The economics of transboundary water management

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International Rivers

- There are 261 international rivers, covering almost one half of the total land surface of the globe and affecting 40% of the world's population.
- Water has been a cause of political tensions between Arabs and Israelis, Indians and Bangladeshis, Americans and Mexicans, and all ten riparian states of the Nile river.
- International water laws are poorly developed, contradictory, and unenforceable.

International Rivers

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- International water laws are poorly developed, contradictory, and unenforceable.
 - Equitable use vs. Obligation not to cause appreciable harm
 - States vs. Political entities

History of Water Conflicts



Treaties Summary Statistics

Signatories Bilateral 124/145 (86%) Multilateral 21/145 (14%)

Principal focus Water supply 53/145 (37%) Hydropower 57/145 (39%) Flood control 13/145 (9%) Industrial uses 9/145 (6%) Navigation 6/145 (4%) Pollution 6/145 (4%) Fishing 1/145 (<1%)

Monitoring Provided 78/145 (54%) No/not available 67/145 (46%)

Conflict resolution Council 43/145 (30%) Other governmental unit 9/145 (6%) United Nations/third party 14/145 (10%) None/not available 79/145 (54%)

Enforcement Council 26/145 (18%) Force 2/145 (1%) Economic 1/145 (<1%) None/not available 116/145 (80%) Unequal power relationship Yes 52/145 (36%) No/unclear 93/145 (64%)

Information sharing Yes 93/145 (64%) No/not available 52/145 (36%)

Water allocation Equal portions 15/145 (10%) Complex but clear 39/145 (27%) Unclear 14/145 (10%) None/not available 77/145 (53%)

Nonwater linkages Money 44/145 (30%) Land 6/145 (4%) Political concessions 2/145 (1%) Other linkages 10/145 (7%)

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Arguments Against Water Wars

- Strategic Argument
 - ► Downstream ∩ Regional hegemon
- Shared Interest Argument
 - Dams, water quality, scenic beauty...
- Institutional resiliency argument
- Economic argument
 - Why go to war over water? For the price of one week's fighting, you could build five desalination plants. No loss of life, no international pressure and a reliable supply you don't have to defend in hostile territory.—Former Israeli Defense Forces Analyst

The River-Sharing Problem: An illustration with N=4



Note: Nodes are countries and arrows indicate water flows: endowments e_b unused water u_b and water use x_i .

- N ≡ (1, 2, ..., n), where countries are ordered such that, for each i, j∈ N, country i is upstream of country j iff i < j
- e for endowment
- x for water use
- u for unused water
- b(x) is the benefit function for water use
- Therefore, a river sharing problem can now be denoted by the triple < *N*, *e*, *b* >

Solution to the River-Sharing Problem

s.t.

$$\max_{x,t} \sum_{t \in N} \pi_i(x_i, t_i) = b_i(x_i) + t_i$$

$$0 \le x_i \le E_i \ \forall i \in N$$

$$\sum_{i \in N} t_i = 0$$

• t is the monetary and in-kind transfers.

Image: A matrix

Three Model Features

- Efficiency
- Sustainability
- Fairness

Image: A matrix

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Efficiency

- Kaldor-Hicks efficiency is obtained when the **total benefits** of water use in the river basin are maximized.
- This measure ignores the distribution of the benefits of water use over the countries, assuming that any undesirable distribution can be corrected via **monetary transfer**.
- Denote the status quo allocation vector by x^0 and the (Kaldor-Hicks) efficient allocation by x^* .

Efficiency

- Assume that the vectors are not equal, so that for at least one country i, we have x_i^{*} < x_i⁰.
- WLOG, assume that this decrease in water use holds for exactly one country.
- The minimal compensation t_i^m to this country equals $t_i^m = b_i(x_i^0) b_i(x_i^*)$.
- Given that x* is Kaldor-Hicks efficient, there is a positive surplus by implementing the efficient allocation vector equal to

$$\sum_{j>i} [b_j(x_j^*) - b_j(x_j^0)] - t_i^m > 0$$

• Given this strict inequality, countries downstream of i can jointly transfer t_i^m to country i and still gain from the implementation.

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Implementation of Efficiency

Implementation of the Efficient Water Allocation Vector

- Transboundary water trade
- Water allocation agreements
- Bargaining

Why Allocations May Not be Efficient

- Political Power
- Water Security
- Water as a contentious good (Non-use value)
- Transaction Costs
- Simple sharing rules

Sustainability

- Sustainbability is the ability to continue a defined behavior indefinitely.
- For renewable resources, the rate of harvest should not exceed the rate of regeneration (sustainable yield).
- Sustainability builds on efficiency in the sense that sustainability assesses the stability of the efficient water allocation vector.
- One threat: the variability of river flow, and the uncertainty of river flow in the next periods

Examples of unsustainable allocations due to low river flow

- Mexico failed to meet its required average water deliveries under the 1944 US-Mexico Water Treaty in the years 1992-97.
- India extended its trial operation of the newly constructed Farakka barrage in the Ganges Basin throughout the 1975-76 dry season, diverting water away from the Ganges and through the new canal at full capacity, causing severe water shortages in Bangladesh.
- Turkey diverted all the water from the Euphrates for a month to create a reservoir behind the newly constructed Ataturk Dam in 1990, depriving downstream Syria and Iraq of water.

Fairness

- The economics discipline usually considers fairness only in the context of social welfare.
- Fairness can refer to an allocation that maximizes social welfare, or an allocation that guarantees water for everyone.
- In some basins, countries may prefer to allocate the welfare derived from water use, although essentially there is not much difference between the two.
- In the vast majority of reported negotiations on river water, the subject of negotiation is actual physical units of water, rather than the benefits derived from water use.

Mekong River Basin



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Mekong River Basin

- In 1995, Cambodia, Laos, Thailand and Vietnam signed a treaty to create the Mekong River Commission (MRC), whose mission is to promote shared use of the river.
- The MRC has been regarded as relatively successful in mitigating conflicts and maintaining cooperation in the basin.
- It seems less likely that the MRC will address the big-picture questions concerning the future of the Mekong dams—which projects go forward, when construction on each project starts, and who is responsible for the transboundary impacts that occur.
- China's upstream hydro-development

- Nile is the longest river in the world and it flows from South to North.
- It passes through eleven countries: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, South Sudan, Tanzania, Uganda and the Democratic Republic of Congo.

Nile River Basin



Nile River Basin

The Nile River basin contains 11 countries. The two major rivers that contribute to the Nile are the Blue Nile and the White Nile.

The Blue Nile originates in Ethiopia and the basin contains territory in Ethiopia, Sudan, and Egypt.

The White Nile originates in Lake Victoria and contains territory in Tanzania, Democratic Republic of the Congo, Burundi, Rwanda, Uganda, South Sudan, Sudan, Eritrea, and Egypt.

The Blue and White Niles converge in Khartourn, Sudan. There are three major dams on the Nile in Sudan and Egypt and two related reservoirs can be seen on this map. Lake Nasser in southern Egypt, and Roseires reservoir in eastern Sudan on the border with Ethiopia.

Lake Tana, in Ethiopia, is the only major natural lake in the Bue Nile basin. Lake Victoria in Uganda, Tanzania, and Kenya; Lake Albert in Uganda and the Democratic Republic of the Corago; Lake Kyoga in Uganda, and Lake Edward in Uganda and the Democratic Republic of the Corago are found within the White Nile basin.

The Nile River extends 6,853 kilometers and is the longest river in the world. It terminates in the Medierranean Sea.

Nile river basin

Nile basin rivers

Countries

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Nile River Basin

- In 1929, the *Nile Water Agreement* was signed between Egypt and British, granting Egypt the right to inspect any upstream Nile-related water projects with the potential to compromise its river flow.
- The 1959 Agreement granted Egypt an annual quota of 55.5B m^3 and Sudan 18.5B m^3 .
- Other basin nations vehemently criticized the legitimacy of these two agreements, as they were not independent at the time to fight for a claim over the water.
- The Entebbe Agreement was signed in 2010 by six Nile Basin countries: Ethiopia, Rwanda, Tanzania, Uganda and Burundi.
- It was rejected by Egypt and Sudan, due to its provisions allowing the reallocation of Nile water quotas.

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Egyptian Demand

- Egypt's "historic rights" to the Nile have encouraged over-dependency on the river. It relies on the Nile for 97% of its water needs.
- Egypt's agricultural sector currently uses 80% of the nation's water supplies, yet domestic production levels are considerably short of demand.
- A tenth of Egypt's electricity generation capacity comes from the Aswan Dam alone.
- The UN warns that Egypt could run out of water by 2025.
- Egypt could experience major water crisis in coming years that could trigger conflicts with its neighbors.