Supplementary Information: Complexity of the Indo-Gangetic aquifer system revealed by in situ observations

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Supplementary Table 1: Groundwater abstraction data sources

Pakistan

Cheema. M. J. M., Immerzeel ,W. W. & Bastiaanssen, W. G. M.. Spatial quantification of groundwater abstraction in the irrigated Indus Basin. *Ground Water* **52**, 25-36 (2014).

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India

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Bangladesh

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Rate of increase of abstraction

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Supplementary Table 2: Data sources for water-table records

India Central Ground Water Board (CGWB) groundwater-level quarterly monitoring data from Indian national groundwater level archive sourced from CGWB, National Data Centre, NH-IV, Faridabad (accessed Feb2014) Six monthly, groundwater level data courtesy of individual state government (Groundwater Directorate or Directorate/Water Resources) in Assam, Bihar, Punjab, Uttar Pradesh, West Bengal. (gathered Monthly groundwater-level monitoring data for Bist-Doab, Punjab, courtesy of Punjab State government 1975-2012.
Pakistan Pakistan Water and Power Development Authority (WAPDA) groundwater monitoring data records for Pakistan across both the Upper and Lower Indus Basin Irrigation System: six-monthly data for Sindh [some monitoring points of which were originally for the Salinity Control and Reclamation

Project (SCARP) Monitoring Organisation (SMO), and six-monthly for Punjab (collated by Department for Land and Reclamation Punjab of the Government department of Irrigation and Power, of the Punjab Irrigation and Drainage Authority Lahore, and deposited with WAPDA).

Some of these data are presented and/or summarised in the following reports and publications:

Basharat, M., Hassan, D., & Bajkani, A. A. & Sultan, S. J. Surface water and groundwater Nexus: groundwater management options for Indus Basin Irrigation System, International Waterlogging and Salinity Research Institute (IWASRI), Lahore, Pakistan Water and Power Development Authority, Publication no. 299, (2014).

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Shamsudduha, M., Chandler, R. E., Taylor, R. G., & Ahmed, K. M. Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta. *Hydrological Earth System Science* **13**, 2373–2385, (2009) *period covered 2003 - 2007*

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Groundwater Resource Development Board (GWRDB) District Monthly groundwater-level monitoring data 2000-2010**.**

GWRDB. Hydrogeological and groundwater potential maps for the Terai Pkains (1:125,000) Groiundwater Resources development Board. Ministry of Irrigation, Government of Nepal Kathmandu (1993)

Supplementary Table 3: Sources for spatial maps on depth to water-table

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Iqbal, R. M. & Hannan, A. 2012. Groundwater monitoring in Punjab: Analysis of trend in groundwater level and an overview of groundwater quality status (2012) *period covered 2001 – 2011*

Basharat, M., Hassan, D., Bajkani, A. A. & Sultan, S.J. *Surface water and groundwater Nexus: groundwater management options for Indus Basin Irrigation System*. International Waterlogging and Salinity Research Institute (IWASRI), Lahore, Pakistan Water and Power Development Authority,

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Bangladesh Shamsudduha, M., Chandler, R. E., Taylor, R. G., & Ahmed, K. M. Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta. *Hydrological Earth System Science* **13**, 2373–2385, (2009) *period covered 2003 - 2007* Shamsudduha, M., Taylor, R. G., & Longuevergne, L., Monitoring groundwater storage changes in the Bengal Basin: validation of GRACE measurements. *Water Resources Research* **48**, W02508 (2012). *Period covered 2003 - 2007*
Nepal Geoconsult. 2012. Study of tube well inventory of 22 Terai and Inner Terai Districts, Nepal. Groundwater Resources Development Board, Ministry of Irrigation, Government of Nepal, Kathmandu (2012). *Period covered 2011*

Supplementary Table 4 Sources for water quality maps

Pakistan IWASRI *Drainage Atlas of Pakistan*. (International Water Logging and Salinity Research Institute, Lahore, 2005). WAPDA. *Hydrogeological map of Pakistan (scale 1:250,000*). (Directorate of Hydrogeology, WAPDA, Lahore, 2001).
India CGWB. *Groundwater quality in shallow aquifers of India*. (Central Groundwater Board, Ministry of Water Resources, New Delhi, 2010) Central Groundwater Board District Groundwater Information 2013 (accessed online July 2014)
Bangladesh Ravenscroft, P., Ahmed, K. M. & Samad, M. A., *Groundwater: Quantity and Quality Issues Affecting Water Supply*. Sector Development Plan (FY 2011-25), Working document number 9, Water Supply and Sanitation Sector in Bangladesh. Policy Support Unit, Local Government Division, Government of Bangladesh. (2009) DPHE/ BGS. Arsenic contamination of groundwater in Bangladesh. Kinniburgh DG & Smedley PL (eds). British Geological Survey Technical Report WC-00-19 (British Geological Survey, Keyworth, 2001)

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Geoconsult. 2012. Study of tube well inventory of 22 Terai and Inner Terai Districts, Nepal.

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Arsenic

Amini, M. et al. Statistical Modelling of Global Geogenic Arsenic contamination in groundwater, Environmental Science and Technology, 42; 3669–3675 (2008)

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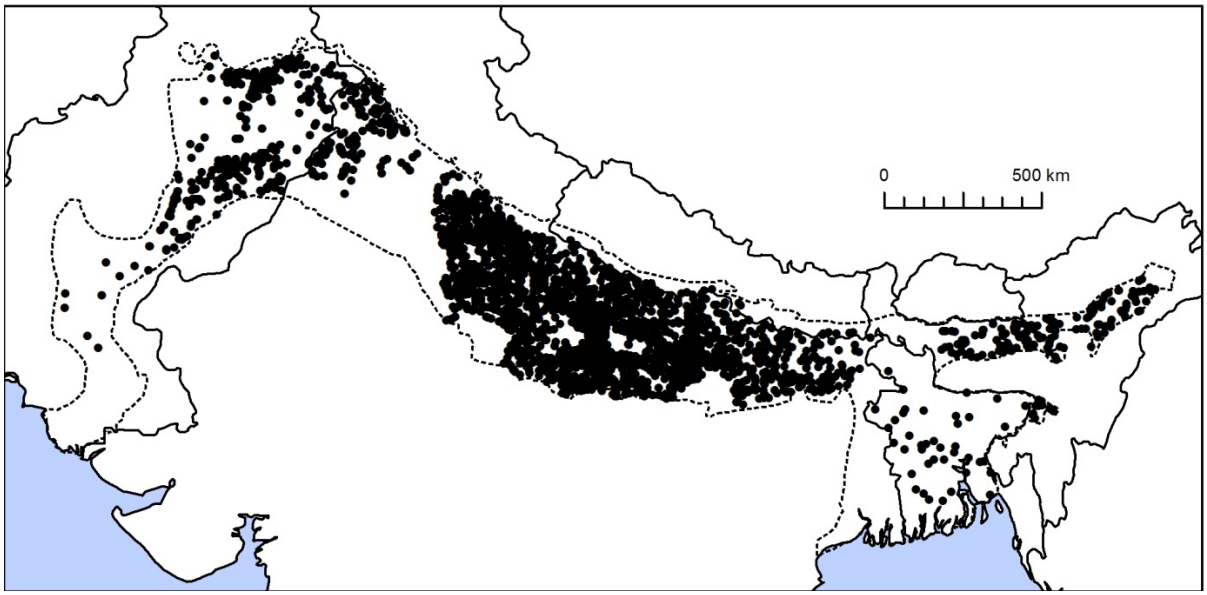
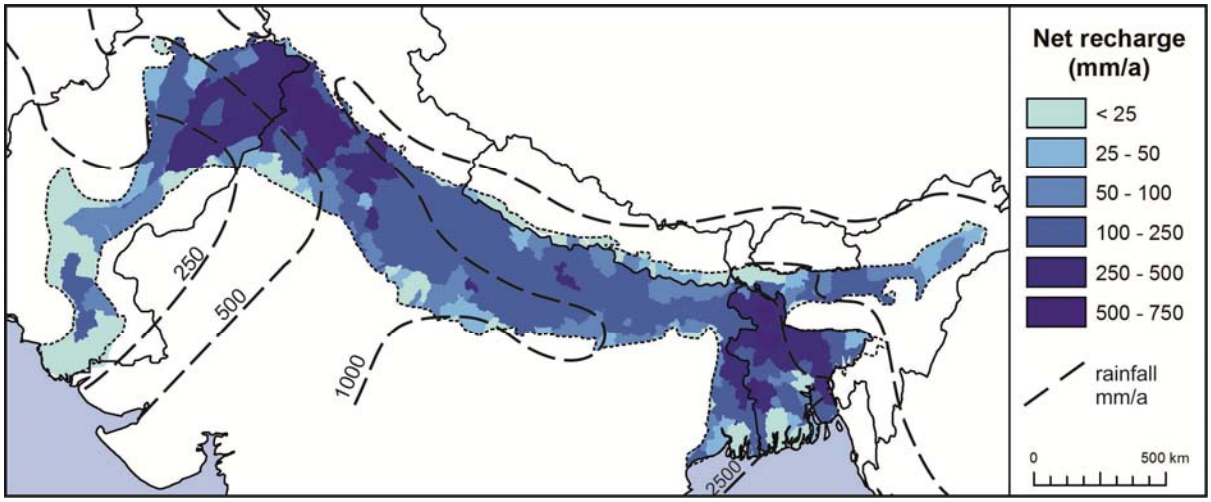
WAPDA. *Hydrogeological map of Pakistan (scale 1:250,000*). (Directorate of Hydrogeology, WAPDA, Lahore, 2001).



Supplementary Figure 1 Distribution of the finalised water-table time series record dataset for the IGB aquifer. There are 3652 individual time series, each with 7 years or more data and 2 or more records per year.



Supplementary Figure 2 Annual net recharge for the IGB aquifer over the period 2000 - 2012, calculated by subtracting the annual change in groundwater storage from the annual abstraction. The net recharge is therefore the volume of recharge required to balance the abstraction. This may be met from a combination of reduced groundwater discharge and annual direct and indirect recharge. In areas of high rainfall (>1000 mm) the recharge could be dominated by rainfall. In areas of low rainfall, (<500 mm) the recharge will be dominated by irrigation returns and canal leakage. In areas of moderate rainfall (500 – 1000mm) recharge is likely to be met by a combination of canal leakage and rainfall recharge.