China-India-Bangladesh in the Trans-boundary Water Issues: a Game Theoretic Analysis

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Research background

Trans-boundary water politics betw. three riparian neighbors China India and Bangladesh in Ganges – Brahmaputra -Meghna basin

Yarlung Tsangpo (China) / Siang River (Arunachal Pradesh, India Brahmaputra (Assam, India) / Jamuna) (Bangladesh) joins with Ganges from India: 2880 Km long

Research background

Various water sharing agreements between India and Bangladesh(1977, 1996, 2011), Indo-Nepal Mahakali river treaty (1996), India-China negotiation on "Great Dam Rush"

For the last 10 years to meet the rising demand for water, China - embarking upon a series of hydro power projects (2.5 billion kilowatt hours of electricity annually) and water-diversion (50 BCM) scheme from south to northern arid zone along on Brahmaputra river,

- significant potential to alter the river flow regime
- Withstanding all sincere effort from Indian side, China has rejected all water negotiation proposals from India

Bangladesh the most downstream nation - found to be most deprived, blaming India's negligence on the water demand of Bangladesh particularly in dry season

In Himalyan fluvial geography upstream nation (s) with numerous sources of river flows enjoys the 'free rider's benefit and control

Research background

External water dependencies determine the bargaining power of the nations in negotiations on trans-boundary water sharing

Country	China	India	Bangladesh
External Water Resources (million m³)	17,169	647,220	1,105,644
Total Water Resources (million m³)	2,840,000	1,907,760	1,210,644
External Dependency Ratio	.9%	33.4%	91.3%

Source: United Nations Food and Agriculture Organization, Aquastat online data 2011

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Research background

In face of water scarcity two globally accepted propositions (World Bank, 1993):

- for each nation, domestic economic policies need to be reformed to rationalize the water use (participation of local stakeholders; Dublin principle, IWRM)

- trans-national agreements on water sharing need to be forged (International water laws: 2 doctrines – (1)Absolute Territorial Sovereignty (ATS); (2) Unlimited Territorial Sovereignty (UTS) (McCaffrey, 2001)

- nations involved in '2-stage game' (Putnam, 1989), the 'double edged diplomacy' : inter-ministerial / inter local governmental disputes – major policy constraints to the negotiation on trans-boundary water issues

Analytical instruments in game theoretic framework

▪ National-international negotiation process in trans-boundary water resources under decentralized institution in domestic frontier – designed with 3 agents at international and 2 agents at each national level

▪ A directed tree matrix (Ambec and Sprumount 2002; Ansink and Houba 2012, 2014) – to describe the hypothetical river geography a trans-national river originated from one spring at the topmost upstream location (agent 1), joins with another spring at the mid upstream location (agent 2) and flows up to the most downstream location (agent 3) with complete water dependence on the upstream agents

The matrix of river geography Ansnik & Houba (2012)

A river with two springs at locations 1 (country) and 2 merge together at location 3. Then it flows through location 4.

$$R = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

$$f = e + (R - I)(e - x)$$

$$Rx \leq Re$$

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Game theoretic framework

Two level game: $G_T \supseteq (G_I, G_N)$

▪ Level- I G_N : Various water sharing and water pricing games with symmetric and asymmetric bargaining power at national / domestic frontier considered

▪ non-cooperative and cooperative: simultaneous and sequential

▪ water extraction value > or < benefit value

▪ in water pricing (Nash- Stahl-Rubinstein bargaining game) maximum willingness to pay of water demander and minimum cost price of water supplier taken into account

▪ Solution by backward induction

▪ Subgame perfect equilibria from G_N goes back to Level- II G_I bargaining game at international level to solve G_T

Game theoretic framework :Results $G_T \supseteq (G_I, G_N)$

- if water extraction value is greater than the benefit (or profit) value of extraction and there is no capacity constraint on water extraction

  - each non-cooperative game (simultaneous / sequential) within each domestic frontier will be the ultimatum game

  - most downstream will have no incentive to participate in the water bargaining game as no water flow would be available for it

- if benefit (or profit) value > water extraction value and there is capacity constraint to achieve maximum benefit

  - both in the cooperative and non-coperative games all 3 agents incl. most downstream will be benefitted to participate in the international water bargaining game

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Game theoretic framework :Results $G_T \supseteq (G_I, G_N)$

If negotiation on water sharing is done on the basis of water pricing game at the domestic frontier

- upstream agent will never optimally choose to extract the whole water
- some amount of water would be available for the most downstream agent without any source of water within its territorial boundary
- most downstream agent will be benefitted in the negotiation game on water sharing

- Game solution: $x_{I1}(w*_{N1}) = ke_1 \quad 0 < k < 1$

$$x_{I2}(w*_{N2}) = \frac{(\theta_1 + \theta_2)}{2\theta_2}(e_2 - 1) \quad x_{I3}(w*_{N3}) = (1-k)e_1 + \frac{(\theta_2 - \theta_1)}{2\theta_2}e_2 + \frac{(\theta_1 + \theta_2)}{2\theta_2}$$

Observation and Conclusion

Various water sharing agreement between India and her riparian neighbours

– primarily concerned with sharing the water flow without sharing the value and uses of the river

- does not take into consideration the effects of upstream use of the river water

- it does not take a whole-of-basin approach to river management

Observation and Conclusion

Conditions for the successful negotiation on trans-boundary water resource management

-(i) capacity constraint of upstream nation has to exist while benefit value of river water > value of the water flow

-(ii) bargaining solution on determining the water price at the domestic frontier to be incorporated into the water sharing decision at the international level

-(iii) relative bargaining power of the upstream nations – one of the most important determinants for successful negotiation

Thank you