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Collaborative Adaptation Research Initiative in Africa and Asia

HI-AWARE

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Socio-economic Development, not Climate Change, the Main Driver of the Future Water Gap in the Indus, Ganges and Brahmaputra Basins

About HI-AWARE

HI-AWARE aims to enhance the adaptive capacities and climate resilience of the poor and vulnerable women, men, and children living in the mountains and flood plains of the Indus, Ganges, and Brahmaputra river basins. It seeks to do this through the development of robust evidence to inform people-centred and gender-inclusive climate change adaptation policies and practices for improving livelihoods.

The HI-AWARE consortium is led by the International Centre for Integrated Mountain Development (ICIMOD). The other consortium members are the Bangladesh Centre for Advanced Studies (BCAS), The Energy and Resources Institute (TERI), the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (CAEWRI-PARC) and Wageningen Environmental Research (Alterra). For more details see www.hi-aware.org.

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Key Message

Water consumption in downstream areas of the Indus, Ganges, and Brahmaputra (IGB) basins is projected to increase by 24%, 42% and 107%, respectively, during the 21st century.

Water use for industrial and domestic purposes is projected to increase three to seven fold. Although it is currently small compared to the volume of water used in agriculture, it will form a significant portion of total water use in future.

Mean annual water availability is likely to increase by 36-42%, 37-46% and 17-46% in the Indus, Ganges and Brahmaputra, respectively, due to an increase in precipitation that is projected consistently across climate models for all three river basins .

The increase in water availability will be stronger in the upstream parts of the three basins, which will increase the dependency of downstream water users on upstream water resources.

We estimate that the current blue water gap, based on unsustainable groundwater withdrawals, is 83 km^3/year in the Indus and 35 km^3/year in the Ganges, and will increase by 7% and 11% towards the end of the century. Socio-economic developments leading to increased demand are the main driver of the increasing water gap.

Introduction

The availability of sufficient and clean freshwater resources is essential for about 900 million people living in the mountains and densely populated plains of the Indus, Ganges and Brahmaputra river basins (IGB).

The water supply in the IGB originates from 3 major sources: precipitation induced rainfall-runoff that is mainly available during the monsoon in summer, glacier and snowmelt in spring and summer, and groundwater. In some of the most intensive agricultural systems, groundwater levels are already declining at rapid rates, a situation that is unsustainable and indicating that there is already a gap between water requirement and water availability.

It is expected that, due to climate change, the amount and timing of both meltwater and monsoon water availability will change. At the same time, rapid and continuous population growth and economic development will increase water demand in the coming decades.

In HI-AWARE we have made an assessment of current and future water availability and water demand, by accounting for the effects of climate change and expected socio-economic developments. This assessment was done at high spatial and temporal resolution, to be able to indicate where and when a water gap can be expected, and the drivers behind it. These insights form important information for policy makers who need to decide on the most effective measures to decrease the gap.

Major Findings

HI-AWARE conducted an assessment of the future changes in water supply, demand, and gap in the IGB. We first developed a high resolution representative climate dataset for the future, based on the latest available global climate model output (Lutz, et al., 2016). At the same time, we developed scenarios for land use change, irrigation water demand and demands of households and industries (Wijngaard et al., 2018). A detailed modelling framework was developed to represent all important processes that influence water availability and demand, i.e. snow and glacier melt, double cropping, irrigation water supply through canals, groundwater depletion, and the operation of large reservoirs. We then calculated potential changes in water availability based on those climate change scenarios for the Indus, Ganges and Brahmaputraa river basins. In order to do so, both the changes in monsoon precipitation and changes in snow and glacier melt were taken into account. We also calculated changes in water demand by taking into account the latest projections regarding population, economic growth, and land use changes.

Our findings indicate that the mean annual water availability in the Indus, Ganges, and Brahmaputra basins is likely to increase due to increasing monsoon precipitation that is projected consistently across climate models (Figure 1).

This increase is 36-42%, 37-46% and 17-46% between the end of the 21st century and 2010 in the Indus, Ganges and Brahmaputra river basins, based on the ensemble mean projections for climate scenarios RCP4.5 and RCP8.5. Despite an expected expansion of irrigated area, the demand for irrigation water might not increase that much because of increases in precipitation in upstream and downstream areas and a shortening of the growing season due to higher temperatures. However, other socioeconomic developments in these areas will generate new and greater demand for water for industrial and domestic purposes. Assessing their combined effects using our improved modelling framework, we demonstrate that the blue water gap in the IGB will increase in the future in all three basins, mainly driven by the expected socio-economic developments (Figures 2 and 3).

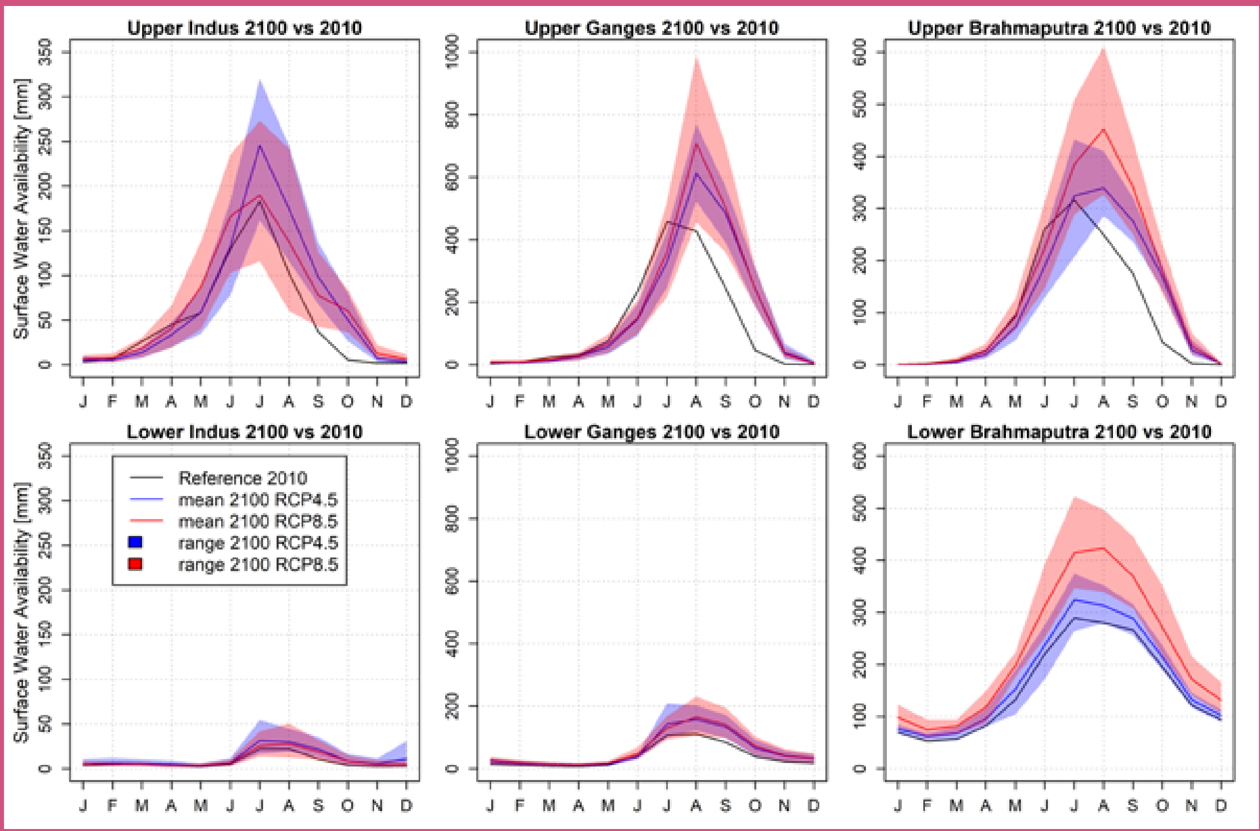

Figure 1. Current and future monthly water availability in the Indus, Ganges and Brahmaputra.

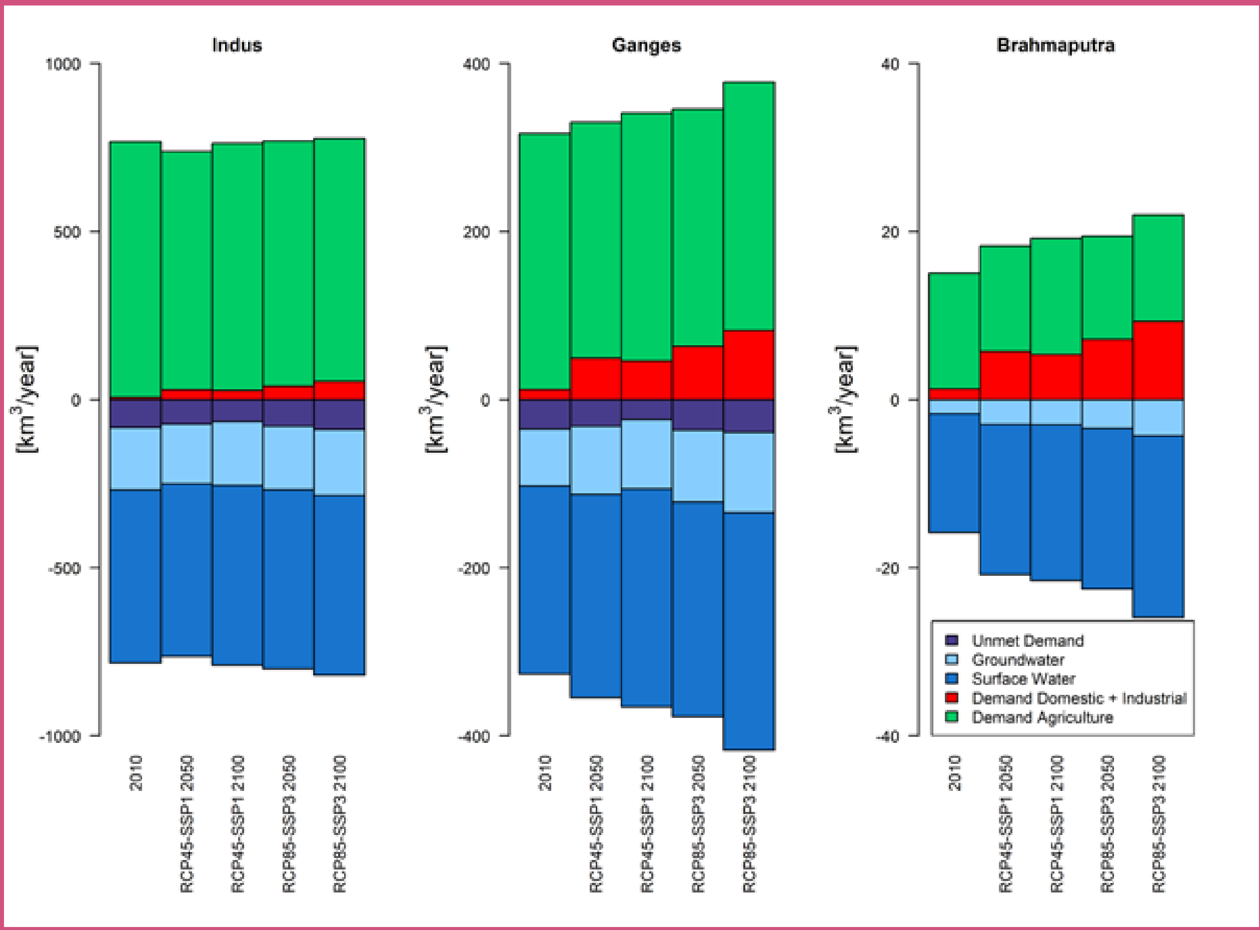

Figure 2. Current and future (RCP4.5-SSP1 and RCP8.5-SSP3 around 2050 and 2100) water demand for irrigation and other users versus supply from surface and groundwater, including its non-renewable part (unmet demand).

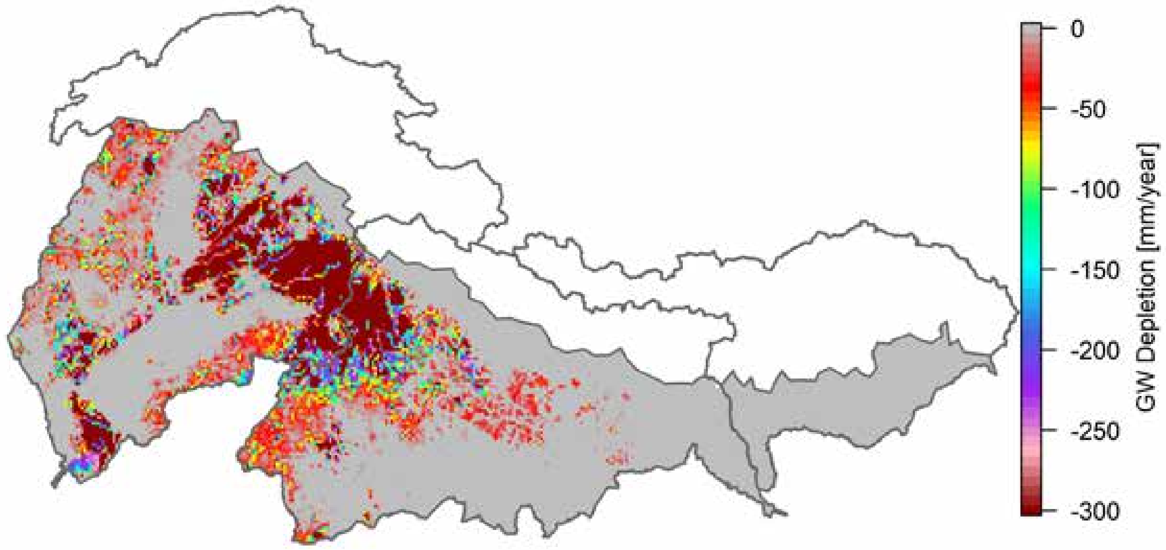

Figure 3. Water gap defined as projected annual unsustainable groundwater depletion towards 2100 under a RCP8.5-SSP3 scenario.

Policy Action

An increased understanding of the drivers of the current and future water gap in South Asia will help raise awareness about the magnitude, timing, and location of future water stress. This detailed analysis and improved understanding of the drivers underlying water stress identifies areas in which action should first be taken, as well as directions for solutions.

Although the increase in irrigation water demand might not be as strong as the increasing demand by other users, agriculture will still remain the largest water user. Efficiency improvements in irrigated agriculture will therefore be needed, especially in regions where the dependency on already depleting groundwater sources is high. At the same time, we would advise to anticipate the strong increase in water use by other sectors by promoting effective water saving measures for these sectors, especially in regions like the Punjab where groundwater depletion is expected to increase.

Looking Ahead

Socio-economic development, especially population and GDP growth, will lead to a strong increase in the demand for water by the domestic and industrial sectors in the downstream areas of the Indus, Gangs and Brahmaputra basins. Irrigation demand will increase less; although there is a projected expansion of irrigated area leading to increased demand, a shortening of the growing season might offset this increase. Availability of water will increase due to greater precipitation. Therefore, the socio-economic developments are the key driver of the future water gap in the region. An improved understanding of the water stress will help inform priorities and policy actions.

This brief is based on the following HI-AWARE publications:

Biemans, Hester, Siderius, Christian, Mishra Ashok, and Ahmad, Bashir (2016). Crop-specific seasonal estimates of irrigation-water demand in South Asia. Hydrol. Earth Syst. Sci., 20 (5), 1971–1982. https://doi.org/10.5194/hess-20-1971-2016.

Lutz, Arthur F., ter Maat, Herbert W., Biemans, Hester, Shrestha, Arun B., Wester, Philippus, and Immerzeel, Walter (2016). Selecting representative climate models for climate change impact studies: An advanced envelope-based selection approach. Int. J. Climatology. https://doi.org/10.1002/joc.4608.

Wijngaard, Rene R., Biemans, Hester, Lutz, Arthur F., Shrestha, Arun B., Wester, Philippus, and Immerzeel, Walter. (2018). Climate change vs. socio-economic development: Understanding the future South-Asian water gap. Hydrol. Earth Syst. Sci., Discuss., 30–36, https://doi.org/10.5194/hess-2018-16.

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