Water allocations and hydrological change: assessing institutional resilience in global transboundary rivers

Kerstin Stahl
Institute of Hydrology
University of Freiburg, Germany

based on a research project for the World Bank in collaboration with:
Lucia de Stefano¹, Aaron T. Wolf¹, Matt Zentner¹, James Duncan¹, Shlomi Dinar¹, Amy McNally³,
¹Oregon State University,
²Florida International University,
³University of California, Santa Barbara

Motivation

- Transboundary river treaties and river basin organizations are important institutions for defining how water is shared between countries
- However, there are concerns about allocations’ vulnerability to predicted climate changes
- Hydrologic models that use climate change scenarios to simulate streamflow changes may be useful tools within an assessment of the ability of countries to meet treaty obligations in the future
  → important information to plan adaptation measures
Recent Studies

• Evaluation of the suitability of such predictions
  
  Water allocation mechanisms globally
  Source: Transboundary Freshwater Dispute Database (TFDD)

  Ability of hydrologic modelling approaches
  Source: literature considered in IPCC reports

• Mapping global areas potentially at risk
  
  Institutional vulnerability
  Score based on treaty components and the existence of a river basin organisation

  Hazard from exposure of transboundary river basins to hydrological change. Example: inter-annual variability of runoff

Global Focus

www.transboundarywaters.orst.edu
### Allocation types and mechanisms

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>fixed quantity</td>
<td>direct allocations</td>
<td>country A must let a minimum flow of x m³/s flow across the border at all or particular times</td>
</tr>
<tr>
<td>B</td>
<td>fixed quantity</td>
<td>direct allocations</td>
<td>country B receives x Million m³ of water per year/season</td>
</tr>
<tr>
<td>B</td>
<td>fixed quantity varying by availability</td>
<td>direct allocations</td>
<td>country B receives y T Million m³ of water per year if a min. of x1 were available, y2 if x2 were avail., etc.</td>
</tr>
<tr>
<td>B</td>
<td>fixed quantity recouped later</td>
<td>direct allocations</td>
<td>country B receives y m³ of water per t years</td>
</tr>
<tr>
<td>C</td>
<td>percentage</td>
<td>indirect allocations</td>
<td>country A and B each receive 50% of flow</td>
</tr>
<tr>
<td>C</td>
<td>entire river</td>
<td>indirect allocations</td>
<td>country A receives 100% of flow</td>
</tr>
<tr>
<td>C</td>
<td>prior approval</td>
<td>indirect allocations</td>
<td>an allocation of country A to B</td>
</tr>
<tr>
<td>C</td>
<td>consultation</td>
<td>principles for allocations</td>
<td>commission decides on allocation</td>
</tr>
</tbody>
</table>

### Defining allocation types by modelling requirements

Allocation type:
- **Type A:** flow rate
- **Type B:** flow volume/time
- **Type C:** relative flow or volume
Defining allocation types by modelling requirements

Model requirements:
- flow rate at allocation point, extremes → high resolution
- Seasonal to annual volumes, inter-annual variability → lower resolution → irrelevant

Approaches to model streamflow change as a result of climate change

GCM: Global Climate Model; RCM: Regional Climate Model; GHM: Global Hydrological Model; WBM: Water Balance Model; RRM: Rainfall Runoff Model; P: precipitation; T: temperature; R: runoff
Global Distribution of allocation types

450 treaties (TFDD) → 72 contain water allocation agreements → 56 considered

<table>
<thead>
<tr>
<th>River Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural flow</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Natural regime, but abstractions</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Regulated</td>
<td>10</td>
<td>3</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Regulated with abstractions</td>
<td>4</td>
<td>11</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>total</td>
<td>14</td>
<td>15</td>
<td>27</td>
<td>56</td>
</tr>
</tbody>
</table>

• Treaties with allocation agreements mostly in regulated rivers ➢ impossible to model without data on regulation (past and future)

Evaluation of model suitability

• Presently, many approaches do not necessarily capture the temporal resolution or spatial detail to determine water availability at the location where water is to be delivered or monitored
• This hampers a global assessment of the resilience of treaties that have explicit streamflow or water volume requirements
• Reliable predictions can only be obtained for a basin, where detailed observed data on
  – river flow and ➢ in Europe ok
  – its regulation ➢ problem even in Europe
  are available for model tuning
Recent Studies

• Evaluation of the suitability of such predictions
  - Water allocation mechanisms globally
    *Source: Transboundary Freshwater Dispute Database (TFDD)*
  - Capabilities of hydrologic modelling approaches
    *Source: literature considered in IPCC reports*

• Mapping global areas potentially at risk
  - Institutional vulnerability
    *Score based on treaty components and the existence of a river basin organisation*
  - Hazard from exposure of transboundary river basins to hydrological change.
    *Example: inter-annual variability of runoff*

<table>
<thead>
<tr>
<th>Treaty/RBO Component</th>
<th>Possible Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one water treaty</td>
<td>0/1</td>
</tr>
<tr>
<td>At least one treaty with an allocation mechanism</td>
<td>0/1</td>
</tr>
<tr>
<td>At least one treaty with a variability management mechanism</td>
<td>0/1</td>
</tr>
<tr>
<td>At least one treaty with a conflict resolution mechanism</td>
<td>0/1</td>
</tr>
<tr>
<td>At least one river basin organization</td>
<td>0/1</td>
</tr>
<tr>
<td><strong>Total possible score for a country-basin unit</strong></td>
<td><strong>0 to 5</strong></td>
</tr>
</tbody>
</table>

→ different levels of risk derived from combinations

Duncan et al. (submitted to JPR)
Conclusions

- The comparison of allocation types with model prediction ability identified a mismatch between the details of transboundary water allocations and the requirements for and the uncertainty of hydrological change predictions
  - Europe: data, particularly on river regulation
- Empirical analysis of institutional capacity in terms of treaties and RBOs indicated that globally, hot spots are in Africa and Asia
  - Europe: unclear climate change signal