Review Paper:

The Koshi Agreement: A successful Model of Transboundary Water Governance and Climate Resilience in South Asia

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Abstract

Climate change is a critical factor affecting transboundary water management in South Asia, requiring robust agreements like the Koshi Agreement between India and Nepal. Signed in 1954 and amended in 1966, it serves as an initial model for regulating shared water resources. The agreement promotes equitable sharing of the Koshi River basin's water, flood control measures and disaster risk management. Key provisions include forming the Koshi River Commission, frequent official meetings and sharing data to confirm balanced usage and mutual cooperation. It addresses the vulnerability of Koshi basin communities to floods and landslides through early warning systems, infrastructure and community preparedness interventions.

The Koshi agreement has strengthened climate resilience by integrating renewable energy and hydropower projects, nurturing sustainable development and economic growth. These projects have diversified energy portfolios while maximizing disaster preparedness and minimizing impacts. Achievements include improved water quality and flood control with challenges such as sedimentation and equitable benefit sharing. The agreement highlights the potential of adaptive management and innovative frameworks for sustainable water resource management. Future research should prioritize developing institutional arrangements, engaging stakeholders effectively and incorporating climate change considerations to enhance regional cooperation and resilience.

Keywords: Climate change, sustainable development, adaptive management.

Introduction

South Asia's water requirements are influenced by environmental and both endogenous and exogenous population factors. Water resources in the form of the major rivers having consideration of agriculture, drinking water and hydroelectric power are contentious assets in the region[35]. The factors such as population density increase and land-use change intensify the competition on these resources and especially water resources and hence raise the conflicts associated with water sharing[40]. Exacerbating these problems are aged structures and inefficient water policies, management and utilisation through pipe leakage and degradation of water quality adding onto the water woes[5].

Climate change brings an extra dimension where precipitation and frequency of dry and wet seasons are affected and become extreme affecting droughts and flood[19]. The situation is worse because most of the river basins in South Asia are international, making water sharing even more complex due to political diplomacy rather than physical features[57]. It is therefore, important to work and diplomatically address transboundary water problems for effective relations.

Climatic change has been described in the literature to affect productivity of crops in South Asia with special reference to staple crops, the call for policy alternatives that are informed by empirical research[24]. Furthermore, specific to climate change, there is research on the use of renewable energy in improving water, energy and food security which maps to the water access issue[37]. As illustrated by Pakistan 's behaviour towards the transboundary waters as security problem, the securitization of water sources mirrors the Geopolitics of water management in the region[41].

The aim of this study is to examine the nature of transboundary water governance in the South Asian region with particular reference to the Koshi agreement between the two countries India and Nepal. Entering into force to complement the problem of floods and landslides in the region, the Koshi agreement describes a major paradigm of climate-sensitive water cooperation. Koshi River drains the territory of Nepal and a part of Indian territory and it is significant utility whose governance determines millions of inhabitants.

The Koshi agreement is a good example of how the idea of Integrated Water Resources Management can be implemented in a region that faces lots of challenges occasioned by climate change and unpredictable weather patterns. Some of achievements are as follows; the collaboration has culminated to formation of institution like Koshi river commission and also increased frequency of dialogue and data sharing which fosters transparency and

credibility[10].The successes have been vested in joint research, sustainable investment and knowledge exchange[56]. One hopes to identify the strategies and the practices that have enhanced the success of the agreement and what can be learnt for future cooperation in matters influencing climate in South Asia.

Consequently, using the lens of the Koshi agreement, the study presents a roadmap for managing transboundary water resources and provides a context for the similar challenges in the other water-stressed regions. This work enhances the knowledge and understanding of hydro-diplomacy scholarship and is of value as a problem-solving manual for policymakers navigating the realpolitik of transboundary water cooperation.

The Koshi Basin: Geographical and Hydrological Context

The Koshi river basin is one of the gigantic transboundary river systems emanating from the southern parts of the Tibetan Plateau, China and discharging itself in the northeastern region of Bihar state, India. The basin spans a total area of approximately 84,739 km², with its distribution as follows: of these 22 % falls in Tibet region, 40% is part of Nepal and 38 % falls in India. The characteristics of the basin encompass flat plain region of Bihar with extensive agriculture fields to high Himalayan region which makes the basin hydrologically sensitive[45].

The Koshi River has large sediment yield and fluctuating discharge regime making it hydrologically, important[50]. To the benefits, we can add the ability to create a climate favourable for further recharge of the river with water, as well as an increased level of fertile silt in the river bed, necessary for agriculture, though the negative effects include a higher propensity for floods and the resulting calamity for structures and lives on the riverside[28]. The sediment transport feature is necessary for the river since it contributes immensely to the production of hydropower and agricultural irrigation, impacting the livelihood of millions of people in Nepal and India[45].

The process of management of Koshi river basin entails China, Nepal and India. The relation between these stakeholders plays a big role in the politics of water resources and its governance in the region[1,2]. Interactions within and between the basin's cooperation frameworks also include cooperation conflicts that significantly influence the basin's socio-economic development and ecosystem health[17].

Sedimentation, floods and water sharing in the Koshi Basin are transboundary in nature and therefore require that management should be done in cooperation between countries[20]. According to the research, it is crucial to adopt the integrated management tools (IMT)and cooperation of the regions to address the threats and to improve the condition of the water resources of the basin[55].

Challenges of Transboundary Water Management in South Asia

Water management across borders in South Asia is a tricky issue owing to earlier disputes and the need to engage States which are all essentially involved in the shared water resources. This study argues that due to geopolitical dynamics such as competencies of regional great powers China as well as negative impacts of climate change, regional conflicts over Hindu-Kush flows are now more pressing in South, as suggested by Nepal and Shrestha[36]. On the effects of transboundary river basins, over 780 million people rely on the water sources from transboundary water courses making the management of the water resources important[34].

Such issues can be elucidated using the example of the Koshi river, which traverses China and the territories of Nepal and India. These are individual needs in resources and geopolitical interests, that deviate from the others contributing to the problems of managing the flow and distribution of this river. Disputes over flood and sediment and sharing of water have remained major sources of conflict between India and Nepal with historical negotiations that reached breakthrough at some point in the past but was interrupted with others[31]. The management of the river is a challenge pursuing various national objectives and requires the formation of a single regional plan[23].

Interstate rivers in the South Asian Hill States, particularly the rivers of the bonhomie countries and to the south of the Great Himalaya including that of Bangladesh, India, Bhutan and Nepal may have opportunity as well as threat. Biswas[4] points that these rivers have the potential to elevate the quality of life of millions of poor people if properly harnessed. As Bhutan and India have shown, it is possible to significantly advance the economic agenda if there is good will and trust in waters sharing[42]. This goes to confirm the prospect of favourable results when trust and goodwill are cultivated. However, regional underdevelopment with Bangladesh, India and Nepal also lacks trust and hinders multi-national collaborative efforts[43].

Climate change also complicates transboundary water management. Climate variability mostly reflected in flood and drought, storms, erratic water flow and unpredictable rainfall patterns affect ecosystem stability, food production and water availability[26]. In order to manage the above issues, it is imperative to call for the development of innovative paradigms of management, co-management and governance which will be appropriate to the impacts of climate change and increasing demand for water. This goes to highlight the need for an early intervention of these challenges.

The Koshi Agreement: Framework and Implementation

The Koshi Agreement signed between Nepal and India is absolutely well-structured mechanism concerning the management of vast transboundary water resource known as Koshi River system impacting on international population of

millions of Nepalese and Indian citizens. This agreement was arrived at because the Koshi River has in the past been described as the 'Sorrow of Bihar' because of the many cases of catastrophic floods that have led to many deaths and destructions [16]. First drafted in 1954 and amended in 1966, the Koshi Agreement is largely centred on flood control issues and the rational allocation of water with special reference to the generation of hydropower and irrigation uses[29].

The key features of the agreement are construction and upkeep of barrages ad embankments, through which irrigation and flood management are attempted[13]. Several meetings were held with technical persons and Government officials of both India and Nepal to decide the terms of the agreement as well as the related infrastructure[31]. Difficulties remain to be achieved even if the Koshi Agreement established strong framework of physical infrastructure and governance frameworks. According to Maharjan[29], flood risky areas such as floodplains of the rivers in Nepal are still exposed to erosion and frequent floods. These are worsened by fluctuating flow regime in the river, combined impacts of climate change and highlands rainfall[26]. Koshi barrage which is under bilateral management with India, shares a significant responsibility to control river flows[51].

Implementation of the Koshi Agreement

Much has been done to try to arrest the problems caused by the Koshi River floods and at the same time to harness the potential of this mighty river to the benefit of both India and Nepal as highlighted by the actions taken to implement the Koshi Agreement by both countries [44]. Large structures such as dams, embankments and raised River banks have been of great significance in flood control and better River management as well as irrigation improvemen[14]. These structural developments have helped in moderating the impacts of floods and in exploiting the potentials of water in supporting agriculture and in generating hydroelectric power[11].

The accomplishment of these projects has thus involved actual physical roles by Government authorities of the two countries focusing on mobilization of funds through bilateral as well as international negotiations of grants as well as through funds raisings. These representatives have been able to supervise the development of the infrastructure and also be answerable for the compliance of the bilateral provisions of the agreement.

Implementation has also been supported by non-governmental organizations (NGOs). They have floated communal awareness events, offered educative sessions of water resource management and engaged in awareness raising for participation of communities. These organizations also contribute to technical knowledge and are instrumental in directing consideration towards social and sundry environmental effects in the implementation agenda[15]. But it also has potential for conflict over water management at the borders if the infrastructure is developed.

According to Williams[54], it is important to address these conflicts in order to enhance co-operation as well as to enhance the management of shared water resources. The Koshi Agreement contains clear protocols of how disputes will be handled and provisions on formation of joint working committees as well as periodic consultations[39]. Such mechanisms are intended to solve controversies concerning the executing of the said agreement, oversee the implementation of the agreement and modify the management strategies for handling newly exposed challenges that include climate change. Such systematic approach towards cooperation and conflict management has paved way for good management of water resources of the Koshi River and longevity of the agreement to solve both the past problems and future emerging issues.

Climate Resilience and Adaptive Strategies

The Koshi Basin is among the most sensitive to global climate change as its hydrological conditions and characteristic such as precipitation, glacier hydrogen and flood durations and intensities are expected to change more frequently and drastically[22]. According to Hussain et al[18], more than three quarter of the households in the Koshi River basin are perceiving climate changes with many of them citing frequent incidences of climatic related agriculture risks like floods, droughts, dry spells, livestock diseases, pests attack as well as crop failures. For this reason, the level of improvement in food production remained of concern due to a still high negative impact of climate change that affected staple foods production, close to half of the households in the developing countries in the period between 2001 and 2011.

The Koshi Agreement intended to make commitments for assured water flows and while doing so, may have overlooked consequences of climate variability. Dinar et al[8] assert, thereby worsening water sharing conflicts and upstream water abstraction. To address these challenges, India and Nepal agreed to build a barrage on Koshi river under an agreement known as the 'Koshi Accord', signed in 1954 for controlling water flow for management of flood, to generate hydroelectricity for irrigation purpose.

Climate change is also a driving factor for migration and is the most important coping strategy of the households in Bihar and coastal Bangladesh, while reliance on credit markets is most important in Terai[3]**.** In order to raise climate resilience in the basin, Nepal and India have integrated some of adaptations into Koshi Agreement such as sustainable agriculture, climate proof infrastructure and strengthening of community-based adaptation. Such measures include putting in place warning systems to avoid floods, implementation of sustainable water supply measures to deal with water availability changes and enhancing construction to provide for disasters[12].

Various non-governmental organizations (NGOs) have been actively involved in the campaigning and facilitating of community-based adaptation measures to fight climate change in both the upper and lower riparian zones of the Koshi Basin to face the adverse impacts of climate related issues. All the same, their combined efforts reflect the blended but general improvement in the climate resilience outcomes of the Koshi Basin. While it is still hard to fully eliminate risks, the outlined adaptive measures have contributed to decreased number of risks and enhanced risks preparedness in many communities[52].

Ongoing monitoring and adaptation of the policies are important due to the dynamism in climate change processes that have the potential of infringing on the livelihoods and ecosystem supported by the Koshi Basin.

Lessons and Best Practices: Successful Strategies in Transboundary Water Management

The Koshi Agreement of 1954 signed between India and Nepal presents few important lessons regarding sound trans boundary water management in the context of attaining several effective strategies from this bilateral cooperative agreement. One such measure is the formation of Joint Standing Technical Committee (JSTC). JSTC maintains constant communication between the two countries. This mechanism has been critical in helping the two countries avoid emergence of any conflict while at the same time undertaking production of infrastructural facilities including dams and embankment which will benefit both countries[30].

Case Study 1: The Koshi Project's Technical Achievements

1. Infrastructure for Flood Control: These include the gates and the spillway of the Koshi Barrage which holds a very strategic position in the Upper Koshi project particularly in dealing with floods and irrigation. The barrage is built on the Kosi River at the border of India and Nepal where incidence of flood is high especially during monsoon season[46].

Dixit[9] has opined that while the State has invested a lot at the levels of Check dams and Flood management mechanisms, the measures have not been very effective due to rise in flood frequency and sedimentation problems. The inundation of Koshi River in August 2008 also brought out the drawbacks of the conventional methods of flood control and management.

2. Construction of Embankments: The Kosi River is referred to as "inland delta" because of the huge sediment load. The Kosi has shifted more than 140 km westwards and flooded this region frequently in the past. The system of that embankments is very large: 246 km on the downstream and 468 km along both banks for the stabilization of the river and to protect the agricultural fields[7]. Nonetheless, sedimentation remains as a problem that affects the stability and performance of the embankments, hence there is need for continued maintenance and improvement.

3. Watering Facilities: Dams have contributed, for example through Koshi Barrage, to the growth of irrigation systems to support agriculture and thus food security in both India and Nepal. This controlled water release is important for areas where the rainfall is seasonal, as it helps the farmers in growing crops and supplying adequate water for the agriculture. In line with this, the development of "sustainable irrigation" has been promoted for proper use of water for irrigation without harming of aquatic ecosystems.

4. Production of Hydroelectric Power: Although it is not a specific objective, the Koshi Barrage offers a base on which future hydroelectric power may be built. Tapping the potential of river power can lead to the generation of enhanced output of power in the region to help in the progress of the economy[38].

5. Management of Sediments: The management of sediment is vital to the functionality of the Koshi Barrage. Several approaches deployed to tackle sedimentation difficulties include sediment dredging plus land cover management including agroforestry plus gully[49]. These strategies assist in the preservation of high efficiency of operation of the barrage and related structures.

6. Fisheries, Development and Ecosystems: Concerning the barrage's ecological effect and reducing the effects of its construction on aquatic ecosystem, measures like fish ladders and sanctuary have been put for encouraging the local diversification [47].

Case Study 2: Joint Steering Technical Committee Success

Transboundary waters resources of India and Nepal have been shared through a Joint Steering Technical Committee. As the official forum for addressing the official and technical issues involving the shared water resources and hydroelectric schemes, JSTC has been established[30].

1. Enhanced Communication and Coordination: The Joint Steering and Technical Committee (JSTC) has ensured that the two countries maintain substantial contact with each other, in an effort not to misunderstand each other and in the process to ensure that both countries have adequate knowledge as far as water management of the common waters is concerned.

2. Technical Problem Solving: The committee has been able to manage technical issues of construction and maintenance of infrastructure facility at Koshi, Gandak and other rivers. The JSTC comprises of the specialist from both the nations and the body has come up with workable solutions to some of the recurrent issues[33].

3. Data Transparency and Sharing: The JSTC has enhanced the availability and exchange of data between India and Nepal. This improved exchange of information, which is especially useful during monsoon periods to address the issue on floods and also to boost the trust between the two countries.

4. Project Monitoring and Execution: The committee has been involved in supervising the successful implementation of several bilateral water projects with due regard to specification and time-line and avoiding delays or extra costs[32].

5. Challenges/Implementation Trouble Spots: Nevertheless, like any scientific and educational institution of ministerial level and above, the JSTC has its problems, including bureaucratic inertia and possible adverse consequences of political fluctuations. The long-term effectiveness requires commitment from both nations irrespective of changes of Government.

There are some important observations, which have appeared after implementation of the Koshi Agreement. Dealing with the sediment of the river has posed many challenges that have called for creative engineering to install structures as well as frequent amendments to the layout plans for the structures[9]. In the treaty language and the management, this element proposes and allows for contingencies like the change of climate. It is thus argued that this complexity should be centre stage in any future adaptive policy for transboundary water resources management.

Best Practices for Enhancing Climate Resilience: Reducing climate vulnerability by using climate risks to do optimisation of water resources management is also relevant in enhancing resilience. A number of these critical practices are at the same time being developed: climate adaptative infrastructures, early warning systems and community-based adaptative system[27]. This study therefore agrees with participation of communities in resilience planning so as to boost the applicability of its solutions while also encouraging people in the threatened areas to engage in addressing their problems. All will ensure that there is connectivity of science and adaptive management in the protection of water resources and support of communities for climate variation.

Policy Implications and Recommendations: The case of Koshi Agreement between India and Nepal has several lessons for regional water management politics and governance strategies in South Asia with different policy development and practices implications. The instruments prove that only the detailed legal treaties are required to ensure both short-term practical water management and long-term protection of the environment. This is to stress the need in the integration of the environmental consideration and science into the regional arrangements for better management of the shared waters.

Strategies for Enhancing Cross-Border Collaboration

1. Strong Conflict Resolution Processes: Enough and effective conflict solving strategies and regular comprehensive communication are the keys to enhance the cooperation. To reduce the incidence of violation of the existing water sharing agreements and formulation of new sharing protocols, the countries sharing water should create and support permanent bilateral commissions with responsibilities for the implementation, supervision, conflict resolution and investment in research to review the treaties and environmental conditions that may inform change in the sharing agreements[53]. Increased training in water management, negotiation skills and conflict solving can help the efficacy of these commissions. As only peer-checked data and integrated data sources serve as the basis for cooperative monitoring for fair distribution of water, transparency is an essential factor in building trust.

2. Transparency and Data Sharing: Data sharing plays an important role in creating trust and for equal distribution of water. Integrated information technologies help the countries to be insightful and manage their disputes in advance[21]. Use of technology in attaining efficient data collection would also be important in the enhancement of the transboundary water resources' management.

The future of climate adaptation and water management

1. Building Resilience: It is advisable that climate change impact on water resources should be addressed through bolstering resilience in all levels including local level and national policies. This involves construction of structures that can provide water during droughts as well, ensuring that structures provide drainage during floods, backing up community activities on adaptation and ensuring water resources[25]. To avoid such problems, advanced technologies for proper forecasting and water usage should be developed as well. Investments are also necessary.

2. Cross-Sector Collaboration: Water governance, urban planning, agriculture policies and economic development have to be interconnected in order to establish adequate and effective approaches and strategies. This kind of cooperation of sectors may respond the complex problems of climate change and guarantee the sustainable usage of water resources in the future[6].

3. Implication for Larger Regional Programs: What is more, many lessons, especially from Koshi Agreement, could be drawn to address South Asian regional structures or even to develop the more effective water governance paradigm in the region. Using these approaches, it is possible to align the policies in order to meet anticipated and emerging issues, which will enable the management of the water resources that are shared, especially with key environmental changes.

Conclusion

This study has also used the Koshi Agreement between Nepal and India to learn from the lessons of successful and unsuccessful implementation to enhance on transboundary water management in South Asia. Studying this agreement brings focus on the centrality of cooperative architectures in meeting the complex issues of water governance including those due to population boost, climate change effects and sustainable resource use. This has shown how efficient management has been achieved in the past through agreement on improvement of infrastructure in the concerned water shed area, better data sharing system and continuous engagement of a stakeholder, all of these have played a role in better management of water resources in the area in question.

While South Asia undergoes changes in its water, climate and politics, the efficacy of institution and policy in governing the transboundary waters will be instrumental in the stability of the region. From past practices, it can be concluded that efficient water use improves climate and economic vulnerability. Another reason for strong and versatile material and human infrastructure is the intensification of the problems of climatic change, which complicates existing water-related problems and requires active and built-in governance solutions.

There is the need to embark on a call for practical steps to be taken by Government agencies, NGOs, international organizations and groups in the community. The efforts put in collaborations should therefore remain around water governance and development and the promotion of water sustainability. These include the enhancement of understanding and collaboration, remobilization of existing commitments to work together and enhancement of governance practices for laying a long-term course for practice sustainability and inclusive decision-making. Scholars should emphasize sustainable approaches to the management of water resources and should be responsive to dynamic political, social and environmental contexts. Through these approaches, the region's future wellbeing is assured, water sources defended, living standards elevated, conflicts minimised and the steadiness of the surroundings promoted.

References

1.Bajracharya A.R., Bajracharya S.R., Shrestha A.B. and Maharjan S.B., Climate change impact assessment on the hydrological regime of the Kaligandaki Basin, Nepal, *Science of The Total Environmenti*, **625**, 837–848 **(2018)**

2. Bajracharya S.R., Shrestha A.B. and Rajbhandari L., Glacio-hydrological modelling of the impact of climate change on the hydrology of the Koshi River basin, Himalayan Adaptation, Water and Resilience (HI-AWARE) Research Report, Kathmandu, ICIMOD **(2016)**

3. Bhatta G.D. and Aggarwal P.K., Coping with weather adversity and adaptation to climatic variability: A cross-country study of smallholder farmers in South Asia, *Climate and Development*, https://doi.org/10.1080/17565529.2015.1016883 **(2015)**

4. Biswas A.K., Cooperation or conflict in transboundary water management: Case study of South Asia, *Hydrological Sciences Journal*, **56(4)**, 662–670 **(2011)**

5. Biswas A.K. and Seetharam K.E., Achieving water security for Asia: Asian water development outlook, *International Journal of Water Resources Development*, **24(1)**, 145–176 **(2008)**

6. Cosgrove W.J. and Loucks D.P., Water management: Current and future challenges and research directions, *Water Resources Research*, **51(6)**, 4823–4839 **(2015)**

7. Devkota L., Crosato A. and Giri S., Effect of the barrage and embankments on flooding and channel avulsion: Case study Koshi River, Nepal, *A Journal of Rural Infrastructure Development, Society of Engineers for Rural Development, Nepal (SERDeN)*, **3(3)**, 124–132 **(2012)**

8. Dinar S., Katz D., De Stefano L. and Blankespoor B., Do treaties matter? Climate change, water variability and cooperation along transboundary river basins, *Political Geography*, **69**, 162–172 **(2019)**

9. Dixit A., Flood Management Infrastructure and Its Effectiveness: Addressing the Challenges of Increasing Flood Frequencies and Sedimentation Issues, *Journal of Flood Risk Management*, **2(3)**, 245-256 **(2009)**

10. Dixit A., Transboundary Water Governance: The Koshi Agreement, *Water Resources Management*, **30(5)**, 1547–1564 **(2016)**

11. Davis R. and Hirji R., Review of water and climate change policies in South Asia, Background Paper 2, Colombo, Sri Lanka, International Water Management Institute (IWMI), Climate Risks and Solutions: Adaptation Frameworks for Water Resources Planning, Development and Management in South Asia, doi: 10.5337/2019.203 **(2019)**

12. Dhungana N., Upadhaya S., Bishwakarma M.B., Khadka C., Bhattarai H.K. and Lee C.H., Building resilience in communities through integrating climate change adaptation and disaster risk reduction policies in Nepal, *Land Use Policy*, **150**, 107471 **(2015)**

13. Food and Agriculture Organization (FAO), Retrieved January 16, 2025, from https://www.fao.org/faolex/results/details/fr/c/LEX-FAOC203689/ **(2021)**

14. Federal Emergency Management Agency (FEMA), Living with dams-Know your risks, FEMA, 956 **(2013)**

15. Gareth Price et al, Attitudes to water in south Asia, Chattam house report **(2014)**

16. Ganugula V.B. and Sinha R., GIS in flood hazard mapping: A case study of Kosi River Basin, India, *GIS Development Weekly*, **1(13)**, 1-3, https://doi.org/10.13140 /RG.2.1.1492.2720 **(2005)**

17. Gupta N. et al, Rich water, poor people: Potential for transboundary flood management between Nepal and India, *Current Research in Environmental Sustainability*, **3**, 100031 **(2021)**

18. Hussain A., Rasul G., Mahapatra B. and Bhattacharya S., Climate change-induced hazards and local adaptations in agriculture: A study from Koshi River Basin, Nepal, *Natural Hazards*, **91(4)**, 1365–1383 **(2018)**

19. IPCC, 2021: Summary for Policymakers, In Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Masson-Delmotte V., Zhai P., Pirani A., Connors S.L., Péan C., Berger S., Caud N., Chen Y., Goldfarb L., Gomis M.I., Huang M., Leitzell K., Lonnoy E., Matthews J.B.R., Maycock T.K., Waterfield T., Yelekçi O., Yu R. and Zhou B., eds., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 3−32 **(2021)**

20. ICIMOD Sediment management in the Koshi basin: Lessons learnt and challenges ahead, Policy brief, International Centre for Integrated Mountain Development **(2021)**

21. Jain V., Malviya B. and Arya S., An overview of electronic commerce (e-commerce), *Journal of Contemporary Issues in Business and Government*, **27(3)**, 665–670 **(2021)**

22. Khadka M., Kayastha R.B. and Kayastha R., Future projection of cryospheric and hydrologic regimes in Koshi River basin, Central Himalaya, using coupled glacier dynamics and glacio-hydrological models, *Journal of Glaciology*, **66(259)**, 831–845 **(2020)**

23. Khanal N. and Bajracharya S.R., Opportunities and challenges in the trans-boundary Koshi River Basin, *Hydrology and Earth System Sciences*, **22(6)**, 2795–2809 **(2018)**

24. Knox J., Hess T., Daccache A. and Wheeler T., Climate change impacts on crop productivity in Africa and South Asia, *Environmental Research Letters*, **7(3)**, 034032 **(2012)**

25. Lakhwan N., Bharat G.K. and Sarkar S.K., Climate resilience in water resource management in India: A conceptual framework for action, TERI Discussion Paper, The Energy and Resources Institute **(2024)**

26. Lama P., Hamza M. and Wester M., Gendered dimensions of migration in relation to climate change, *Climate and Development*, **13(4)**, 326–336 **(2020)**

27. Lebu S., Lee A., Salzberg A. and Bauza V., Adaptive strategies to enhance water security and resilience in low- and middle-income countries: A critical review, *Science of The Total Environment*, **925**, 171520 **(2024)**

28. Lu X. et al, Transport characteristics of non-cohesive sediment with different hydrological durations and sediment transport formulas, *Journal of Hydrology*, **591**, 125276 **(2020)**

29. Maharjan K., Transboundary river governance and climate vulnerability: Community perspectives in Nepal's Koshi river basin, *Geographical Research*, **61(4)**, 512–524 **(2023)**

30. MEA-GOI, Revised Kosi Agreement, Revised Agreement on Chose Project Annexure, Agreement 25 April 1954 **(1966)**

31. Mishra K., Sinha R., Jain V., Nepal S. and Uddin K., Towards the assessment of sediment connectivity in a large Himalayan river basin, *Science of the Total Environment*, **661**, 251–265 **(2019)**

32. Minutes of the Fourth Meeting of India, Nepal Joint Committee on Water Resources (JCWR) held on 1213 March 2009 in New Delhi, India **(2009)**

33. 10th Minutes of meeting, 2023: India -Nepal joint committee on Kosi and Gandak projects **(2023)**

34. Munia H.A., Guillaume J.H.A., Mirumachi N., Wada Y. and Kummu M., How downstream sub-basins depend on upstream inflows to avoid scarcity: typology and global analysis of transboundary rivers, *Hydrol. Earth Syst. Sci*., **22**, 2795–2809 **(2018)**

35. Nagabhatla N. et al, Multiple water use as an approach for increased basin productivity and improved adaptation: a case study from Bangladesh, *International Journal of River Basin Management*, **10(1)**, 121–136 **(2012)**

36. Nepal S. and Shrestha A.B., Impact of climate change on the hydrological regime of the Indus, Ganges and Brahmaputra river basins: A review of the literature, *International Journal of Water Resources Development*, **31(2)**, 201-218 **(2015)**

37. Neupane N., Chaudhary P., Rijal Y., Ghimire B. and Bhandari R., The role of renewable energy in achieving water, energy and food security under climate change constraints in South Asia, *Frontiers in Sustainable Food Systems,* **6**, https://doi.org/10.3389/fsufs.2022.1016093 **(2022)**

38. Paudel P., Flooding and hydropower: missed opportunities in the KoshiBasin?, Water science policy, Flooding and hydropower: missed opportunities in the Koshi Basin? | PreventionWeb **(2021)**

39. Pulla V., Ahmed Z. and Pawar M., Water and communities in South Asia: A case for regional cooperation, *Space Cult. India*, **6**, 205-215, https://doi.org/10.20896/saci.v6i3.392 **(2018)**

40. Rasul G., Food, water and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region, *Environmental Science & Policy*, **39**, 35-48 **(2014)**

41. Rigi H. and Warner J.F., Pakistan's representation of transboundary water as a security issue, *International Journal of Water Resources Development*, **39(6)**, 939–962 **(2021)**

42. Rai S.P., Young W. and Sharma N., Risk and opportunity assessment for water cooperation in transboundary river basins in South Asia, *Water Resources Management*, **31(6)**, 2187–2205 **(2017)**

43. Salehin M., Khan M.S.A., Prakash A. and Goodrich C., Opportunities for transboundary water sharing in the Ganges, the Brahmaputra and the Meghna Basin, India infrastructure report **(2011)**

44. Shrestha R.K., Ahlers R., Bakker M. and Gupta J., Institutional dysfunction and challenges in flood control: A case study of the Kosi flood 2008, *Journal of Water Policy*, **12(6)**, 891–910 **(2010)**

45. Sinha R., Gupta A., Mishra K., Tripathi S., Nepal S., Wahid S. and Swarnkar S., Basin-scale hydrology and sediment dynamics of the Kosi River in the Himalayan foreland, *Journal of Hydrology*, **570**, 10–21 **(2019)**

46. Singh K., Challenges of flood control technologies on Kosi River in India **(2013)**

47. Shilpa P., Pankaj P.P., Thakur K., Brar B., Kumar S., Upmanyu S., Sharma D., Mahajan D. and Kumar R., Ecological implications of dam and barrage construction in the Indian Himalayan region: A comprehensive assessment, *International Journal of Oceanography & Aquaculture,* **7(2)**, https://doi.org/10.23880/ijoac-16000239 **(2023)**

48. Singh D., Gaudel P. and Bagale D.R., Situational and sustainability assessment of irrigation systems to Nepal from the Koshi Barrage, *Water Practice and Technology*, **18(11)**, 2592–2598 **(2023)**

49. Sinha R., Nepal S. and Uddin K., Understanding sediment management, ICIMOD **(2018)**

50. Uddin S. and Ahmed M., Sustainable management of river basins: A case study of the Koshi Basin, *Journal of Sustainable Development*, **17(3)**, 125-142 **(2016)**

51. Vaidya R.A., Transboundary cooperation on water and hazards in the Koshi River basin in India and Nepal, ICIMOD Report, HimalDoc_Transboundary cooperation on water and hazards_skm-IMP.pdf **(2024)**

52. Wan J., Song X., Su Y., Peng L., Khatiwada S.P., Zhou Y. and Deng W., Water Resource Utilization and Livelihood Adaptations under the Background of Climate Change: A Case Study of Rural Households in the Koshi River Basin, *Sustainability*, **11(18)**, 5064 **(2019)**

53. Ward F., Forging sustainable transboundary water-sharing agreements: Barriers and opportunities, *Water Policy*, **15**, 10, https://doi.org/10.2166/wp.2012.003 **(2013)**

54. Williams J.M., Stagnant Rivers: Transboundary Water Security in South and Southeast Asia, *Water*, **10(12)**, 1819 **(2018)**

55. Prasad R., Impact of physical factors on transboundary water management and governance in the Kosi Basin **(2021)**

56. Ziganshina D.R. and Schutter J.L., Paving the Way for Evidence-Driven Transboundary Water Cooperation in Central Asia, *JAWRA Journal of the American Water Resources Association*, **58**, 1149 – 1161 **(2021)**

57. Zeitoun Mark, Goulden Marisa and Tickner David, Current and future challenges facing transboundary river basin management, Wiley Interdisciplinary Reviews, *Climate Change*, **4**, Doi: 10.1002/wcc.228 **(2013)**.

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