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

Yoshihide Wada, Dr.

NASA Goddard Institute for Space Studies
Center for Climate Systems Research, The Earth Institute
Columbia University
Department of Physical Geography, Utrecht University
(y.wada@uu.nl)
Human Water Use
20th and Early 21st Century

The graph illustrates the consumption and abstraction of water over time from 1900 to 2010. The categories include households, industry, livestock, irrigation, groundwater abstraction, and total withdrawal. The data shows a significant increase in water use over the 20th century, particularly in the last few decades of the early 21st century.
Water Scarcity Index

\[ WSI = \frac{D}{A} \]

Global population under high water stress (WSI > 0.4)

<table>
<thead>
<tr>
<th>Year</th>
<th>Billions</th>
<th>(% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>0.5</td>
<td>(17%)</td>
</tr>
<tr>
<td>1970</td>
<td>0.7</td>
<td>(19%)</td>
</tr>
<tr>
<td>1980</td>
<td>1.0</td>
<td>(23%)</td>
</tr>
<tr>
<td>1990</td>
<td>1.2</td>
<td>(23%)</td>
</tr>
<tr>
<td>2000</td>
<td>1.8</td>
<td>(30%)</td>
</tr>
</tbody>
</table>
Human and Climate System

- Water use: Agriculture: 60%, Industry: 30% and Households: 10%
- Water scarcity since 1980s has been anthropogenically driven rather than climate induced.

![Water scarcity graph for Romania](image)
Is there enough water for all (humankind...)?

and

Will there be enough water?
Global Hydrological Model

Wada et al. (2014; Earth System Dynamics)
Irrigation water use [million cubic meter per year]

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10
Water Futures and Solutions (WFaS)

Consists of three major coalitions

- Sponsor Coalition
- Science Coalition
- Stakeholder Coalition

Ensuring consistency & usefulness of outputs

Organized into the following groups

- Governing Board
- Project Team
- Sector Actors Group
  - WaterFutures4 the World
- External experts
- Secretariat
- Project Director
- Scenario Focus Group
About 30% of the global population currently lives with water stress. This fraction may increase up to about 50%.

We present six strategies, or water-stress wedges, that collectively lead to a reduction in the population affected by water stress by 2050, despite an increasing population.

Wada et al. (2014), Nature Geoscience, doi:10.1038/ngeo2241
Future projections: Climate and socio-economic change

<table>
<thead>
<tr>
<th>RCP</th>
<th>Radiative forcing</th>
<th>CO₂ equivalent concentration</th>
<th>Rate of change in radiative forcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>8.5 W/m²</td>
<td>1350 ppm</td>
<td>Rising</td>
</tr>
<tr>
<td><strong>6.0</strong></td>
<td><strong>6.0 W/m²</strong></td>
<td><strong>850 ppm</strong></td>
<td>Stabilizing</td>
</tr>
<tr>
<td>4.5</td>
<td>4.5 W/m²</td>
<td>650 ppm</td>
<td>Stabilizing</td>
</tr>
<tr>
<td>2.6</td>
<td>2.6 W/m²</td>
<td>450 ppm</td>
<td>Declining</td>
</tr>
</tbody>
</table>

![Graph showing warming above 1980-2010 average (°C) over years for different RCP and SSP scenarios.](image)
Global change in future irrigation water demand

RCP 2.6

RCP 4.5

RCP 6.0

RCP 8.5

Relative increase compared to the present-day condition (2000), i.e. mean of 1980-2010

Wada et al. (2013; GRL)

Global change by 2050

%
Industry

Water use intensity

Reference year: 2010

1. Business-as-usual scenario

No improvement

2. TECH scenario

An improvement based on energy consumption per unit electricity production

(energy consumption intensity)
Households

Water use intensity

Reference year: 2010

1. Business-as-usual scenario

No improvement

2. TECH scenario

An improvement based on energy consumption per unit electricity production

(energy consumption intensity)
Human water consumption

Wada and Bierkens (2014; ERL)
In cooperation with IIASA for WFaS project
Relative change in human water consumption

2100 – 2010
Future water availability (2100)

Schew et al. (2013)

Results analyzed for 5 climate models and 4 RCPs

Relative change in annual discharge at 2 °C compared with present day, under RCP8.5.

Country area under severe water stress [%]
We present six strategies, or water-stress wedges, that collectively lead to a reduction in the population affected by water stress by 2050, despite an increasing population.

- Water productivity – crop per drop
- Irrigation efficiency – decrease losses
- Water use intensity – industry and domestic
- Population
- Reservoir storage
- Desalination

**Wedge approach to water stress**

![Chart showing the wedge approach to water stress](chart)

Each solution = 2% reduction

We present six strategies, or water-stress wedges, that collectively lead to a reduction in the population affected by water stress by 2050, despite an increasing population.

- Water productivity – crop per drop
- Irrigation efficiency – decrease losses
- Water use intensity – industry and domestic
- Population
- Reservoir storage
- Desalination

**Hard path vs. Soft path**

*Wada et al. (2014), Nature Geoscience*
Different basins lend themselves to different measures for reducing water stress:

Agricultural water productivity, Irrigation efficiency, Improvements in domestic and industrial water-use intensity, Limiting the rate of population growth, Increasing water storage in reservoirs, Desalination of seawater

Wada et al. (2014), Nature Geoscience, doi:10.1038/ngeo2241
More Crop Per Drop

Improvement in water productivity at 0.5% per year (20% by 2050)

Efficiency increase by 1% per year (40% by 2050)

Limit population growth by 0.5 billion (8.5 billion by 2050)

Improvement of 0.5% per year (20% by total)

Average Indoor Household Water Use

- Toilet 20%
- Clothes Washer 19%
- Shower 19%
- Faucets 19%
Additional 600 km³ reservoir storage (by 2050)

50 times increase in desalination capacity (by 2050)
WFaS approach

- Significant reductions in the number of people that live with water stress are possible by 2050, compared with a business-as-usual situation.

- Water availability and use are inherently regional concerns. However, a global-scale approach to evaluating strategies to reduce water stress can help maximize mitigation.

- A strong commitment and strategic efforts are required to make the solutions happen.

- Economic and environmental costs need to be considered.

- Stronger link to food and energy sector.