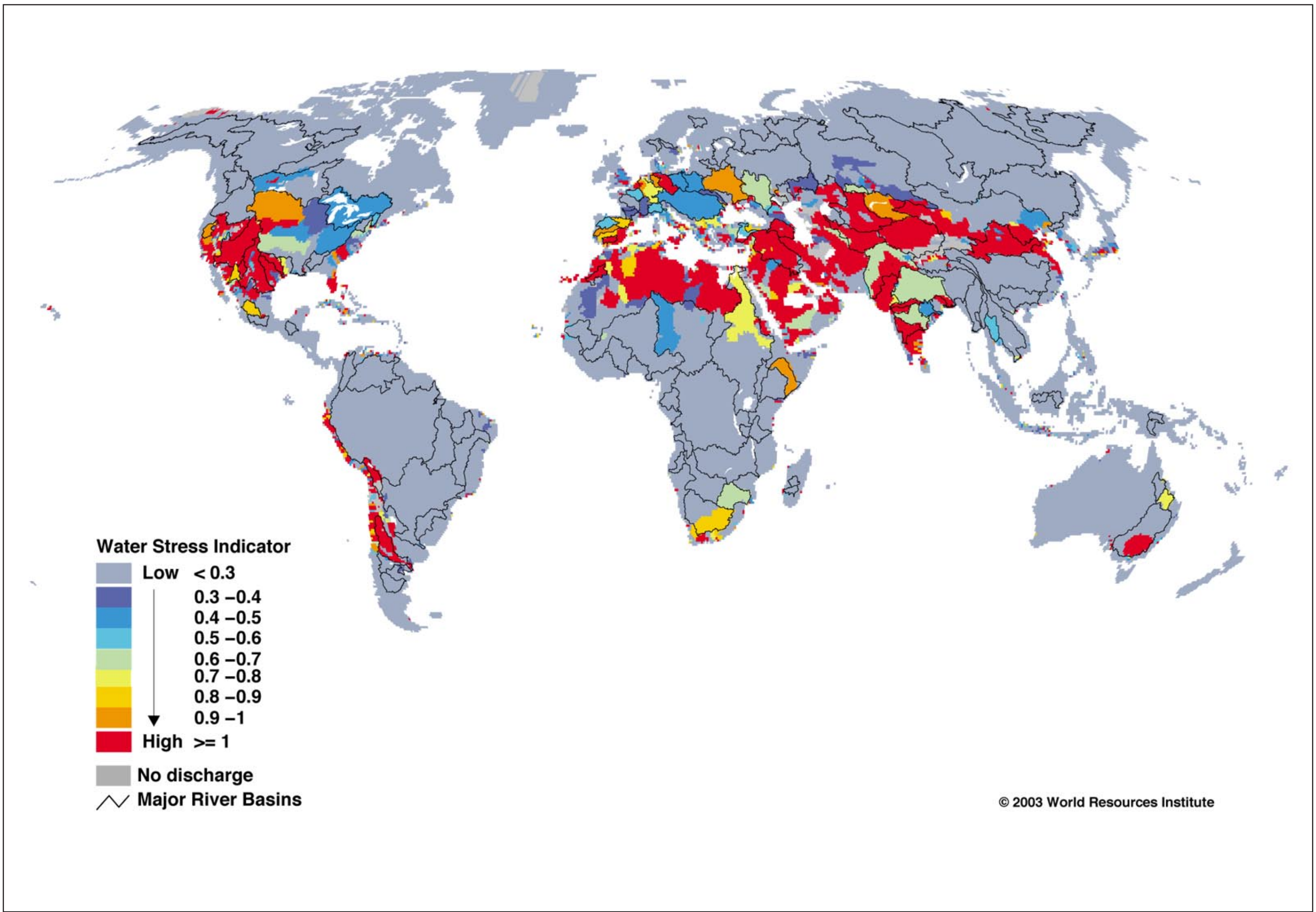
Watersheds of the World : Global Maps

16. Environmental Water Scarcity Index by Basin



Map Description

There is a growing awareness that increased water use by humans does not only reduce the amount of water available for industrial and agricultural development but has a profound effect on aquatic ecosystems and their dependent species. Human activities have severely affected the condition of freshwater ecosystems, to a point where many freshwater species are facing rapid population declines or extinction.

Every aquatic ecosystem requires a certain amount of water to sustain their ecological processes and their animal and plant communities. The prevailing pattern of water flow that is typical of a particular river over a given time varies widely from one basin to another. Some rivers naturally have stable flow regimes, while in others it varies from low discharges during dry months to very high peaks during the short wet season. Ecosystems and the native species inhabiting them are adapted to these flow regimes and rely on them for their survival. In order to maintain the ability of freshwater ecosystems to support fish production and biodiversity, their environmental water requirements must be established and sustained.

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Recognition of the need to establish environmental water requirements, has resulted in the development of concepts such as environmental or instream flow requirements, or environmental water allocations. Methods used to estimate environmental water demand range from purely hydrological models to holistic multidisciplinary methodologies. Determining environmental water requirements for an ecosystem involves identifying those aspects of the natural hydrological regime that are most important for maintaining its key ecosystem features and processes. It is also important to identify the risks of further ecological degradation, should the ecosystem's environmental water requirements not be met. Information and understanding of the ecological processes of aquatic ecosystems and the impacts of changing flow regimes on these processes and species assemblages, however, is currently lacking for most of the world. At the global level, it is therefore only possible to consider rough estimates of environmental water needs using hydrologically-based methods.

This map provides a first global picture of environmental water scarcity by basin based purely on a hydrological model. In this map, the term environmental water scarcity (represented as a water stress indicator on the map), refers to cases where the amount of water removed from the system puts the ecosystem at risk by tapping into the environmental water demand-–that is, the amount of water needed to sustain the integrity of the ecosystem. This concept is similar to the human water scarcity measures that put people and development at risk when there is not enough water to meet their needs. The map shows that in many parts of the world we are tapping into the water that is needed to sustain healthy ecosystems and their dependent species, as well as damaging the livelihoods of fishers and local communities that depend on these water resources.

The water stress indicator in this map measures the proportion of water withdrawal with respect to water available to human use. Water available to human use is equal to the total amount of water available in the basin minus the estimated environmental water demand (the water needed by the ecosystem to sustain its integrity). Basins with a water stress indicator above 0.4 are already considered, from an ecosystem perspective, as areas under environmental stress. Basins with a stress indicator higher than 0.8 (orange and red areas in the map) are considered environmentally highly-stressed basins.

Three examples of basins where over-abstraction of water is causing problems to the ecosystem and to the people that depend on the environmental services that the ecosystem provides, include the Murray-Darling Basin in Australia, the Huang He Basin in China, and the Orange River Basin in Southern Africa. Both the Murray-Darling and Huang He have a water stress indicator greater than 1, while the Orange River basin has a water stress indicator of 0.8-0.9. The Huang He River Basin is an extreme example of human and environmental water scarcity. The river has nearly reached the level of complete water resource exploitation, with the duration of low flow periods in the river increasing from forty days in the early 1990s to two hundred days in 1997. This has placed enormous stress on the more than 100 million people in the basin, their capacity to grow crops, as well as taken a toll on the freshwater species and habitats. The basin can be defined as an area in crisis both for people and nature.

The results of this first attempt to calculate environmental water scarcity by basin points to the urgent need to set and implement environmental water requirements for river basins and to conserve other important freshwater habitats such as wetlands and floodplains. Although it is no longer appropriate to manage water in a fragmented and sectoral manner, management of this type has prevailed with entrenched institutional structures. To achieve sustainable development, future water management will require an ecosystem approach, which recognizes that adequate water supply and development objectives are dependent on protecting functioning ecosystems. Basin-level dialogues among different users, including local communities, to negotiate and agree on the allocation of water resources, in combination with improved data on water availability, water use, and water quality, and improved information on ecosystem requirements, can lead to a range of technical, political, and financial measures to prevent water scarcity in the future and to meet development needs while maintaining functioning ecosystems.

Mapping Details

The map was developed based on basin-specific information on river discharges and water use simulated by the global water model WaterGAP 2 (Alcamo et al., 2003; Döll et al., 2003) and a simple conceptual rule for estimation of environmental water requirements from simulated hydrological records. The WaterGAP 2 model has a spatial resolution of 0.5° by 0.5°, and carries out the calculations for over 67,000 cells over the entire globe. It simulates the impact of demographic, socioeconomic, and technological change on water use as well as the impact of climate change and variability on water availability and irrigation water requirements. The data sets used include simulated monthly river discharges for the period 1961-1990 and the computed total water use around 1995.

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Because the conservation of aquatic ecosystems should be considered in the context of natural variability of a flow regime (taking into account both low flows and high flows), the method used to develop environmental water demand for this map incorporates these two flow regime components. The environmental low flow measure ensures the basic requirements of aquatic life throughout the year. The environmental high flow measure is important for wetland flooding, aquatic species, and riparian vegetation. The environmental low-flow requirement used in this model is equal to the monthly discharge value that is exceeded nine out of ten months, referred to as monthly Q90. The high flow component ranged from 5-20 percent and was established based on empirical case studies from South Africa, and following a rule-of-thumb associated with the Q90 values of different flow regimes. It should be noted that the resolution of the data and methodology used need further refinement; therefore these values should be interpreted with caution.

Map Projection

Robinson

Sources

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