

# *Moving towards sustainable Nepal - India water relations in the present context of federalism in Nepal*

Sudip Gautam  
School of Civil and Construction Engineering  
Oregon State University  
Corvallis, OR, USA  
gautams@oregonstate.edu

Pravin Kumar  
Bheri-Babai Diversion Multipurpose Project  
Department of Water Resources and Irrigation  
Kathmandu, Nepal  
kumar27pravin@gmail.com

**Abstract**— Nepal and India have a unique relationship fueled by open border, similarity in culture and religious practices. Nepalese rivers contribute more than half of water in the Ganges River. Nepal and India have signed three major water treaties: Koshi Agreement, Gandak Treaty and Mahakali Treaty. Although these water treaties were supposed to be mutually advantageous, Nepal has not been benefitted by these deals as agreed.

The water availability in the Ganges River Basin is affected by the changing climate as well as increasing water demand. There have been certain issues with trans-boundary water sharing between Nepal and India. With Nepal moving to the Federal System, there might be water related issues between the states in Nepal as well. In this context, it is important to understand how the water relationship with India will be affected.

Nepal mostly got raw deals with fewer benefits from the previous treaties, and there is a dire need to revise the treaties taking the recent developments into consideration. In doing so, flood control benefits received by India should be shared with Nepal. This paper presents a detail review of the existing Nepal – India water relations and discusses the way ahead for sharing trans-boundary waters.

**Keywords**— Nepal, India, Trans-boundary, Water Treaty, Water Sharing

## I. INTRODUCTION

Nepal is a Himalayan country rich in water resources, extending between the latitudes 26022' N - 30027' N and longitudes 80004' E - 88012' E. It is estimated that the available surface water in Nepal is 225 billion m<sup>3</sup> per year from over 6000 rivers with a total drainage area of 194,471 km<sup>2</sup>, out of which 74 % area lies within Nepal [1]. Koshi, Narayani (Gandaki), Karnali and Mahakali are the four major river systems in Nepal that originate in the Himalayas and flow North-South (Figure 1). Apart from these major river systems, Nepal also has medium rivers that originate from the Mahabharat range and other smaller rivers in Terai that originate in the Siwalik range. These rivers have seasonal variation in the flow, with the flows reaching peak values during the monsoon season in

July- August and hitting low values during February - March dry season.

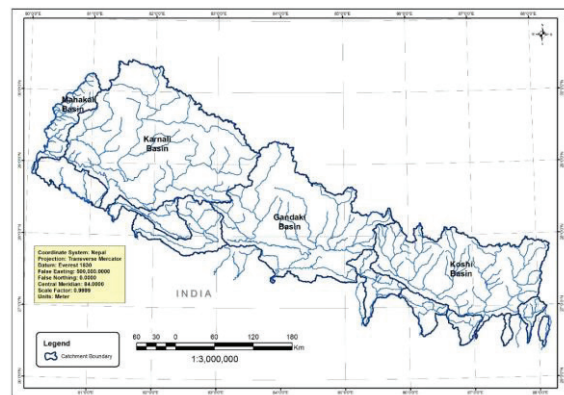


Figure 1: Major River Basins in Nepal

These rivers have huge potential for hydropower generation and enough water for domestic, irrigation and industrial purposes. Water storage behind dams and reservoirs in the Himalayan catchment of Nepal can be used for flood control in the downstream regions in Nepal, India and Bangladesh. Thus, Nepal recognizes the water resource as the key natural resource with the potential to bring in the economic growth and help in development of the country.

The four major rivers, Koshi, Narayani (Gandaki), Karnali and Mahakali, originate from the Himalayas and run south to meet Ganges River in India. These rivers are transboundary in nature and form the upper portion of Ganges River Basin (GRB). The rivers draining from Nepal into the Ganges comprise about 45% of the average annual flow and 70% of the dry season flow [2], even though Nepal occupies only 14% of area of the GRB.

## II. WATER RESOURCES STRATEGY OF NEPAL

The Government of Nepal introduced Water Resources Act in 1992, prioritizing the usage of water in the order of drinking water, irrigation, other agricultural use, hydroelectricity, and so on. It also introduced the licenses for non-domestic use and gave the government power to acquire land and other infrastructures for the utilization and development of

water resources. Similarly, Hydropower development policy was introduced in 1992, so as to assist and enhance the development of hydropower projects in Nepal and motivate national and foreign private investments in hydropower development. The policy was revised 2001 to include the environmental flow requirement, and policies regarding promotion of hydropower, extension of national electricity grid, etc.

In 2002, Water and Energy Commission Secretariat (WECS) formulated the comprehensive Water Resources Strategy for the holistic and systematic development and management of Water Resources following the principles of Integrated Water Resources Management (IWRM), and recognizes that the water resources development needs to be integrated with sustainable social and economic development. It states that the sharing of water resource benefits among the co-riparian countries shall be on an equitable basis for mutual benefit [3].

The Government of Nepal introduced National Water Plan in 2005 to implement the Water Resources Strategy through a series of planning frameworks and action plans. The national water sector goal was defined as ‘living conditions of Nepali people are significantly improved in a sustainable manner’ [4]. It developed short (5-year), medium (15-year) and long-term (25-year) action plans for the water resources sector that included project activities, investments and institutional aspects. The purpose of this was to “advance the long-term purpose of the Water Resources Strategy to maximize benefits through sustainable management of the resource” [4].

Similarly, the government introduced Irrigation Policy in 2003 with the aim of maximizing the year-round irrigation by promoting Water Users Association and user’s participation, and released a revised policy in 2013 with the vision to enhance crop productivity through year round irrigation of all the arable land in Nepal.

Currently, the Department of Water Resources and Irrigation is preparing Irrigation Master Plan by utilizing the concept of Integrated River Basin Planning, irrigation water-use inventory and irrigation policy under the Water Resources Project Preparatory Facility (WRPPF). Similarly, WECS is preparing River Basin Plans and Hydropower Master Plans under the Irrigation and Water Resources Management Program (IWRMP). This river basin plan will take into account all the water uses, including hydropower, irrigation, drinking water and environmental flow. The river basin plan will consider the optimal use of water in different sectors; whereas the hydropower master plan will determine the optimal capacity and type of hydropower plant in the basin. The outcome of the study will provide a roadmap for the development of water resources projects in Nepal in near future.

### III. NEPAL – INDIA WATER TREATIES

With the north-south gradient in Nepal, all the waters originating from the Himalayas flow through Nepal to join the Ganges River; making India the only water ally of Nepal. While Nepal-India have had water relation and several treaties dating back to the British rule in India, three major water treaties stand out: Koshi Agreement, Gandak Treaty and Mahakali Treaty signed in 1954, 1959 and 1996 respectively.

#### A. Koshi Agreement

The Koshi agreement was first signed between Nepal and India on 25th April, 1954 with an agreement to construct a barrage with under sluice on both sides along with afflux and flood banks in the territory of Nepal about 3 miles upstream of Hanuman Nagar to help in flood protection and cater the irrigation needs of the two countries. Many believed that the treaty went against Nepal in many ways including extraterritorial rights provided to Indian side for infinite period, restriction in the use of water upstream of project site, lack of compensation for the submerged lands in Nepal, and loss of huge fertile lands. The treaty was thus revised on 19th December, 1966 after facing continued criticism [5].

#### B. Gandak Treaty

The Gandak agreement was signed between Nepal and India on 4th December, 1959 and formed the basis for the construction of Gandak barrage, canal systems serving India and Nepal, and a hydropower plant. A barrage was constructed in the Gandaki River near Bhaisalotan with two canals taking off from either side. The main Eastern Canal lies in the Indian territory but one of its branches Don Branch Canal reaches Indo Nepal border and bifurcates into two canals one of which is the Nepal Eastern Canal that passes through Bara, Parsa and Rautahat districts of Nepal. The main Western Canal passes through a few kilometers in Nepal before entering the Indian Territory. The project irrigates a total Gross Command Area of 17843 lakh Ha of land in India; and is supposed to irrigate 58000 ha in Nepal as per the agreement, which has not been attained till date. Like Koshi Agreement, this agreement also caused a lot of dissatisfaction among Nepal's part. The major issues included sovereignty issues as well the protection of riparian rights in Nepal upstream of the Barrage to withdraw water as required. The Agreement was revised on 30th April, 1964 after facing many protests from the opposition political parties [6].

#### C. Mahakali Treaty

With grave dissatisfactions on Koshi and Gandak agreements, Nepal took a rather cautious approach to signing of any further treaties. The Mahakali treaty was hugely politicized before it was finally signed as “Treaty between Nepal and India Concerning the Integrated Development of the Mahakali River Including Sarada Barrage, Tanakpur Barrage and

Pancheshwar Project” on 12th February, 1996. Besides the proposed Pancheshwar Project, which had immense hydropower prospects; the major benefits of the treaty were irrigation and flood control management. As per the agreement, Nepal is to receive irrigation and power benefits in return of the lands utilized by India for the Sarada and Tanakpur barrage [7]. The Pancheshwar Multipurpose Project was to be developed jointly, with both nations having equal entitlement in the utilization of the waters of the river and the power generated, while a portion of Nepal's share of energy is to be sold to India.

#### D. Issues with the treaties

Although these water treaties were supposed to be mutually advantageous, Nepal has not been benefitted by these deals as agreed. On both Koshi and Gandak treaties, experts believe that Nepal remains more on a losing side as these projects were particularly planned and executed with India's flood protection and irrigation water requirements in focus. There was a lack of joint consultations to obtain optimum equal benefits, resulting in Nepal getting a raw deal as vast stretches of its land is submerged. It is evident that these projects would have irrigated still larger tracts of land in Nepal and India if the barrage was located further upstream closer to Devghat in case of Gandak Project and near Chatara in case of Koshi Project [8].

Gandak irrigation canals have had poor performance, and the benefits planned in the designs of the Gandak Project did not materialize. The canals serve a smaller area than planned and there is little coordination between the farmers and the barrage operators. As a result, the gains in agricultural productivity have been far less than anticipated [9]. Furthermore, Article 9 of Gandak Treaty has hindered the development of many lucrative trans-valley projects in Nepal. In case of Koshi Agreement, Nepal did not receive benefits commensurate to its lands and socio-cultural losses. The Chatara canal that was supposed to irrigate 66,000 ha lands in Nepal was neither complete nor functional and hardly irrigated even 20,000 ha of land when handed over to Nepal [10].

In case of the Mahakali treaty too, the Pancheshwar project has not seen much of development with both nations having dissatisfaction in many points including the existing consumptive use, economics, equal sharing, and phasing of the project.

#### IV. TRANSBOUNDARY WATER RESOURCES & CONFLICTS

Transboundary water resources management is a complex issue that requires bilateral and multilateral agreements and cooperation. There are several natural, social, political and economic complexities when it comes to water sharing between different states and nations.

People in many countries of the world depend on the water resources that originate beyond their

borders, and thus their water security is highly dependent on the activities taking place in the upstream catchments. There have been many instances where states and countries have disagreement over the shared water. The intensity of water conflict varies across the basins and time, and affects all levels and aspects of the society. Some of the transboundary water disputes include [11]:

- a) Dispute over the water in Nile river basin among Egypt, Ethiopia and Sudan (1944 – present)
- b) Turkey, Syria and Iraq conflict over the Euphrates-Tigris Basin waters (1960 – present)
- c) Transboundary water dispute between Afghanistan and Iran over the waters of the Helmand River (2001 – present)
- d) Dispute in the Mekong River Basin among China, Laos, Cambodia, Vietnam and Thailand due to extensive dam building by China and Laos (1995 – present)
- e) Turkey – Armenia conflict in sharing the waters of Arpacay River (1990 – present)

Similarly, the water conflict between the Indian States of Karnataka and Tamil Nadu over the water from Cauvery River has been ongoing from 1974, leading to legal battles as well as water riots with Karnataka limiting the release of water to Tamil Nadu. Another inter-state water dispute in India, the Krishna-Godavari water dispute involves the states of Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh and Orissa which started in 1950s and lasted till 1969 [12]. The conflict was resolved by dividing the area into sub-basins and allocating the flows from the sub-basins to the individual states.

#### V. EFFECTS OF CHANGING CLIMATE

Various studies have been done in the past to understand the impacts of climate change in the Ganges River Basin as well as in smaller scales in various basins in Nepal. Studies in the GRB indicate trends toward rising temperatures, unpredictable and intense rainfall, alternating extremes of flood and drought, etc. [13]. Moors et al. [14] used a group of regional climate models to study the impacts of climate change in the basin over the period 2000 to 2050 and found that there will be an increase in the mean annual temperature and annual mean precipitation. Water availability in the basin will be affected mostly by the timing of runoff from snowmelt that occurs in early spring and summer. Jeuland et al. [15] came to a similar finding in their study and argue that the rise in temperature coupled with other uncertainties and precipitation changes could affect the basin's water cycle, which affects the glacier and snow melt, runoff, agricultural water demand, etc. This will affect the activities going on in the basin such as hydropower generation, irrigation, etc. These studies indicate that climate change will introduce new additional challenges in the basin that needs to be addressed in a timely manner.



Study of the observed climatic trends of Nepal over the period 1971 to 2014 [16] indicates increasing trend for maximum temperature during all seasons, significant positive trend for minimum temperature during the monsoon season, and no significant trends in the precipitation. Studies on the water-surplus Koshi River basin show very little impact at annual, full-basin scale [17], [18]. Bharati et al. [17] projected the water yield to increase in the basin most of the basin except for the A2 scenario during the 2030s. In addition, the flow volumes are projected to increase during the monsoon and post-monsoon but decrease during the winter and pre-monsoon seasons. Devkota and Gyawali [18] found that under the ECHAM05 based future conditions, the monthly flow will decrease by more than 30% during the drier months and increases by more than 25% in the wet months compared to the baseline conditions.

Bajracharya et al. [19] modeled the impacts of climate change on the water balance of the snow dominated Kaligandaki Basin using GCM outputs for RCP Scenarios 4.5 and 8.5, which represent low and high greenhouse gases (GHG) emission scenarios respectively. They predicted the discharge at the basin outlet to increase by 50%, with an increased snowmelt contribution by 90%. They concluded that the increase in temperature and precipitation will affect the water balance components of snowmelt, evapotranspiration, and water yield at higher elevations in the basin.

Dahal et al. [20] studied the impacts of climate change in the Bagmati basin and reported an increase in annual water yield mostly during the water-surplus monsoon season, which could result in more flooding during the rainy season. These studies indicate that water availability in the river basins in Nepal will be affected by the changing climate more in temporal scale than spatial. This will affect the activities going on in the basin such as hydropower generation, irrigation, flood control, etc.

#### VI. RECENT DEVELOPMENTS IN NEPAL

Nepal is moving towards the political and economic stability following the 10-year political conflict and a devastating earthquake. With the increase in the development activities in Nepal, water demand will keep on rising. There are several ambitious projects under study, with some of them already in the design or construction phase. Out of the 45000 MW of hydroelectricity that can be economically harnessed [1], at present Nepal has a total installed capacity of 964 MW [21] that supplies electricity to 70% of the population. The Government of Nepal has identified 109 projects as basket projects with total capacity of 2930 MW and has issued construction license for 209 projects with capacity of 7952 MW [29]. There are 49 projects currently under study with total capacity of 8000 MW.

The national water supply coverage of Nepal has reached to 83.59% whereas the sanitation coverage is 70.28% [22]. However, these numbers are not proper indicators of the field situation, and various programs

are being taken up to improve the Water, Sanitation and Hygiene (WASH) sector. The Department of Water Supply and Sewerage is undertaking a study that aims to supply bulk water to the districts in Terai along the East-West Highway with water from the perennial rivers.

Similarly, several inter-basin transfer projects have been studied such as Kaligandaki-Tinau, Kaligandaki-Nawalparasi, Madi-Dang, Sunkoshi-Marin, Sunkoshi-Kamala, etc. Bheri-Babai diversion project is already in the construction phase, which channels water from Bheri River into the Babai River for Irrigation and power generation. The project is expected to provide year-round irrigation services to 51,000 ha of cultivation land in Banke and Bardiya districts after the construction is completed, along with generation of hydro-power of 48 MW. Detailed Design of the Kaligandaki – Tinau Diversion Project is also being carried out, and will soon enter the construction phase. Development of these large-scale infrastructures alter the natural water regime and cause ecological degradation in the river basins. This affects the water availability in the Ganges River and might be a source of conflict.

#### VII. FEDERALISM IN NEPAL

Nepal has recently been transformed into a federal democratic state, with the Constitution of Nepal 2015 dividing the country into seven states. Major Transboundary Rivers of Nepal lie in multiple states (Figure 2). Koshi River lies in states no. 1, 2 and 3; Gandaki River in states no. 3, 4, and 5; Karnali River in states no. 5, 6 and 7 and Mahakali River in state no. 7.

The Constitution of Nepal has provision for power division among the Federal, Provincial and Local Level regarding the policy formulation, use, construction and management of water resources (Table 1). Article 30 of the constitution of Nepal, 2015 states that 'Each person shall have the right to live in a healthy and clean environment' and article 35(4) states that 'Each citizen shall have the right to access to clean water and hygiene'. The constitution provides the federal level the power to policies and criteria regarding the protection and multi-dimensional use of water resources. It provides the jurisdiction regarding central level mega projects for electricity, irrigation, and other water uses to Federal government. There is concurrent federal and provincial jurisdiction for province Border Rivers, waterways, environment protection and biodiversity [23]. The constitution also provides concurrent rights to federal, provincial and local level in relation to water resource management. These constitutional provisions also help develop a sustainable irrigation system by controlling water-related natural disasters with the river systems management [24].

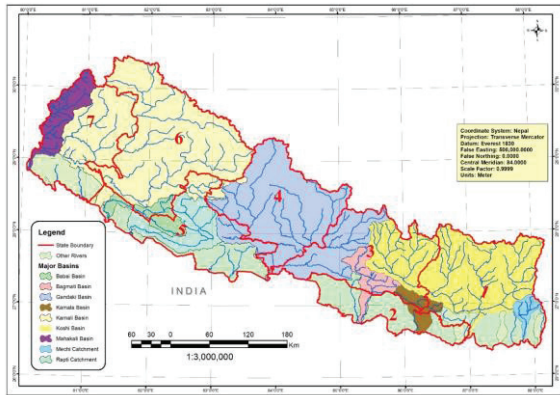


Figure 2: Distribution of River Basins in different provinces in Nepal

Table 1: Jurisdiction of different executive levels regarding Water Resources in Nepal

Schedule	Related to Article	Executive level	Powers/Jurisdiction (clause number)
5	57(1) and 109	Federal	7. Policies and criteria related protection and multi-dimensional use of water resources  10. Central level mega projects for electricity, irrigation and other projects
6	57(2), 162(4), 197, 231(3), 232(7), 274(4), and 296(4)	Province	7. Provincial level electricity, irrigation projects, drinking water, transport  19. Management of national forest, water resources and ecology within the province
7	57(3), 109, 162 (4), and 197	Federal and Province (Concurrent)	13. Province border rivers, waterways, environment protection, biodiversity  18. Tourism, drinking water and sanitation  23. Inter-provincial forest, wildlife, birds, mountains, national parks and water uses
8	57(4), 214(2), 221(2), and 226(1)	Local Level (Municipalities/ Gaupalika)	19. Drinking water, small electricity projects, alternative energy
9	57(5), 109, 162(4), 197, 214(2), 221(2), and 226(1)	Federal, Province and Local Level (Concurrent)	5. Services like electricity, drinking water, irrigation  7. Forest, wildlife, birds, water use, environment, ecology and biodiversity

However, conflicts might arise in projects that impact/benefit multiple states regarding the benefit sharing. The disputes are resolved through Supreme Court, High Court and District Court according to the provision of the Constitution. The judicial system is expected to address the local issues of water governance in future more effectively since it recognizes the decentralization and devolution of power [24].

Nepal still has a long way to go in formulating policies regarding the distribution of water between states from the shared rivers and setting up laws for conflict management. There have already been certain issues with trans-boundary water sharing between Nepal and India, and the inter-state conflicts may add more complexity in that regard. The federal and provincial roles in dealing with trans-boundary waters need to be clearly devised. Article 279 of the Constitution of Nepal stipulates that major treaties or agreement need to be ratified and approved by two thirds majority of the total members in both houses of federal legislature while simple majority of the present members of House of Representatives can ratify and approve ordinary type of treaty or agreement that do not have wide, grave or long term impact on the nation [23].

VIII. THE WAY FORWARD

Cooperation instead of conflict can be used to propel Nepal and India towards economic and social prosperity. Below, we discuss some of the things that can be implemented in improving Nepal-India water relations moving forward.

A. Institutional Capacity Building

Building institutional capacity through the creation of river basin organizations is one of the effective ways of resolving conflicts. Institutions help mitigate the impacts of various change and variability in the basin, and prevent the conflict. Although we currently have Joint Committee on Koshi and Gandak Project, it is not very effective. These institutions should have multilateral involvement, including Bangladesh in the conversation along with Nepal and India as these countries deal with the Ganges waters. The Ganges treaty was signed between India and Bangladesh in 1996 [28].

B. Managing the Change

River changes its course over time and other components of the ecosystem adapt to it accordingly. Similarly, the climate is changing, which alters the runoff and discharge regimes in the rivers. There are other anthropogenic changes occurring in the basins such as migration of people and development works that govern the water use. Due to these dynamic changes, the water availability and time of its availability constantly change. For the effective transboundary water management, we must take this

dynamic change into account. This requires reevaluation of the existing treaties and expanding their scope to account all the changes in the basin. This flexibility challenges current static policy regimes such as guaranteed water flows [25].

### C. *Sharing of Benefits*

Most of the water treaties around the world are based on sharing of the waters. But it often results in one country obtaining more benefit than the other, as in case of Nepal-India water treaties. We need to shift the focus from sharing the water to sharing the benefits of shared water so that there is more flexibility in the negotiations and more opportunities for cooperation [26]. This can come in the form of technical and financial aid for development, sharing the revenue generated, etc.

### D. *Improving Data and Information Exchange*

Water management decisions in the basins are often based on the historical hydrological patterns and future predictions for the basin. At present, there is no proper mechanism for data and information exchange between Nepal and India, and it often hinders the research activities undertaken to understand the basin and its characteristics. For example, there is no gaging station present downstream of Narayanghat in the Gandaki River, which makes it difficult to setup a hydrological model for the entire Gandaki Basin. If there is an easy access to flow data on the Indian side of the river, the whole basin can be studied at once benefitting both the countries through sharing of the research findings. This exchange of information also helps in making watershed management plans.

### E. *Joint Research and Monitoring Programs*

Joint research by water sharing countries like Nepal and India can produce credible information based on the research findings, which is useful in preparing national water policies in both the nations. Joint research and monitoring programs help in monitoring the flood and drought risk levels, explore potential development programs and provide guidance in the national decision-making processes. These programs can also be achieved through regional organizations such as International Centre for Integrated Mountain Development and International Water Management Institute.

### F. *Resolving Water Conflicts*

Water conflicts arise not due to the shortage or lack of water, but from how it is governed and managed [27]. Water management institutions, particularly in developing countries such as Nepal, often lack the human, technical and financial resources to develop and implement comprehensive management plans to attain the sufficient governing mechanisms [25]. The involved parties need to evaluate the opportunities that arise from the cooperation, instead of the conflict and resolve the

existing water conflicts following the International Water Law.

## IX. CONCLUSION

Nepal's major water treaties with India have, in general been less favorable with Nepal getting raw deal and lesser benefits. Those treaties were executed with focus on India's irrigation and flood control. With changes occurring in the Ganges river basin and recent developments in Nepal and India, there is a dire need to revise these treaties. This gives us a chance to climate-proof the existing treaties and share the flood control benefits received by India through these treaties. Challenges in managing the transboundary waters between Nepal and India, while ensuring inter-state water sharing in Nepal should be approached in a systematic and holistic manner, making the region more resilient to changes. Proper institutional capacity building can help resolve the conflicts and increase water security in the region. This should be taken as an opportunity to move towards cooperative water relations.

## ACKNOWLEDGMENT

The authors express their gratitude to Dr. Rabin Bhattarai, Assistant Professor of Soil & Water Resources Engineering at the University of Illinois at Urbana-Champaign for his valuable feedbacks during the manuscript preparation.

## REFERENCES

- [1] Water and Energy Commission Secretariat (WECS), "Water resources of Nepal in the context of climate change," Kathmandu, Nepal, 2011.
- [2] T. Upreti, *International Watercourses Law and its Application in South Asia*. Kathmandu: Pairavi Prakashan, 2006.
- [3] Water and Energy Commission Secretariat (WECS), "Water Resources Strategy - Nepal," Kathmandu, Nepal, 2002.
- [4] Water and Energy Commission Secretariat (WECS), "National Water Plan - Nepal," Kathmandu, Nepal, 2005.
- [5] G. of Nepal, "Revised Agreement between His Majesty's Government of Nepal and the Government of India on The Koshi Project. Nepal – India. Dec 19, 1966," 1966.
- [6] G. of Nepal, "Agreement between His Majesty's Government of Nepal and the Government of India on the Gandak Irrigation and Power Project. Nepal – India. Apr 30, 1964," 1964.
- [7] G. of Nepal, "Treaty between His Majesty's Government of Nepal and The Government of India Concerning the Integrated Development of the Mahakali Barrage Including Sarada Barrage, Tanakpur Barrage and Pancheshwar Project. Nepal – India. Feb 12, 1996," 1996.
- [8] H. B. Jha, "Nepal-India Cooperation in River Water Management," *Strateg. Anal.*, vol. 37, no. 2, pp. 217–

- 230, Mar. 2013.
- [9] A. Dixit and A. Shukla, "Benefits and Burden: A Case Study of Gandak River Agreement," Kathmandu, 2017.
- [10] B. K. Pradhan, "Personal Reflections: Nepal-India Water Relations," in *The NepalIndia Water Relationships: Challenges*, 2009, pp. 243–267.
- [11] A. Detges, B. Pohl, and S. Schaller, "Editor's Pick: 10 Violent Water Conflicts," 2017. [Online]. Available: <https://www.newclimateforpeace.org/blog/editor's-pick-10-violent-water-conflicts>. [Accessed: 01-Mar-2018].
- [12] A. Richards and N. Singh, "Inter-state Water Disputes in India: Institutions and Policies," *Int. J. Water Resour. Dev.*, vol. 18, no. 4, pp. 611–625, Dec. 2002.
- [13] C. Sadoff et al., "Ten fundamental questions for water resources development in the Ganges: myths and realities," *Water Policy*, vol. 15, no. S1, p. 147, Oct. 2013.
- [14] E. J. Moors et al., "Adaptation to changing water resources in the Ganges basin, northern India," *Environ. Sci. Policy*, vol. 14, no. 7, pp. 758–769, Nov. 2011.
- [15] M. Jeuland, N. Harshadeep, J. Escurra, D. Blackmore, and C. Sadoff, "Implications of climate change for water resources development in the Ganges basin," *Water Policy*, vol. 15, no. S1, p. 26, Oct. 2013.
- [16] DHM, "Observed Climate Trend Analysis of Nepal (1971-2014)," Kathmandu, 2017.
- [17] L. Bharati, P. Gurung, P. Jayakody, V. Smakhtin, and U. Bhattarai, "The Projected Impact of Climate Change on Water Availability and Development in the Koshi Basin, Nepal," *Mt. Res. Dev.*, vol. 34, no. 2, pp. 118–130, May 2014.
- [18] L. P. Devkota and D. R. Gyawali, "Impacts of climate change on hydrological regime and water resources management of the Koshi River Basin, Nepal," *J. Hydrol. Reg. Stud.*, vol. 4, pp. 502–515, Sep. 2015.
- [19] A. R. Bajracharya, S. R. Bajracharya, A. B. Shrestha, and S. B. Maharjan, "Climate change impact assessment on the hydrological regime of the Kaligandaki Basin, Nepal," *Sci. Total Environ.*, vol. 625, pp. 837–848, Jun. 2018.
- [20] V. Dahal, N. M. Shakya, and R. Bhattarai, "Estimating the Impact of Climate Change on Water Availability in Bagmati Basin, Nepal," *Environ. Process.*, vol. 3, no. 1, pp. 1–17, Mar. 2016.
- [21] DOED, "Operating Hydropower Projects," 2018. [Online]. Available: [http://www.doed.gov.np/operating\\_projects\\_hydro.php](http://www.doed.gov.np/operating_projects_hydro.php). [Accessed: 01-Mar-2018].
- [22] D. of W. S. & S. (DWSS), "Nationwide Coverage and Functionality Status of Water Supply and Sanitation in Nepal," Kathmandu, Nepal, 2014.
- [23] G. of Nepal, "The Constitution of Nepal," Kathmandu, Nepal, 2015.
- [24] I. C. for I. M. D. (ICIMOD), "Policy Gaps and Institutional Arrangements for Water Resources Management in Nepal.," Kathmandu, Nepal, 2018.
- [25] J. D. Petersen-Perlman, J. C. Veilleux, and A. T. Wolf, "International water conflict and cooperation: challenges and opportunities," *Water Int.*, vol. 42, no. 2, pp. 105–120, Feb. 2017.
- [26] G. Rasul, "Why Eastern Himalayan countries should cooperate in transboundary water resource management," *Water Policy*, vol. 16, no. 1, p. 19, Feb. 2014.
- [27] S. B. Yoffe, A. T. Wolf, and M. Giordano, "Conflict and cooperation over international freshwater resources: Indicators of basins at risk," *J. Am. Water Resour. Assoc.*, vol. 39, no. 5, pp. 1109–1126, 2003.
- [28] Treaty Between the government of the Republic of India and the government of the People's Republic of Bangladesh on Sharing of the Ganga/Ganges Waters at Farakka. December 12, 1996.
- [29] G. of Nepal Reserved list and Issued Licenses, DOED-Nepal <https://www.doed.gov.np/download.php>