



## **A lowland view on highland water resources from mid-20th to mid-21st century**

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The world's highland areas (i.e. mountains, elevated plateaux and hills) often provide disproportionately high runoff to the subjacent lowlands. While this disproportionality is well known today, the extent to which the lowlands actually depend on highland runoff contributions has not been examined so far. We therefore take a new viewpoint here and map and quantify for the first time the number of lowland inhabitants depending on highland water resources world-wide.

Our analysis is based on the high-resolution Global Hydrological Model PCR-GLOBWB v2.0 (5 arc minutes, ~9 km at the Equator) and spans a timeframe from 1961 to 2050. We incorporate the changing conditions of both runoff and water consumption and can therefore quantify changes in the Anthropocene era as well as make projections for mid-21st century using a business-as-usual scenario (RCP6.0-SSP2 pathway).

We show that the number of lowland inhabitants critically depending on essential runoff contributions from highlands is projected to grow from ~0.2 billion (8% of world's lowland population) in 1961–1970 to ~1.4 B (23%) in 2041–2050. This growth is mainly due to increased local water consumption in the lowlands and turns out particularly marked in mid-latitude regions of the Northern Hemisphere, which also provide the greatest share of food supply. There, more than one quarter of the region's lowland population of ~3.1 B is projected to critically depend on highland runoff contributions in 2041–2050.

Extending our view to food security, we also show that one third of global lowland area equipped for irrigation is currently located in regions that both depend heavily on runoff contributions from highlands and make unsustainable use of local blue water resources. This figure is likely to rise to well over 50% in the coming decades.

The results of these analyses highlight the critical importance of highland-lowland hydrosolidarity and imply that the contribution of highlands should receive particular attention in basin-wide water resources management and in lowland food production. Furthermore, they underscore the special protection and attention highlands deserve in efforts towards sustainable development.