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Sustainable management of water in an arid region: water supply measures compared

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Water shortages in water stressed regions can be alleviated by building large infrastructures, such as water transfer systems or saltwater desalination plants, which increase the supply of water. However, a new study, which compares the environmental impact of water supply alternatives in a region of Spain, concludes that reducing water use, rather than increasing supplies, is a more sustainable solution.

An expanding global population, with competing demands for water from domestic, industrial and agricultural users, particularly in arid regions, is placing an ever greater strain on water resources. This scarcity also threatens the availability of water needed to sustain aquatic and terrestrial ecosystems.

The Segura Basin in southeast Spain is one such water-stressed region. It receives around 400 mm of rain a year and periodically faces droughts. There is insufficient water to meet annual demand of around 1483 Mm^3 (million cubic metres). Local surface water availability, mainly stored in reservoirs, is only around 318 Mm^3 in an average year.

To meet the annual water demand for crop irrigation (about 1117 Mm^3), urban consumption (336 Mm^3) and water allocated to maintain ecosystem functions (30 Mm^3), water is transferred to the region via the pipes, canals, aqueducts and tunnels of the Tajo-Segura water transfer system and supplied from saltwater desalination plants. Any further local water deficits are met by extracting groundwater. Some aquifers are carefully controlled, and a balance is maintained between recharge and extraction. However, others are overexploited.

This study investigated the environmental impact of alternative means of supplying water for irrigation, urban and environmental purposes in the region. It used a life cycle approach, covering the construction, operational and dismantling phases of supply, to compare the impact of two external sources: the Tajo-Segura water transfer system and seawater desalination. It also compared the impact of using two local water sources – natural surface waters and groundwater resources. Environmental impact was judged in terms of damage to human health and ecosystems, and resource availability.

Additionally, the researchers estimated the life cycle impact of water used in urban areas (including drinking water and wastewater treatment), for irrigation and for the environment, to see whether expanding supply options would be feasible, as current rates of local water depletion are unsustainable. For example, water used for drinking purposes requires the construction of plants and infrastructure to make the water fit for consumption and wastewater from industry needs to be cleaned before being returned to the environment. Furthermore, uncontrolled extraction of groundwater (used for irrigation) can reduce the amount of water available to aquatic and terrestrial ecosystems.

Using information from public authorities and previous research, the researchers developed four scenarios of water availability: (i) a base case derived from an average year's (2009) water demand and water supply; (ii) a good rainfall year; (iii) a drought year; and (iv) a year with almost no water arriving from the Tajo-Segura water transfer system due to operational problems.

Continued on next page

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The results revealed that, under the base case scenario, seawater desalination accounted for 25.6% of the total environmental impact attributed to the supply of water, even though it only provided 9.9% of the water demand. The transfer system was responsible for 45% of the total impact, while supplying 24.7% of the water demand. Pumping groundwater accounted for 16.2% of the total impact, but supplied 31.8% of the water demand. Providing water from local surface sources caused 7.5% of the overall impact and delivered 21.5% of the water demand.

Under the good rainfall scenario, the environmental impact of supplying water was reduced, compared with an average year, as less water was needed from desalination plants or from groundwater sources. In a drought year, additional water required from desalination plants and groundwater pumping, or restricted water supplies from the transfer system, would increase the overall environmental impact of supplying water to the region.

By far, the greatest environmental impact in terms of damage to human health, ecosystems and resource availability however, was caused by water use, rather than supplying water. In all four scenarios, water used for irrigation, as well as for urban purposes and to maintain ecosystem integrity accounted for over 85% of the overall environmental impact from the combined water supply and use. The researchers say that this implies the best way to sustainably manage the critical shortage of water in the region is to gradually reduce water use, especially for irrigation. Merely trying to increase the water supply from external sources or by using energy intensive technologies will not solve the problem.