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Brahmaputra River governance under climate pressure: Evidence synthesis on transboundary water management and climate-induced displacement in South Asia

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Abstract
The Brahmaputra River presents a critical test case for transboundary water governance in the Global South. Supporting livelihoods for over 140 million people across Tibet, India, Bangladesh, and Myanmar, the river faces pressures from climate change-induced hydrological variability and upstream development expansion. India and Bangladesh maintain no formal bilateral agreement governing Brahmaputra water-sharing despite the river's transnational nature and critical importance for both countries. This evidence synthesis examines 79 peer-reviewed publications (2000-2025) addressing Brahmaputra governance mechanisms, climate change impacts on water resources, water scarcitydisplacement linkages, and institutional prerequisites for sustainable basin management. The synthesis reveals fragmented governance across national and subnational jurisdictions without trilateral coordination mechanisms involving upstream China. Existing frameworks—including the 1996 Ganges Treaty for the Ganges-Padma system, national disaster management acts, and water resource policies— provide partial models while proving inadequate for Brahmaputra's scale and complexity. Meta-analysis of 42 climate projection studies establishes consensus: dry-season water reductions of 28-40% are projected by 2050 under mainstream climate scenarios (RCP 4.5). These reductions substantially exceed the adaptive capacity of institutional frameworks designed for historical hydrological patterns. Water scarcity operates as displacement driver through documented livelihood collapse pathways examined in 24 publications: dry-season water reduction triggers agricultural yield decline, forcing occupational shifts and migration. Salinization of freshwater aquifers renders agricultural land unsuitable within 4-6 years, compelling livelihood transitions. Repeated flooding reduces livelihood recovery capacity, intensifying vulnerability. Systematic comparison of transboundary governance models (Indus Waters Treaty, Ganges Treaty, Mekong River Commission, SAARC mechanisms) identifies institutional features associated with functional success: permanent institutional mechanisms, technical expertise emphasis, periodic adaptation provisions, and international facilitation. Identified governance gaps include absence of trilateral India-Bangladesh-China mechanism, inadequate adaptation to climatedriven variability, institutional separation between water management and displacement policy, and state-level conflicts within Indian federalism. Policy recommendations emerging from reviewed literature identify five institutional prerequisites: permanent trilateral commission, adaptive watersharing framework, climate adaptation integration, displacement-livelihood protection mechanisms, and international financing structures. The synthesis concludes that governance failures reflect institutional inadequacy and political choices rather than technical or resource constraints, suggesting that reform remains feasible if political commitment materializes.

Keywords: Transboundary water governance, Brahmaputra River, climate change, institutional analysis, South Asia

Introduction

The Brahmaputra River originates in the Tibetan plateau (designated Yarlang Tsangpo in Chinese geographical nomenclature) and flows across political boundaries through India's northeastern states, into Bangladesh, and ultimately to the Bay of Bengal. The river's annual discharge approximates 600 billion cubic meters, making it Asia's second-largest water resource by volume. Yet governance of this transnational system remains compartmentalized across national boundaries and state jurisdictions without institutional mechanisms enabling integrated management.

India and Bangladesh, while maintaining cooperative arrangements addressing water-sharing (Ganges Treaty), biodiversity conservation (Joint Sundarbans Working Group), and disaster management coordination, lack any bilateral agreement specifically governing Brahmaputra water allocation or basin management. This governance gap reflects neither technical incapacity nor resource scarcity but rather political choices and institutional inertia. Understanding why governance remains fragmented despite decades of India-Bangladesh cooperation on related issues requires examining both historical patterns and contemporary geopolitical constraints.

Climate change adds urgency to governance reform. Himalayan glaciers feeding the Brahmaputra are retreating at accelerating rates. Monsoon patterns are shifting. Hydrological modeling projects dryseason water reductions of 28-40% by 2050—reductions substantially exceeding the adaptive capacity of current institutional arrangements. These projections establish that proactive institutional reform cannot be delayed; decisions made in coming years will determine whether South Asia develops cooperative governance managing climate impacts through planned mechanisms, or defaults to crisisdriven responses as climate impacts intensify.

This evidence synthesis responds to a specific research need: synthesizing existing published knowledge about Brahmaputra governance and climate impacts rather than generating new primary data. The approach involves systematic examination of peer-reviewed literature to identify governance gaps, assess existing institutional arrangements, synthesize hydrological projections, and

synthesize policy recommendations emerging from scholarly analysis.

Core research questions: First, what governance mechanisms currently address Brahmaputra management, and what limitations constrain their effectiveness? Second, what does literature consensus establish regarding climate change impacts on Brahmaputra flows and associated timelines? Third, how do publications characterize linkages between water availability and climate-induced displacement? Fourth, what institutional innovations do scholars recommend for sustainable Brahmaputra governance addressing both water allocation and displacement management?

Methodology

Systematic review methodology provides organizational structure. Literature searches employed Web of Science, Scopus, and region-specific academic portals. Search strategies addressed three dimensions: Brahmaputra governance mechanisms; climate change impacts on South Asian water resources; transboundary water management frameworks and institutional analysis.

Inclusion criteria specified peer-reviewed publications from 2000-2025 examining Brahmaputra River management, transboundary water governance, climate projections for South Asian water resources, or institutional frameworks relevant to basin management. Temporal scope reflects the period when climate change emerged as explicit concern in water resource discussions.

Two independent reviewers applied inclusion criteria at title/abstract and full-text stages using standardized assessment forms. Disagreements resolved through consensus discussion. Seventy-nine publications met final inclusion criteria.

Quality assessment employed Newcastle-Ottawa Scale for observational studies, CASP Qualitative Checklist for qualitative research, and Joanna Briggs Institute Checklist for policy analyses. Studies classified as low, moderate, or high-quality risk of bias. Sensitivity analyses examined whether excluding lower-quality studies substantially altered conclusions.

Data extraction employed standardized forms capturing: author and year; governance dimensions examined; climate stressors and projections; hydrological data presented; institutional mechanisms discussed; policy recommendations; identified implementation barriers.

Synthesis methods included quantitative meta-analysis for studies reporting comparable climate projection data, qualitative thematic analysis for governance findings, and comparative institutional analysis examining water governance models.

Search Results and Included Studies

Initial database searches identified 2,156 potentially relevant publications. Title and abstract screening eliminated 1,754 publications lacking relevance to Brahmaputra governance or climate-water linkages. Full-text assessment of 402 publications meeting preliminary criteria yielded 79 meeting final inclusion requirements.

Geographic distribution indicated representation of India-based scholarship (39%), Bangladesh-based scholarship (23%), international authors (25%), and regional South Asian scholars (13%). This distribution reflects the transboundary nature of Brahmaputra governance while preserving diverse scholarly perspectives.

Study design distribution included hydrological and climate research (30%), governance and institutional analysis (23%), policy analyses (19%), qualitative case studies (15%), and existing systematic reviews or meta-analyses (13%). This heterogeneity reflects the interdisciplinary nature of water governance questions.

Temporal distribution revealed increasing publication intensity post-2015. Publications from 2000-2009 represented 10% of included studies; 2010-2015 represented 23%; 2016-2020 represented 34%; 20212025 represented 33%. The acceleration post-2015 reflects heightened scholarly attention following Paris Agreement and climate change impacts on South Asian water resources.

Key Findings from Literature Synthesis

1. Current Governance Mechanisms and Identified Limitations

Systematic examination of institutional frameworks governing Brahmaputra identified four distinct governance levels, each with significant limitations. At bilateral level, India and Bangladesh maintain the Joint Rivers Commission (established 1972), which provides forum for discussing shared water issues. However, the Commission lacks formal treaty basis, enforcement authority, or binding mechanisms. No explicit agreement governs Brahmaputra water allocation despite the river's critical importance for both countries.

The 1996 Ganges Treaty, by contrast, established explicit water-sharing mechanism for the GangesPadma system, allocating dry-season flows through fixed formulas adjusted every 10 days based on measured discharges. This treaty represents the most developed India-Bangladesh water cooperation mechanism but addresses only Ganges water, not Brahmaputra. Extension of Ganges Treaty principles to Brahmaputra has not occurred despite recognition that the framework could provide useful model.

At national level, India's Disaster Management Act (2005) and Bangladesh's Disaster Management Act (2012) provide frameworks for disaster response but lack provisions specific to water scarcity management or planned population relocation. Water Resource Ministries in both countries maintain policies addressing allocation and development but lack mechanisms for transboundary coordination.

At state level within India, Arunachal Pradesh maintains substantial autonomy regarding hydropower development on Brahmaputra tributaries and main river. Over 168 hydropower projects at various planning stages could substantially alter downstream flows. Assam, while interested in maintaining irrigation and agricultural water security, possesses less political influence over hydropower development decisions made at state or central government levels.

Upstream, China maintains minimal transparency regarding Yarlung Tsangpo (Brahmaputra's Tibetan name) water development plans. No formal arrangement provides for prior notification to India or Bangladesh of Chinese projects. This upstream opacity constrains India-Bangladesh bilateral planning since downstream countries cannot reliably predict Chinese development decisions.

2. Climate Projections: Hydrological Change Synthesis

Meta-synthesis of 42 climate projection studies examining hydrological changes in Brahmaputra basin synthesized findings regarding dry-season flow reductions. Publications employing different climate scenarios and modeling approaches converged on similar projections: by 2050, dry-season water reductions range from 18-40% depending on scenario assumptions, with median projections around

2835% under moderate warming assumptions (RCP 4.5, approximately 2°C warming).

High warming scenarios (RCP 8.5, 3-4°C warming) project reductions approaching 38-40%. Low warming scenarios (RCP 2.6, 1.5°C warming) project reductions of 18-25%. The range reflects genuine scientific uncertainty regarding future emissions trajectories and climate sensitivity, but convergence around 28-35% reduction provides reasonable basis for planning under mainstream scenario assumptions.

Glacial retreat contributes substantially to projected dry-season reductions. Himalayan glaciers supplying approximately 25% of Brahmaputra annual flows are retreating at rates of 0.6-0.8 meters annually. Total glacial volume loss projections for 2100 range from 30-50%, with accelerating retreat expected during 2050-2100 period. Since glacial melt contributes disproportionately to dry-season flows, accelerating glacier loss will intensify dry-season water scarcity.

Monsoon pattern changes create additional hydrological complexity. Publications examining monsoon dynamics projected shifts in monsoon onset timing (potentially earlier or later, with substantial uncertainty) and in precipitation intensity. Greater seasonal flow variability appears likely, with intensified monsoon-season precipitation coexisting with extended dry-season duration.

3. Water Scarcity-Displacement Linkages: Documented Causal Pathways

Twenty-four publications examining relationships between water availability and population movement identified three documented pathways through which water scarcity drives displacement. First pathway involves direct livelihoods collapse: dry-season water scarcity reduces irrigation water availability for agriculture. Publications examining agricultural water requirements documented that 20-30% water reduction triggers agricultural yield declines of 25-40%. Reduced agricultural income forces farmdependent households toward alternative livelihoods, often involving migration to urban areas or other regions where alternative employment opportunities exist.

Second pathway operates through land degradation: saltwater intrusion into freshwater aquifers, accelerated by sea-level rise in coastal zones, renders agricultural land unsuitable for cultivation. Publications examining salinization processes in Bangladesh delta documented that agricultural land experiences reduced productivity within 2-3 years of exposure to saline water and becomes unsuitable for traditional rice cultivation within 4-6 years. Farmers facing salinized land must shift occupations, with urban migration or non-agricultural livelihood transitions representing common responses.

Third pathway involves repeated flood damage: increased flooding frequency, driven by intensified precipitation extremes, reduces household livelihood recovery capacity. Publications examining flooddriven displacement documented that repeated losses prevent asset accumulation; households facing repeated flooding-induced income losses eventually adopt permanent relocation as adaptation strategy. Migration to urban areas or inland higher-ground settlements becomes rational response when livelihood recovery proves impossible.

These pathways operate simultaneously rather than sequentially. In delta regions, water scarcity coexists with increased flooding; salinization occurs alongside flood damage impacts. Multiple displacement drivers create complex vulnerability landscapes where populations facing water scarcity simultaneously experience flooding and salinization impacts.

4. Comparative Governance Models: Institutional Strengths and Limitations

Systematic comparison of transboundary water governance arrangements identified both functional models and instructive failures. The Indus Waters Treaty (1960), examined across eleven publications, established institutional arrangements that have functioned for over 65 years despite broader IndiaPakistan geopolitical tensions. Critical institutional features enabling longevity included: permanent Indus Commission with continuous representation enabling ongoing coordination; technical expertise emphasis in dispute resolution; international involvement (World Bank mediation) reducing bilateral tension; explicit provisions for periodic renegotiation enabling framework adaptation.

Application of Indus Treaty model to Brahmaputra faces both opportunities and obstacles. Opportunities include that the Indus model demonstrates technical-diplomatic approaches for managing transboundary water despite political tensions. Obstacles include that the Indus arrangement addresses bilateral India-Pakistan water-sharing, while Brahmaputra governance requires trilateral coordination including upstream China; that Indus Treaty focuses purely on water allocation, while Brahmaputra governance must address displacement dimensions; that Indus waters involve finite allocation among relatively similar-scale economies, while Brahmaputra governance involves vastly different development levels across riparian states.

The 1996 Ganges Treaty, examined across fourteen publications, represents more recent South Asian model with direct relevance to Brahmaputra questions. The treaty established allocation mechanisms ensuring Bangladesh received guaranteed minimum dry-season flows even during water-scarce periods. The mechanism functioned effectively for 30 years, preventing major water-sharing conflicts. However, climate-driven hydrological changes now challenge the treaty's viability. The fixed allocation formula presumes relatively stable baseline flows with modest variability (±15%); climate-projected reductions of 28-40% exceed the formula's design parameters, requiring renegotiation.

Regional arrangements including SAARC mechanisms and disaster reduction task forces provide additional governance precedent. Eight publications examining regional cooperation frameworks revealed institutional weakness: SAARC disaster reduction mechanisms lack enforcement authority, dedicated independent funding, and organizational capacity. Bilateral tensions, particularly IndiaPakistan relations, frequently paralyze regional mechanism effectiveness. Regional cooperation, while potentially valuable, demonstrates limitations when member states prioritize bilateral concerns over regional cooperation.

5. Identified Governance Gaps and Implementation Barriers

Systematic analysis identified multiple governance gaps constraining effective Brahmaputra management. First, absence of trilateral coordination mechanism: governance remains bilateral (IndiaBangladesh) or national, without including upstream China. As originating state, China's water development decisions substantially affect downstream flows; yet India and Bangladesh cannot influence Chinese decision-making through institutional

mechanisms. This upstream governance gap represents a critical constraint.

Second, inadequate adaptation to climate-driven variability: governance frameworks designed for historical hydrological patterns prove inadequate when climate change drives variability exceeding design parameters. The Ganges Treaty's fixed allocation mechanism, while successful in stable conditions, cannot accommodate the 28-40% dry-season reductions projected by 2050.

Third, institutional separation between water management and displacement policy: water resource ministries manage allocation; disaster management authorities handle emergencies; migration authorities address population movement—without coordination. This separation prevents integrated governance recognizing that water scarcity drives displacement and that displacement management requires coordinated water security, livelihood restoration, and social integration planning.

Fourth, competing state-level interests within Indian federalism: Arunachal Pradesh hydropower development ambitions conflict with Assam agricultural interests and Bangladesh downstream concerns. No mechanism within Indian federalism coordinates these divergent interests or ensures that bilateral commitments receive priority over state-level development aspirations.

Implementation barriers complementing governance gaps include political reluctance to designate water governance as depoliticized technical domain; fiscal constraints limiting investment in bilateral coordination, monitoring, and livelihood programs; administrative capacity constraints preventing effective implementation of existing policies; uncertainty regarding Chinese development intentions.

6. Policy Recommendations Synthesis

Meta-synthesis of 31 policy analysis publications examining institutional solutions yielded convergent recommendations. First, establishment of permanent trilateral commission (endorsed across 24 publications): India, Bangladesh, and China should establish permanent institutional mechanism enabling ongoing coordination. Quarterly meetings would establish continuity; technical expertise emphasis would focus dispute resolution on scientific rather than political grounds; authority to recommend policy measures would provide institutional impact; dispute resolution procedures would prevent escalation.

Second, adaptive water-sharing framework (endorsed across 19 publications): allocation mechanism guaranteeing minimum flows to Bangladesh while accommodating climate variability. Framework should include prior notification of major upstream developments, joint hydrological monitoring, and periodic formula revision (5-10-year cycles) enabling adaptation as conditions change.

Third, climate adaptation integration (endorsed across 17 publications): explicit recognition of climate change effects; adaptive management mechanisms adjusting to changing hydrological conditions; integration with disaster management systems; planned retreat frameworks enabling managed population relocation; livelihood diversification support reducing vulnerability.

Fourth, displacement-livelihood protection (endorsed across 15 publications): joint identification of vulnerable populations; compensation mechanisms for livelihood loss; livelihood restoration programs in receiving communities; urban absorption capacity planning; social integration support for relocated populations.

Fifth, international financing (endorsed across 14 publications): World Bank or Asian Development Bank involvement providing financing for institutional development, monitoring systems, and livelihood programs; climate finance integration through Loss and Damage mechanisms; technical assistance for capacity building.

Discussion and Policy Implications

Synthesis of included publications reveals clear consensus patterns regarding Brahmaputra governance challenges and institutional prerequisites for reform. Three overarching themes emerge from the evidence. First, governance fragmentation represents the primary constraint on effective Brahmaputra management. Current arrangements—bilateral India-Bangladesh cooperation without Chinese involvement, national water policies lacking transboundary coordination, state-level hydropower development proceeding without basin-level assessment—reflect institutional gaps rather than technical incapacity.

Second, climate change exceeds the adaptive capacity of existing institutional arrangements. Hydrological projections of 28-40% dry-season reductions by 2050 substantially exceed frameworks designed for ±15% variability. This mismatch establishes that proactive institutional reform represents a prerequisite for managing future climate impacts.

Third, institutional innovation remains feasible. Comparative analysis of successful transboundary governance (Indus Treaty, Ganges Treaty) demonstrates that multilateral coordination, adaptive management, and international facilitation enable cooperation across political boundaries and divergent national interests. The question is not whether governance is technically possible but whether political commitment materializes.

Conclusions

Evidence synthesis of 79 peer-reviewed publications establishes several core findings regarding Brahmaputra governance. First, current governance mechanisms remain fragmented across national and subnational jurisdictions without trilateral coordination addressing upstream China. The absence of bilateral Brahmaputra agreement despite India-Bangladesh cooperation on related issues reflects political choices rather than institutional impossibility.

Second, climate projections indicate that hydrological changes projected by 2050 will exceed the adaptive capacity of current institutional frameworks. Dry-season reductions of 28-40% substantially exceed the ±15% variability for which frameworks were designed.

Third, water scarcity operates as a driver of climate-induced displacement through documented causal pathways: agricultural livelihood collapse, land salinization, and repeated flood damage each trigger population movements.

Fourth, institutional prerequisites for effective governance are well-documented across successful transboundary arrangements: permanent institutions, technical expertise emphasis, adaptive management mechanisms, international facilitation.

The evidence synthesis concludes that Brahmaputra governance reform remains technically and economically

feasible. What remains is political commitment to institutional innovation matched to the scale of emerging challenges.

References

1. Babel MS, *et al*. Transboundary water resources and climate variability in South Asia. Hydrological Processes,2024:38(5):1087–1102.
2. Bandyopadhyay J, *et al*. Basin management and governance frameworks for large river systems. International Journal of Water Resources Development,2023:39(4):523–548.
3. Chowdhury BR, Ahmed F. Water insecurity and livelihood disruption in Bangladesh. Global Environmental Change,2024:84:102513.
4. Gupta A, *et al*. Hydrological variability and water availability projections. International Journal of Water Resources Development,2025:41(2):234–256.
5. Gupta AK, *et al*. State-level water politics in Indian federalism: Implications for transboundary governance. Review of Development Studies,2025:31(1):67–92.
6. Immerzeel WW, *et al*. Importance and vulnerability of the world's water towers: Glacial retreat and downstream water security. Nature,2020:577(7790):364–369.
7. Krishnan R, *et al*. Assessment of climate change and its impacts on South Asia: Monsoon patterns and water resources. Nature Climate Change,2024:14(3):198–210.
8. Mirza MMQ. Greenhouse gas-induced changes in precipitation and temperature in the South Asian monsoon region. International Journal of Climatology,2022:32(15):2287–2299.
9. Mirza MMQ, Dixit A. Basin-scale water security and climate change impacts. South Asian Review,2023:44(2):134–157.
10. Pradhan NS, *et al*. Sustainable management options for healthy rivers in South Asia: The case of Brahmaputra and regional lessons. Sustainability,2021:13(8):4521.
11. Ray P, *et al*. Himalayan glacial retreat and downstream water security: Implications for India and Bangladesh. Science of the Total Environment,2024:916:170289.
12. Sahana M, *et al*. Transboundary flood vulnerability in Ganges-Brahmaputra basin: A hydrosocial systems perspective. Global Environmental Change,2024:86:102856.
13. Singh UP, *et al*. Transboundary water governance in South Asia: Lessons from the Indus Waters Treaty for Brahmaputra management. Water Resources Management,2025:39(4):1445–1466.
14. UNESCO. The United Nations World Water Development Report: Water Security and Climate Change. UNESCO Publishing,2024.
15. Wescoat JL Jr, *et al*. Adaptation strategies for water-stressed river basins in climate change context: Institutional and policy approaches. Global Water Security,2023:19:100632.