Global water marginal cost curves to battle the future water gap

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Introduction

Water scarcity affects a major part of the globe, and is expected to increase significantly until 2100 as a result of climate change and socioeconomic developments. Yet, global projections are unavailable on the effectiveness and costs of adaptation measures to close the future water gap under global change. **Here, we present water marginal cost curves under two climate and socio-economic scenarios with maximum contrast for the 21st century: RCP2.6 / SSP1(s1) and RCP8.5 / SSP5(s5).**

Methods

We coupled a global hydrological model to a water demand and redistribution model (Fig. 1), and forced them with five General Circulation Models (GCMs) to assess the future water gap for 1604 water provinces (Fig. 2) covering the global land mass. Subsequently, we determined the water gap reduction from adaptations.

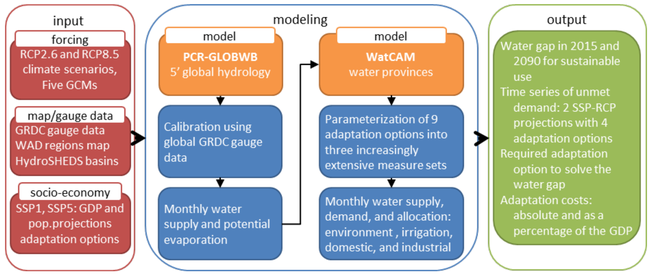

Figure 1 Overview of the workflow

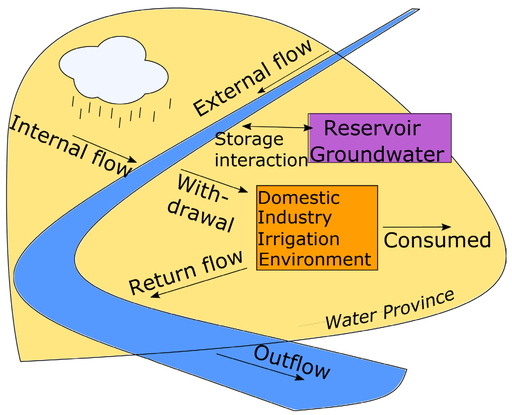

Figure 2 Water provinces: intersection of administrative areas and major basins used to aggregate model output

Results

The current and future water gap, based on sustainable exploration of surface and groundwater, showed hotspots in the USA, India, and China (Fig. 3). The total annual water gap in the period 2006 – 2025 increased gradually towards the end of the century (2080-2099) for the s1 scenario, but even more for the s5 scenario (Fig. 3).

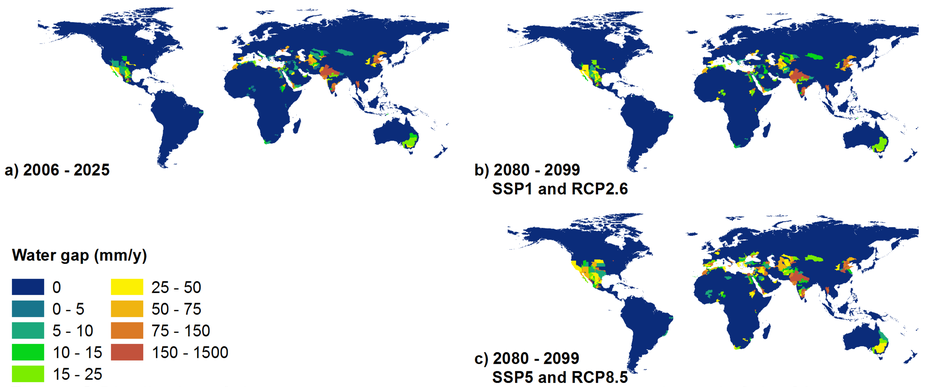

Figure 3 Distribution of the water gap at present and for scenarios at the end of the 21st century.

The envelope of the global annual water gap (km³) showed large differences between 2006 and 2099 under the two most extreme climate and socioeconomic scenarios (Fig. 4, 5). The four adaptation options were unable to close the water gap globally. Adaptations consisted of

1. improving the water efficiency of agriculture (Imp.Agr.),
2. Imp.agr combined with increasing the supply by increasing the reservoir capacity (Inc.Sup.), and
3. Inc.Sup plus a reduction in the water demand (Red.Dem.)

The water marginal cost curves (Fig. 6) indicate the extent to which the water gap can be closed with the current selected adaptation options. For s1, the gap can only be closed in South Americal, but large gaps remain in other continents. For s5, around 50% of the water gap can be closed with these measures. Already for the current adaptation measures, a significant fraction of the GDP is required, even for s1 (Fig. 7)

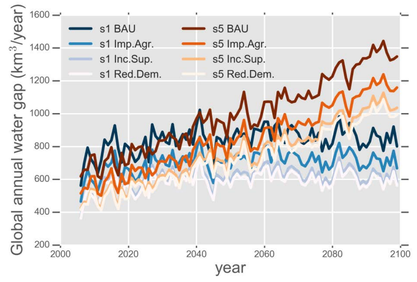

Figure 4 Scenarios of annual water gap for two climate and four adaptation scenarios.

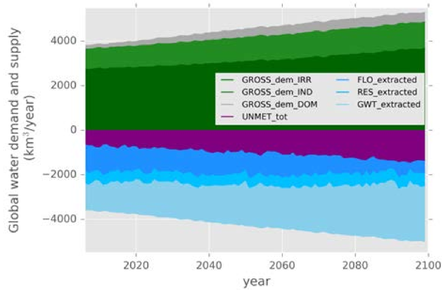

Figure 5 Water demand and supply between 2006 and 2100 (km3 year-1) for the s5 BAU scenario.

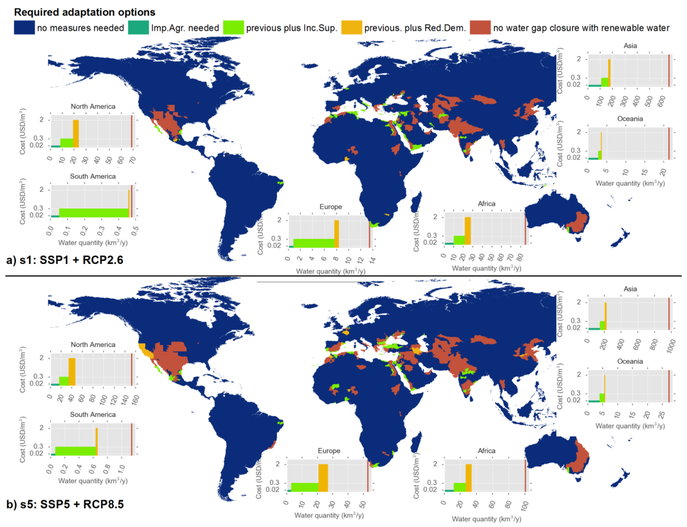

Figure 6 Water marginal cost curves per continent for two scenarios

Conclusion

We found distinct global effects on the water gap due to climate and socioeconomic projections after 2045, and we demonstrated the impossibility of water gap closure with either hard or soft measures, when minimum river flows should be maintained, under growing domestic, industrial and agricultural water demands. The results provide important input to the discussion on climate change adaptation funding. Especially for developing economies, these adaptations limit further growth.

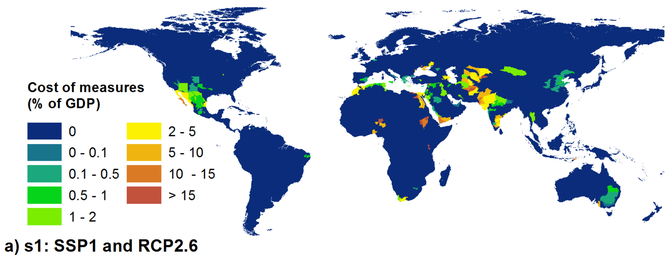

Figure 7 Cost of required measures as a percentage of the GDP.