impact of storm surges

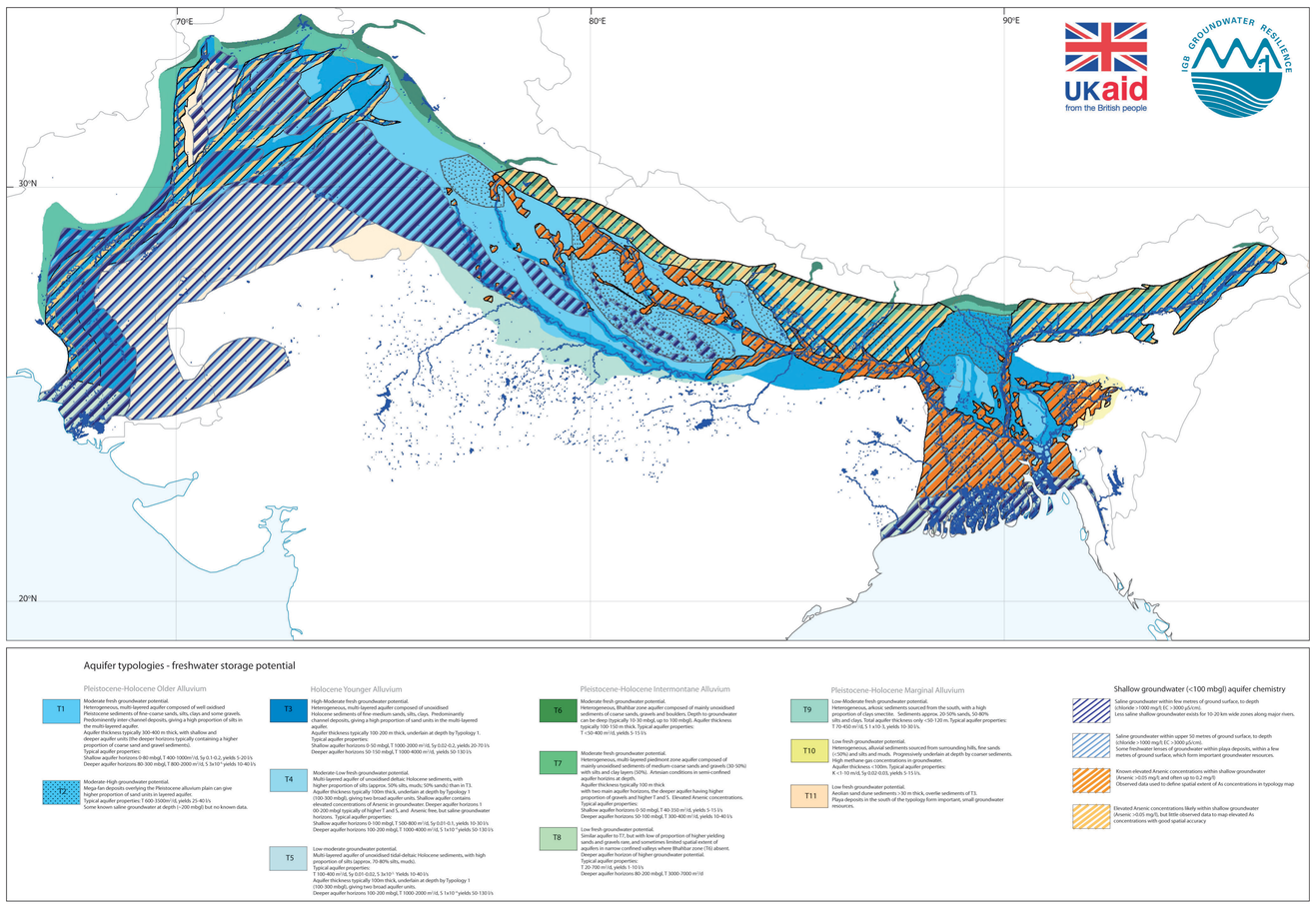


Holocene alluvium: very high yielding multilayered aquifer, typically 100–200 m thick, commonly supporting boreholes with yields of 20–100 l/s. The aquifer is generally underlain by older alluvium. The aquifer material can be unoxidised, and elevated arsenic concentrations are common; saline groundwater also occurs where recharge is low, or waterlogging common.



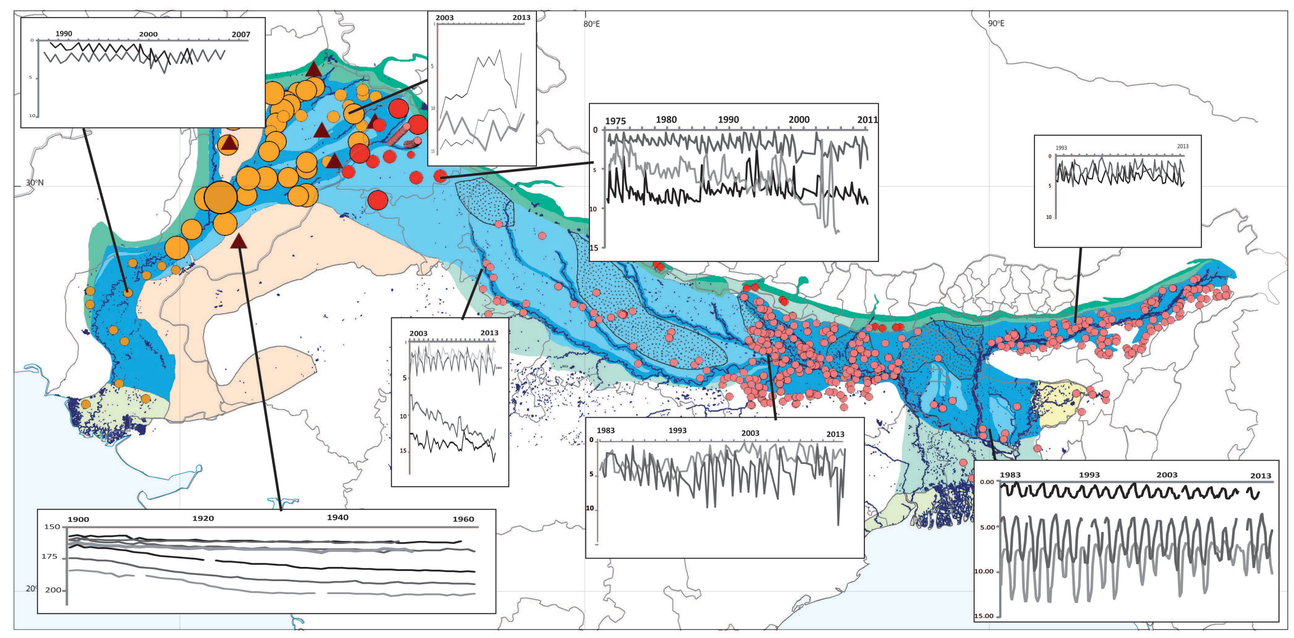


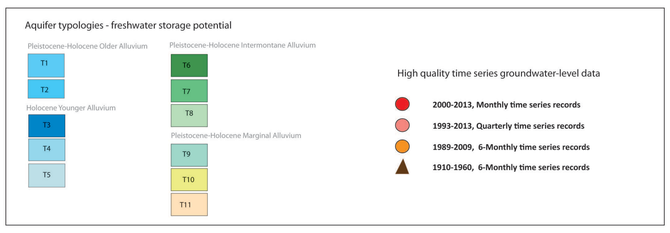
Pleistocene–Holocene piedmont deposits: moderate yielding, multilayered aquifer, typically 100 m thick and commonly supporting borehole yields of 1–15 l/s. Groundwater is generally fresh, but can contain elevated arsenic concentrations in places.



Groundwater response to climate and pumping

The groundwater resources have undergone major changes in the past 200 years: from (1) equilibrium conditions where groundwater was recharged by rainfall and river flow before 1850; to (2) large scale river irrigation leading to rising groundwater levels and salinisation (1860–1960s); (3) increased abstraction of shallow groundwater throughout the basin (1960s–2010); and now (4) an increased use of deeper groundwater (>100 m). Each typology represents a distinct part of the aquifer with similar groundwater dynamics, water quality or recharge characteristics.





Groundwater level data has been collated for the basin, with an emphasis on capturing monthly or quarterly data. Different responses are observed across the basin reflecting the interplay between rainfall recharge, recharge from irrigation, long term abstraction, and annual abstraction patterns. Although parts of the basin show evidence of falling water tables, this is not universal. There is evidence in some locations that increased groundwater abstraction has led to an increase in groundwater recharge. In the more intensely irrigated areas of the Punjab, groundwater levels are generally falling, however, this is not observed in the middle parts of the basin where abstraction is lower. At the scale of a canal command area, the pattern is more complicated by the balance between waterlogging from canal leakage and groundwater abstraction.

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