Reducing water scarcity possible by 2050: Linking global assessments to policy dimensions

Panel contribution to the Population-Environment Research Network Cyberseminar, "Water and Population Dynamics" (05 October 2015 to 16 October 2015),
https://www.populationenvironmentresearch.org/cyberseminars

By Yoshihide Wada, PhD.

NASA Goddard Institute for Space Studies, New York, USA
Center for Climate Systems Research, Columbia University, New York, USA
Department of Physical Geography, Utrecht University, Utrecht, The Netherlands
(y.wada@uu.nl)

This contribution is based on "Wada, Y., T. Gleeson, and L. Esnault (2014), Wedge approach to water stress, *Nature Geosci.*, ***7***, 615–617, doi:10.1038/ngeo2241.".

Stabilizing rapidly growing population numbers may be the most important of six strategies to successfully reduce global water scarcity

Water scarcity is not a problem just for the developing world. In California, legislators are currently proposing a $7.5 billion emergency water plan to their voters; and U.S. federal officials last year warned residents of Arizona and Nevada that they could face cuts in Colorado River water deliveries in 2016.

Irrigation techniques, industrial and residential habits combined with climate change lie at the root of the problem. But despite what appears to be an insurmountable problem, it is possible to turn the situation around and significantly reduce water scarcity in the next 35 years.

In order to effectively reduce water stress, outline strategies are identified in six key areas that they believe can be combined in different ways in different parts of the world. Water stress occurs in an area where more than 40% of the available water from rivers is unavailable because it is already being used (**Figure 1**) – a situation that currently affects about a third of the global population, and may affect as many as half the people in the world by the end of the century if the current pattern of water use continues.

Six key strategy areas for reducing water stress are distinguished into "hard path" measures, involving building more reservoirs and increasing desalination efforts of sea water, and "soft path" measures that focus on reducing water demand rather than increasing water supply thanks to community-scale efforts and decision-making, combining efficient technology and environmental protection. While there are some economic, cultural and social factors that may make certain of the "soft path" measures such as reducing/stabilizing population growth difficult, the "soft path" measures offer the more realistic path forward in terms of reducing water stress by 2050.

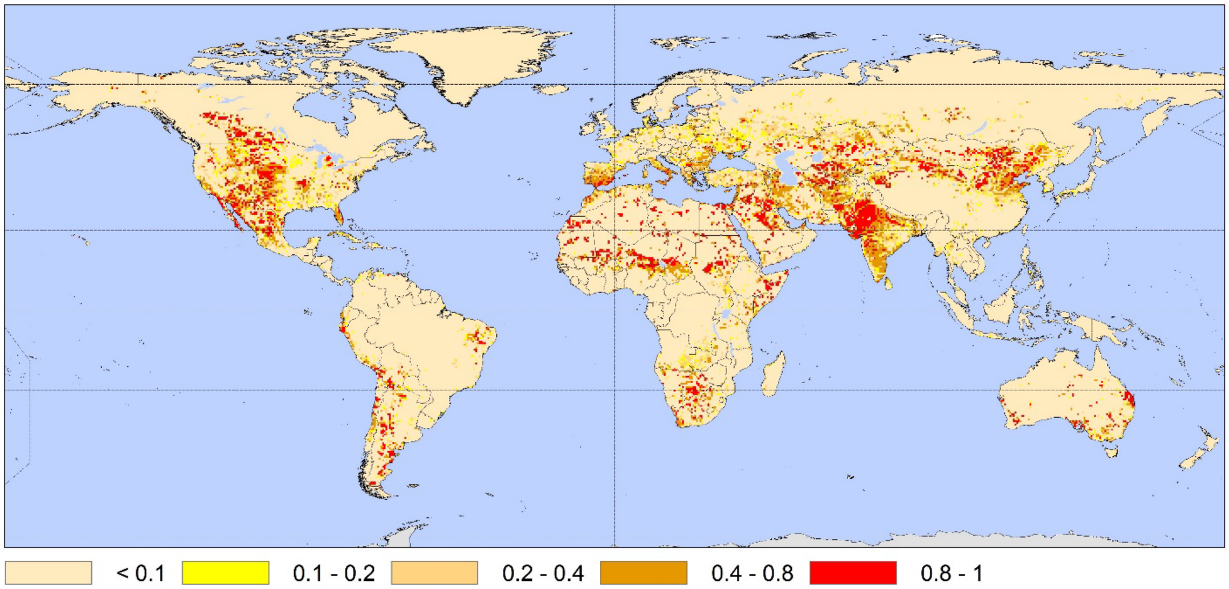

Figure 1. Global map of water stress calculated as water demand divided by water availability for the present climate and human demand.

Despite its regional nature, water stress is exacerbated by global processes. These global-scale influences include climate change[1], population and economic growth[2], and food production and trade. Because of these global-scale influences and the global importance of this problem, it is therefore helpful to find a way of evaluating the efficiency of any policies aimed at mitigating water stress at the global level.

A wedge-based approach

Stabilization wedges for carbon emissions have become an influential climate change mitigation concept[3]. In this concept, each wedge represents one of a number of strategies that could together stabilize carbon emissions.

We analyze six potential water stress wedges to determine the effort required for each wedge to contribute a 2% decrease in the proportion of the population living in water stressed regions by 2050. Two percent is considered a reasonable value for a water stress wedge since it can result in a discernable change with a reasonable effort. Four of these water wedges applied together could stabilize the proportion of the growing water-stressed population by 2050 (**Figure 2**). They thus make a discernable change. The reduction in population living with water stress is evaluated relative to a business-as-usual projection in 2050 whereas the effort for each wedge is evaluated relative to current conditions, and does not explicitly include economic costs.

Of the six wedges we evaluate (**Table 1**), two follow the more traditional 'hard path' category[4], of building infrastructure to supply water. Complementing these, we propose four wedges that instead represent 'soft path' measures[4], associated with community-scale efforts and decision making, combining efficient technology and environmental protection, and focusing on water demand rather than supply.

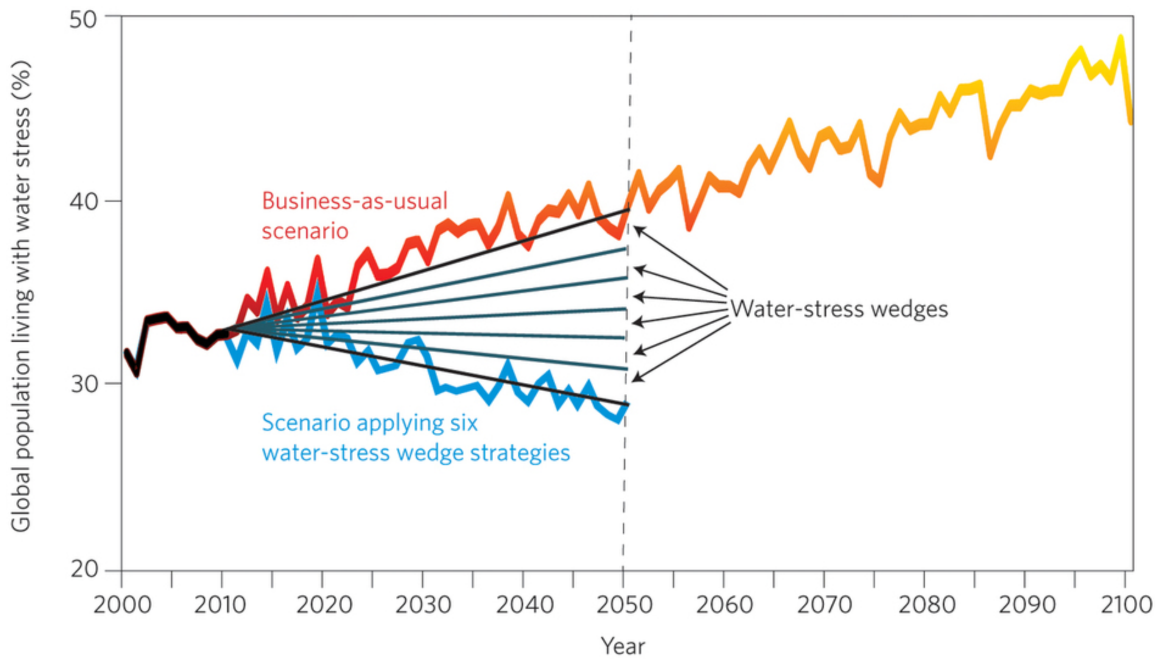

Figure 2. *About 30% of the global population currently lives in water stressed regions, that is, in basins where more than 40% of the available water is withdrawn for human uses. This fraction may increase up to about 50% by the end of the century. We present six strategies, or water wedges, that collectively lead to a reduction in the population affected by water stress by 2050, despite an increasing population. For simplicity, the water wedges are shown here as linear implementations although the proposed efforts are unlikely to produce consistent and linear results. Climatic variability of precipitation is included in the colored lines whereas the water wedges are simplified straight-line projections.*

Specifically, we propose two agricultural soft path wedges. The first wedge requires an increase in irrigation efficiency by 40% by 2050 (or by ~1% per year). The second aims to raise agricultural productivity per unit amount of water, sometimes called ‘crop per drop’, by 20% by 2050, or by ~0.5% per year. In addition we suggest the soft path wedge of increasing domestic and industrial water use intensity by 20%. Because all three uses of water are currently inefficient in many water stressed regions, significant gains in these three wedges are plausible. *One more soft path wedge could consist of decreasing the rate of population growth in water stressed regions from a business-as-usual pathway that would lead to a population of more than 9 billion by 2050 to a more sustainable world with less than 8.5 billion people.*

Hard path wedges we evaluate are an increase in reservoir volume and a higher volume of desalination of seawater. Storing the required amount of an additional 600 km^3 of water in reservoirs in basins affected by water stress may be difficult. Similarly, increasing the current desalination capacity by 50 times may be difficult: desalination capacity has only expanded 10 times over the last 50 years.

To implement these measures, water resource research and policy needs to integrate cultural and socioeconomic dimensions more explicitly.

Table 1. Strategies to reduce water stress

Agricultural water productivity	could be improved in stressed basins where agriculture is commonly irrigated. To reduce the fraction of water stressed population by 2% by the year 2050 would require a linear improvement in productivity per unit of water by 0.5 % (20% in total), and could be achieved with the help of new cultivars, or higher efficiency of nutrients application. Concerns include the impacts of genetic modification and eutrophication.
Irrigation efficiency	could also be improved in irrigated agricultural basins. For a 2% reduction in the global water stressed population, efficiency would need to be raised by 1% per year (40% in total). A switch from flood irrigation to sprinklers or drips could help achieve this goal, but capital costs are significant and soil salinisation could ensue.
Improvements in domestic and industrial water use intensity	could be achieved in stressed basins with significant domestic or industrial water use. An improvement of 0.5 % per year (20% in total) would be necessary to achieve a full wedge of reduction in water stressed population fraction, for example by reducing leakage in the water infrastructure and improving water recycling facilities.
Limiting the rate of population growth	could help in all stressed basins, but a full wedge of water stress relief would require to keep the population in 2050 below 8.5 billion, for example through help with family planning and tax incentives. However, this could be difficult to achieve, given current trends.
A higher volume of water storage in reservoirs could,	in principle, help in all stressed basins with reservoirs . One wedge would require an additional 600 km3 of reservoir capacity, for example by making existing reservoirs larger, reducing sedimentation or building new ones. This wedge would require significant capital investment, and could have negative ecological and social impacts.
Desalination of seawater	could be ramped up in coastal water stressed basins, by increasing either the number or capacity of desalination plants. A 50-fold increase would be required for one wedge, which would imply significant capital and energy costs, and it would generate waste water that would need to be disposed safely.

Evaluation in context

The largest population living with water stress is concentrated in Asia and the Middle East, mostly in developing countries with moderate to high population densities. Strategies to reduce water stress globally should therefore focus on interventions that are appropriate and effective in these cultural and socioeconomic regions.

We argue that significant reductions in the number of people that live with water stress are possible by 2050, compared to a business-as-usual situation. However, the six water stress wedges analysed here each would require strong commitment, and each also has associated concerns.

We note that water policy must be decided in the context of many considerations since it often directly impacts agricultural production, the environment or trade, and is affected by economic, social, legal and political issues such as international or subnational water treaties, rights or disputes.

References

1	Schewe, J. et al. Multimodel assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences 111, 3245-3250, doi:10.1073/pnas.1222460110 (2014).

2	Hanasaki, N. et al. A global water scarcity assessment under Shared Socio-economic Pathways – Part 2: Water availability and scarcity. Hydrol. Earth Syst. Sci. 17, 2393-2413, doi:10.5194/hess-17-2393-2013 (2013).

3	Pacala, S. & Socolow, R. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. Science 305, 968-972, doi:10.1126/science.1100103 (2004).

4	Gleick, P. H. Global freshwater resources: soft-path solutions for the 21st century. Science 302, 1524-1528, doi:10.1126/science.1089967 (2003).