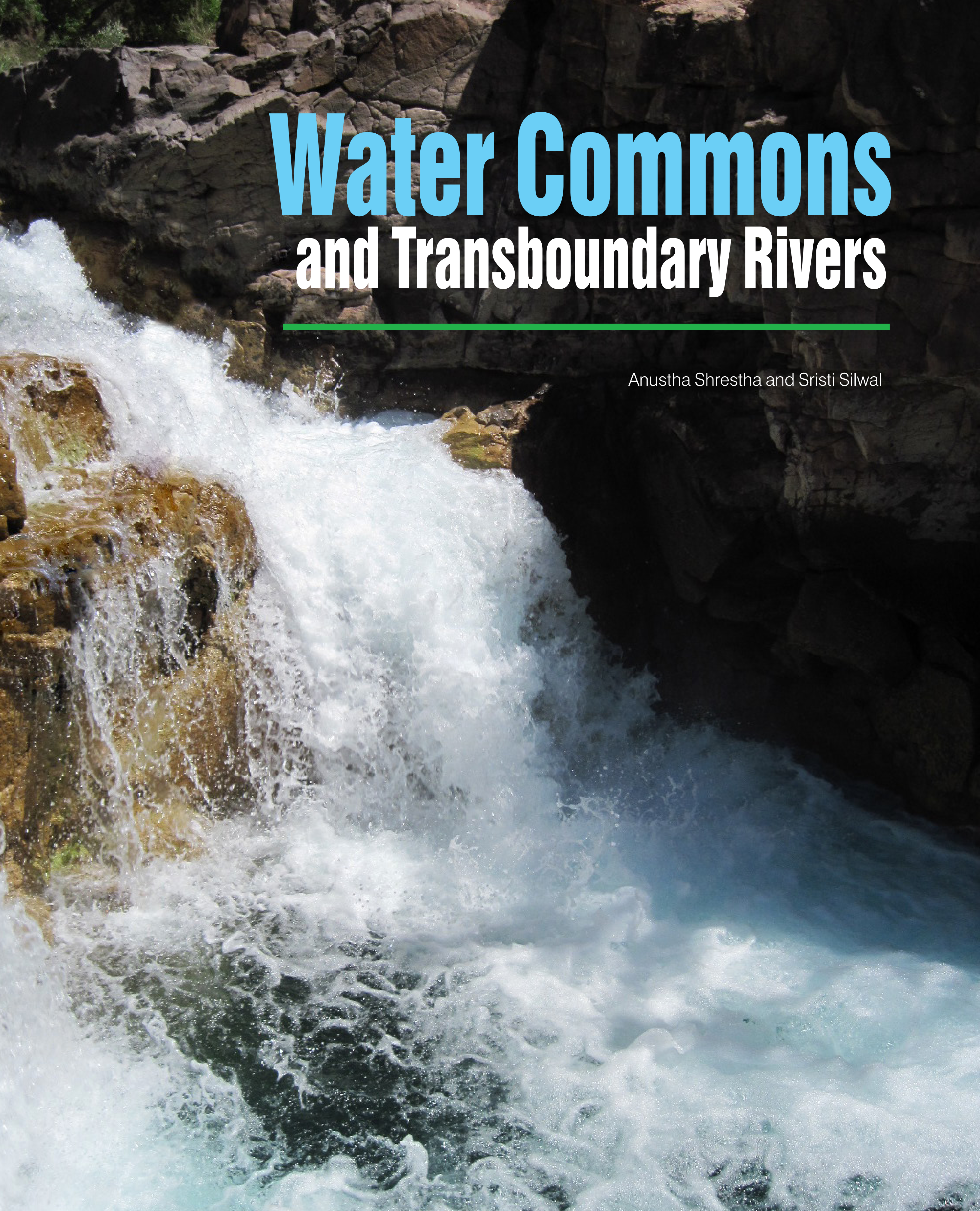
Water Commons and Transboundary Rivers

Anustha Shrestha and Sristi Silwal



Foreword

Water is life. Assured access to safe water ensures a family's health, well being and dignity. Poor access to basic water is a reflection of poverty and deprivation. Ensuring access to safe water is one of the pro-poor priorities and meeting this objective is a governance challenge.

Lack of livelihood opportunities is a hurdle to well being in Bangladesh, India and Nepal. In these countries, large section of the population depends on trans boundary water commons for livelihood and living, but their perspectives are not reflected in public policies. Trans boundary nature of the rivers adds a complex dimension in improving access to water and its services as well as in conserving water commons.

ActionAid Nepal together with grassroots peoples' organizations, civil society groups, think-tanks and policy makers is involved in promoting better understanding of water commons. This effort is aimed at raising awareness amongst stakeholders about the importance of water commons and getting their concerns reflected in discourse on public policies.

This report, a collaborative effort by ActionAid Nepal and ISET-Nepal examines water commons in the context of treaties on trans boundary rivers with an aim to capture voices of people depending on them. It has examined challenges faced by the riparian communities in terms of water use and flood disasters. The study has also explored the problems of inundation, displacement, compensation, and rehabilitation of the families affected by floods.

I thank the team for its efforts in examining these issues and hope that the report will be useful for academics, researchers, policy makers and community members for effective conservation of water commons.

Bimal Kumar Phnuyal
Country Director
Action Aid Nepal

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FIRST EDITION 2017

ISET-NEPAL AND ACTIONAID NEPAL

CITATION

Shrestha, A. and Silwal, S. (2017)
Water Commons and Transboundary Rivers, ISET-Nepal and ActionAid Nepal

PUBLISHED BY

Institute for Social and Environmental Transition (ISET)-Nepal and ActionAid Nepal.

ISBN

978-9937-8519-7-8

Acknowledgement

This report is an outcome of the water commons research conducted by ISET-Nepal in partnership with and support from ActionAid. We would like to acknowledge and thank ISET-Nepal's Executive Director Mr. Ajaya Dixit and Senior Researcher Prof. Ashutosh Shukla for their continuous guidance and supervision. We also thank ISET-Nepal's researchers Ms. Shobha Kumari Yadav for assessing the hydro-meteorological data and Mr. Ratna Deep Lohani for data arrangement. The study team is also grateful towards ISET-Nepal's Research Associate, Mr. Sravan Shrestha for GIS mapping.

We would like to thank ISET-Nepal's researchers Ms. Rabi Wenju, Ms. Minakshi Rokka Chhetri, Mr. Yubraj Satyal and interns Ms. Emma Karki and Mr. Shuvanu Khanal for their assistance during the field visits. We extend gratitude towards Mr. Keshab Poudel from Aviyan Nepal, Mr. Dev Narayan Yadav from Koshi Victim Society, Mr. Badri Subedi from Indreni Social Development Forum and Mr. Bishnu Awasthi from Forum for Local Development (FOLD)-Kanchanpur for the overall management during field interactions. We would also thank the support staffs of Nepal Water for Health (NEWAH)-Biratnagar for their support. We would like to thank Mr. Prabin Aryal and Rooster-Logic Pvt Ltd. for helping collect data using the REMO software. Ms. Agne Buraityte and Ms. Sneha Pandey are also thanked for their review and input at various stages of the preparation of the report.

We thank our publication officer Mr. Narayanshree Adhikari for coordinating the layout and design. We also appreciate the effort of our support staffs Ms. Ganga Shrestha and Ms. Gita Bhomi for enhancing the map quality and helping us with the reference. ISET-Nepal would like to acknowledge the support of finance and administrative staffs Mr. Pushkar Acharya, Mr. Rahul K.C., Ms.Inu Khadka, Mr. Bishnu Shrestha, Mr. Krishna Gautam and Mr. Gopal Adhikari for their help with logistic arrangements.

We would like to express our sincere gratitude towards the local stakeholders of Sunsari, Morang, Saptari, Nawalparasi and Kanchanpur for providing valuable information for our research. We would like to express thanks to Mr. Bimal Phuyal, the Country Representative of ActionAid Nepal and Mr. Dinesh Gurung, the Senior Program Manager of ActionAid for their support. We also thank the team members of similar studies from India, Bangladesh and Pakistan for their support.

Lastly, we are thankful towards Mr. Suresh Shrestha and Mr. Shashi Kapali of DG scan for their help with the design of this report.

Executive Summary

This study explored water commons in selected regions of Nepal in the context of the country's agreement with India on the Koshi, Gandak and Mahakali rivers. The study sites lie in Nepal's Sunsari, Morang, Saptari, Nawalparasi and Kanchanpur districts. Ten VDCs representing the head and tail ends of the canal systems from the transboundary projects were selected. The VDCs receive services in the form of irrigation and flood control measures.

The study examined how the projects affected livelihood of the riparian communities in terms of water use and disaster risk management. It collected people's perspectives on perceived benefits, inundation problems, their knowledge on treaties and the support that communities received during disaster events. The study explored the civic action initiated by riparian communities and highlight issues of displacement, compensation and inundation.

The study touched upon the disputes regarding water use at the national and transnational level. The treaties, in principle, aimed to address the various challenges faced by the riparian communities of both countries - including their low socio-economic condition, food insecurity, and poverty. In their current form, the treaties do not meet these stated goals and are not sensitive to the challenges faced by the riparian communities. The present development approaches pursued within the context of the treaties have, instead, created problems for local communities particularly the poor.

People had mixed views regarding the transboundary projects. In all the study areas felt that India had benefitted more from the projects than Nepal. Flood was recognized as the major disaster in the study areas. People felt that hydro-engineering structures have blocked the natural drainage and elevated the riverbeds increasing instances of inundation. They were also displaced when land was acquired for developing the projects. Although compensation was provided to the affected families, no support was provided to help them re-establish their homes and build their livelihoods. Generally, the amount compensated was inadequate, low literacy level of the affected families, lack of adequate information and bureaucratic approach hindered compensation management.

In the future, the competition for water is likely to increase at the local, regional and transnational scale. Such competition will magnify disputes as water is allocated among different users. Cooperative development of rivers needs to be based on the principle of equitable sharing and distribution of benefits not only between the countries but also with the riparian communities within a country. The concerns and interests of riverine communities as well as the need to the river ecosystems that help local livelihoods are often neglected when governments agree on sharing river waters. Innovative approaches are needed to empower local communities so that their adaptive capacities to deal with various shocks are enhanced.

Contents

1 Introduction

Fresh water is essential for the survival of the humans and their well-being. Its availability and distribution in adequate quantity and quality is important for meeting many basic human needs. Fresh water, however, is unevenly distributed in space and time and creates physical constraints to meet such needs. These constraints are amplified by overuse, increasing pollution and poor management of water limiting its access to those who need it the most. As a result, millions of people live without clean water, which adversely impacts health, food security, livelihoods and well-being of the poor and marginalized households in developing countries. These conditions further exacerbate hunger, malnutrition and gender disparity.

Indeed, the United Nations World Water Development report of 2015 has suggested that by 2030, the world is likely to face a 40 per cent deficiency in fresh water supplies, much of the consequences of this deficiency manifesting in the developing countries. Million of people without access to clean drinking water live in river basins where rate of use exceeds the rate of natural recharge. In many cases, wastewater is discharged into rivers and other water bodies without treatment. Though almost two third of all fresh water abstracted from rivers, lakes and aquifers is used for irrigation, many families face food insecurity. Transboundary nature of rivers and aquifers further exacerbate these challenges.

The Ganga, the Brahmaputra, the Meghna and the Indus are South Asia's major transboundary basins. The Ganga basin in shared by China, Nepal, India and Bangladesh while the Brahmaputra basin includes China, India, Bhutan and Bangladesh. The Indus River flows across China, Afghanistan, Pakistan and India. These basins, home to nearly 1.6 billion people, face rise in population, urbanization and economic expansion that have increased the needs of water for hydropower, irrigation and industries in addition to domestic and commercial needs. These needs not only exert pressure on fresh water but also pollute it, as the generated wastewater is not treated before it is disposed in water bodies. Climate change is a new stress likely to change the dynamics of availability of water that can aggravate the condition of too much water and too little water. Lack of clean water and scarcity while lowering overall human security and can also fuel disputes at local, national and transboundary levels.

Though countries have entered into agreements on using rivers shared by more than one country or states (or provinces) within a country, sharing of the benefits have remained a contentious

TABLE 1

Designed benefits of the three Indo-Nepal treaties

Rivers	Name of Project	Mean Flow (m^3/s)	Date of Agreement	Benefits (Design and actual)											
				Irrigation (x1000ha)				Flood Mitigation (x1000ha)				EnergyVPower KWhx105/MW			
				Designed or Intended		Actual		Designed or Intended		Actual		Designed or Intended		Actual	
				Nepal	India	Nepal	India	Nepal	India	Nepal	India	Nepal	India	Nepal	India
Mahakali	Sarada Barrage	657.3	1920			11.51	NA			NA	NA	None	40 MW	None	40 MW
Koshi	Koshi Barrage	1500	1954 Revised in 1966	Total 98 Chatara 73 Koshi Pump and Koshi West 25	712[3]	Total 98 Chatara 73[2] Koshi Pump and Koshi West 254	213[4]	60.7	214	NA	NA	10 MW	10 MW	NA	NA
Gandak	Gandak Barrage	1583.1	1959 Revised in 1964	Nepal East and Gandak West 57.95	1,850.52[6]	Total 39 Nepal East 28.77 Gandak West 8.7 Gandak Main 1.6	342[8]	NA	NA	NA	NA	15 MW	None	15 MW	None
Mahakali	Tanakpur Barrage	657.3	1991 Revised in 1992			4.5	NA	Afflux bund pro- vides food control	NA	NA	NA	20kWh	424 kWh	NA	NA
Mahakali	Proposed Pancheswar Project	657.3	1996	1996	93	1610						6,840			

Source: 1 and 7, UN (2000); 2, HMG, Nepal (Undated); 3,4 and 8, Gyawali (1999); 5 and 6, Salman and Uprety (2002)

Note: There is substantial variation on the figure of the benefits to Nepal and India from these projects. Rana (1998) cites Economic Times 3, March 1979, which suggests that the Gandak Project was expected to irrigate 3,995,000 acres (1,616,754 ha) and 143,900 acres (58,235 ha) in India and Nepal respectively. The numbers in the table demonstrates uncertainty in quantifying benefits associated with the projects. Whether Nepal receives electricity from Koshi and Tanakpur barrages is also unclear. The annual reports of NEA make no mention of electricity supply as per the provisions of the two agreements issue while the quality of rivers have been degraded. Addressing these challenges requires innovative approaches to develop and manage water within a country and well as between countries. Both at transboundary and national levels solutions must come from continuous dialogue, exchanges, engagement and cooperation among various users within a country as well as between governments representing the countries.

This report is a part of a larger study on water commons in South Asia's four countries: Nepal, Bangladesh, Indian and Pakistan. In Nepal, the study was conducted along the riparian region of Koshi, Gandak and Mahakali rivers in the Tarai region of Nepal. The treaties on these rivers signed by Nepal and India have paved the way for building infrastructures for flood control, irrigation and hydropower benefits (Table 1)[1].

The study hopes to contribute in creating alternative discourse to equitable benefits from the transboundary rivers at national, sub national and local levels. It brings perspectives of riparian groups and communities (smallholders, women, fishers, ethnic minorities and farmers) in selected regions of these countries. The perspectives of riparian communities, the availability of services and impacts from the interventions are useful lessons in conceiving pro-people and pro-water commons policies and in pursuing sustainable development agenda.

Man washing his clothes

2 Objectives and Method

Objectives

This study has examined the context of water commons and the dependent communities in selected regions of Nepal. The areas lie along the Tarai and inner-Tarai regions of Saptari, Sunsari and Morang, (collectively called SapSuM), Nawalparasi and Kanchanpur (Figure 2) districts. The community living in these areas receive benefit as well as face negative impacts of the infrastructures constructed on the rivers.

The study also assessed the perceptions of local communities with regards to the governance and management of water commons emerging from the infrastructures developed as a part of the treaties in the three areas. By understanding these perspectives, the study aimed to draw lessons that would contribute to shaping and furthering discourse on transboundary water and water commons. Such insights are expected to help inform public policy making in the two countries at higher level while helping ground them locally. This would help contribute to conservation and management of water commons broadly and in pursuing water stewardship.

The specific objectives are as follows:

- Gathering qualitative evidences regarding the impact of transboundary water development efforts on riparian communities, particularly their access to benefits, livelihood gains, exposure to water-induced disasters (floods, bank erosion and inundation), and displacement caused by the development of hydropower, irrigation systems, and flood control embankments, and using these evidences to initiate pro-people and pro-riparian public discourse.

- Documenting people's perceptions on management practices in transboundary water development and identifying the roles that local communities can play in addressing the stresses that degrade water commons.

Guided by these objectives, the study has attempted to examine the limitations and ineffectiveness in the implementation of the treaties and their contribution, or lack thereof, to the environmental sustainability and livelihoods of the communities dependent

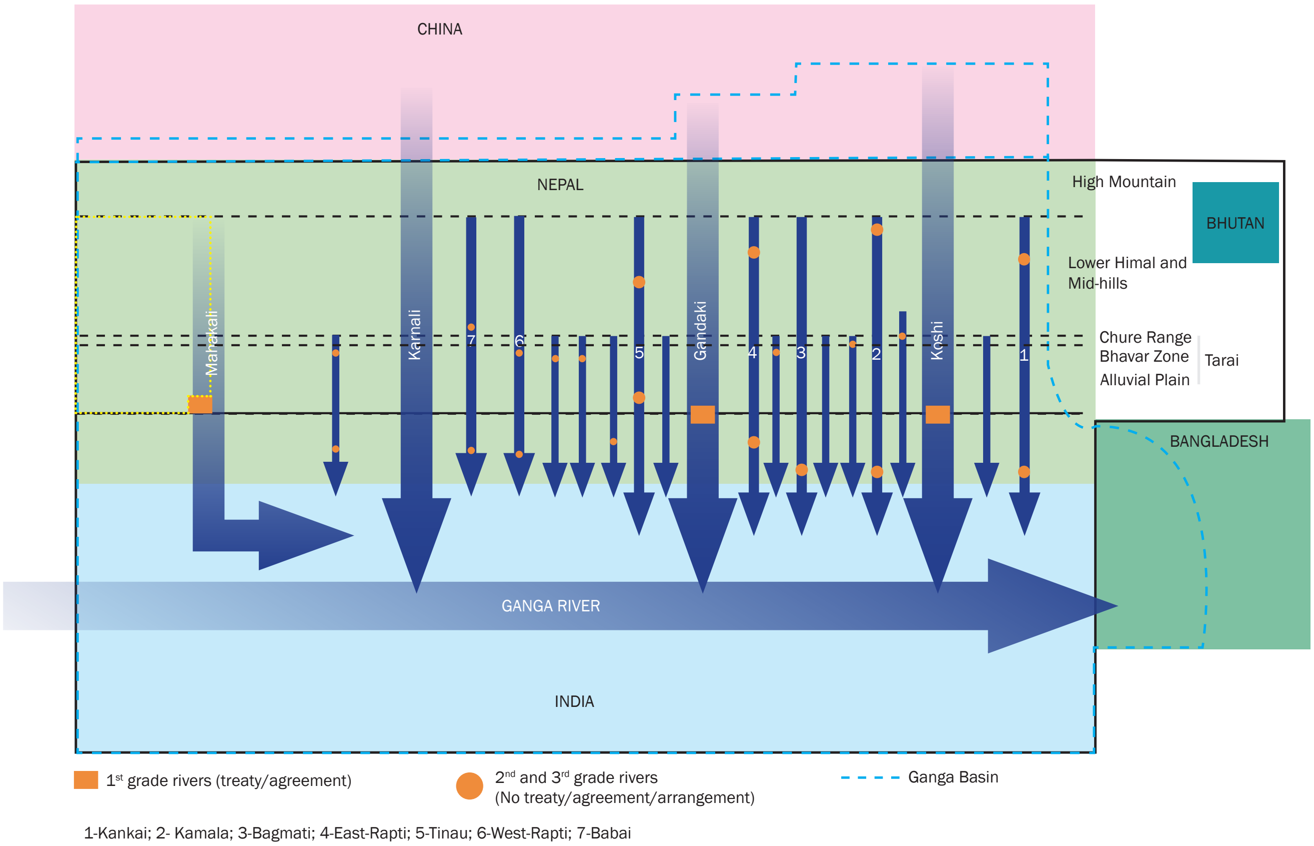


Figure 1
Study framework

on the river water. In this backdrop, it aimed to propose ways and means to promote water stewardship in a transboundary water development context.

To meet the objectives the study used a framework (Figure 1) that unpacks the context of transboudnary treaties. The treaties focus on (i) the snow-fed rivers, Koshi, Gandak and Mahakali while the Mahabharat and Chure rivers receive little attention, ii) since the treaties were signed, the pattern of water use has changed due to increasing population, infrastructure and services in the region and iii) the infrastructure development have ignored environmental and livelihood issues without recognizing the upstream and downstream linkages.

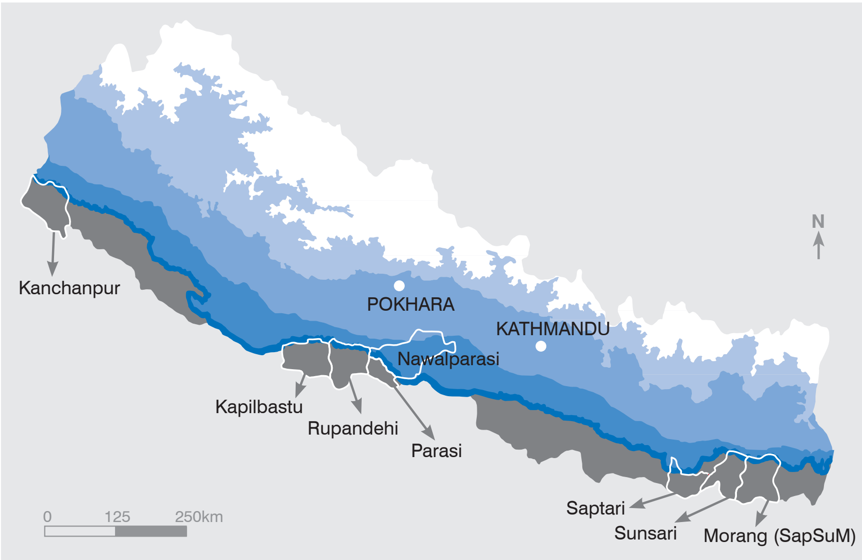


Figure 2
The districts studied

TABLE 2

The HDI of the five districts in 2014

Morang	Sunsari	Saptari	Parasi	Kanchanpur
0.500-0.549	0.450-0.499	0.400-0.499	0.400-0.499	0.450-0.499

Nepal Human Development Report, 2014

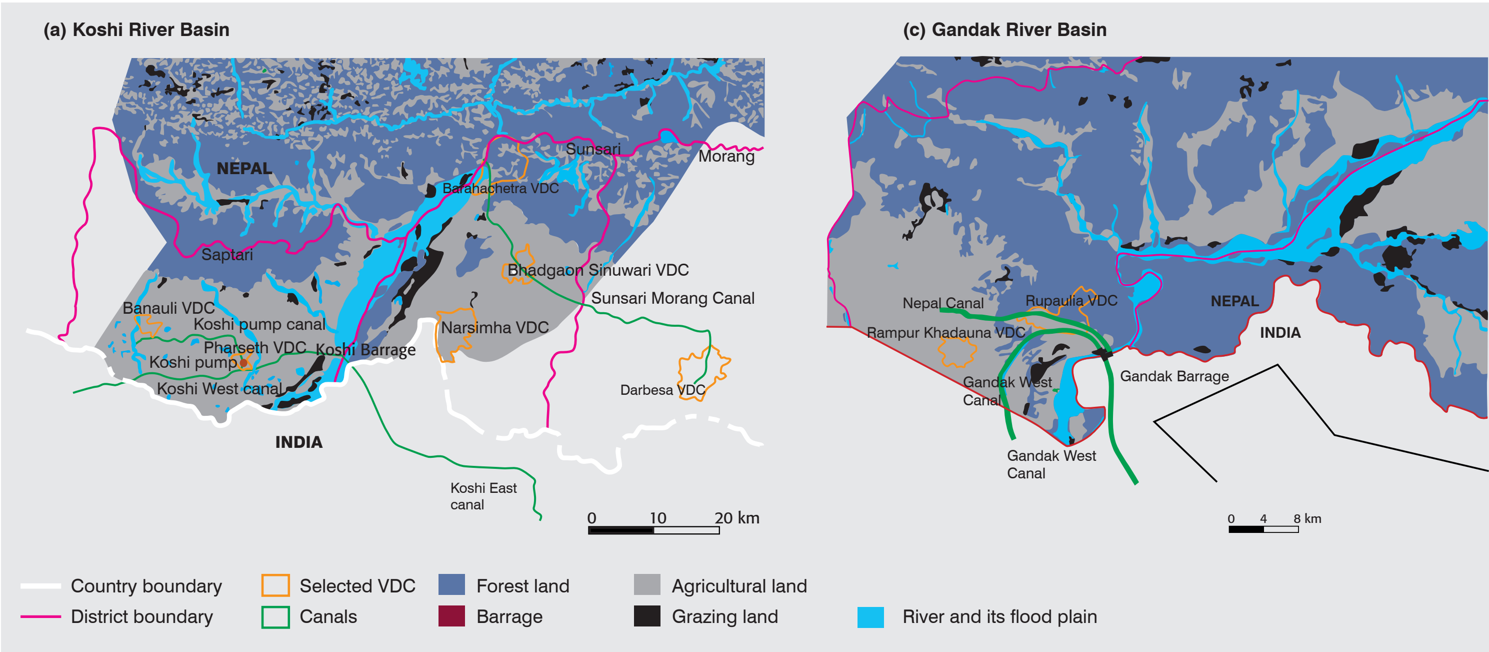
Methodology

Study area delineation: The study was conducted in specific areas of Nepal designed to receive benefits from the infrastructures built as a part of treaties on transboundary rivers involving Nepal and India. The study particularly looks at irrigation and flood mitigation challenges in the selected regions extending from the Chure range to the Indian border. Because the study focuses on flood and irrigation it does not cover the issues related to hydropower development which would require a separate treatment.

The Tarai, an extension of the Ganga plains, encompasses two distinct landforms: the porous colluvial formation of the Bhabar zone in the foothills along Chure and alluvial plains in the South[2], both constituting Nepal's Tarai region.

The Koshi irrigation system built under the Koshi Treaty serves the SapSuM districts. The barrage built under the Gandak Treaty serves the Tarai portion of the Nawalparasi District which is referred to Parasi.

Of all the districts of Nepal, Nawalparasi is unique in that its geography encompasses the hills, the Doon Valley and Tarai[3]. A canal from the Gandak barrage serves Parasi, the Tarai part of the district. Socio-economically, Parasi is similar to the



adjoining Rupandehi and Kapilbastu districts. Another canal from the Gandak barrage serves areas in Nepal's Parsa, Bara and Rautahat districts. Since these three districts are not contiguous to the Gandaki Basin they were not included in the study. The Mahakali Irrigation Canal (MIC) receives water from the Sharada Barrage and serves areas in Nepal's Kanchanpur District.

The research team selected village development committees (VDCs) within each of the three regions (Kanchanpur, Parasi, and SapSuM) for detailed investigations. As Nepal's lowest level of government, the VDC is both an administrative and a political unit and each is further divided into nine wards[4]. A total of 10 VDCs were selected, one in Morang, two in Saptari, three in Sunsari and two each in Nawalparasi and Kanchanpur. The VDCs were located in the head and the tail region of the three irrigation systems mentioned above. The VDCs were also selected with two other variables in mind: i) proximity to the international border, and ii) proximity to one of the

Figure 3
Locations of the studied VDCs

Figure 4
Research steps

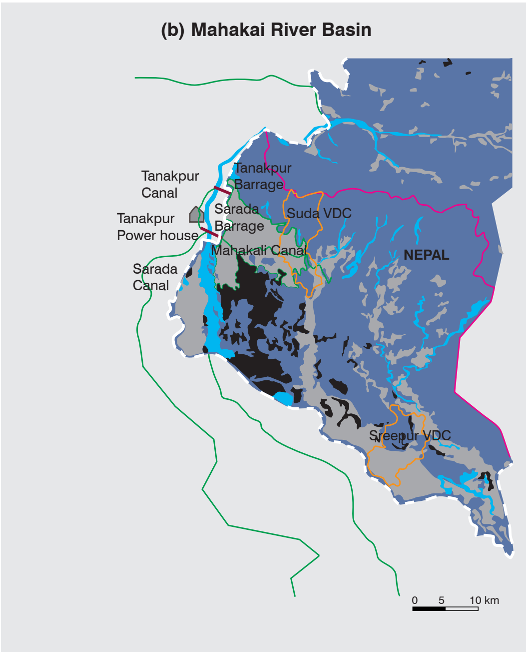
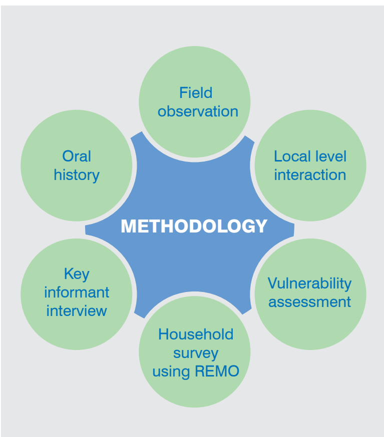


TABLE 3

The VDCs studied

River Basin	Districts	VDCs	Close to border	Close to river	Away from river/border
Koshi	Morang	Darbesa			
	Saptari	Pharseth			
		Banauli			
	Sunsari	Barahchhetra			
		Bhadgaon Sinuwari			
		Narsimha			
Gandaki	Nawalparasi	Rupaulia			
		Rampur Khadauna			
Mahakali	Kanchanpur	Suda			
		Sreepur			



three rivers, i.e. the Koshi, Gandak and Mahakali (Table 3; Figure 3).

The researchers gathered information from each of the selected VDCs through key informant interviews, household and community level surveys, case studies and oral histories (Figure 4). They also collected secondary information related to changes in the key technical elements of the three water systems including: changes in water use, discharge, sedimentation, groundwater, and flood frequency and intensity. The household surveys included questions regarding the use and management of transboundary river, the water commons and other natural resources, the impacts on riparian communities, stemming from irrigation flood mitigation infrastructures provided and the benefits and consequences.

Ten per cent of the total population, or 2,565 households, were surveyed (Table 4) using the Research and Monitoring (REMO) software developed by Rooster Logic, a Nepal based company. REMO

TABLE 4

The studied VDCs: Demography

District	VDC	Total area (Ha)	Total HHs	Population			Sample HHs for survey (10%)
				Male	Female	Total	
Morang	Darbesa	4,400	3,639	7,819	8,833	16,652	363
	Pharseth	497.74	638	1,780	1,735	3,515	63
Saptari	Banauli	1,015.8	1,047	2,766	2,991	5,757	104
	Barahchhetra	5,013	3,013	5,781	6,718	12,499	301
	Bhadgaon Sinuwari	2,485	3,837	8,069	9,199	17,268	383
Sunsari	Narsimha		3,399	10,473	10,621	21,094	339
	Rupaulia		1,747	3,977	4,599	8,576	174
Nawalparasi	Rampur Khadauna		717	2,272	2,226	4,498	71
	Suda		4,128	10,507	11,491	21,998	412
Kanchanpur	Sreepur		3,554	10,223	11,164	21,387	355
							2565

Source: District profile, 2013

TABLE 5

Indicators for assessing vulnerability

System	Indicators	Remarks
Core	Energy, Water, Land, Forest, Food, Ecosystem services	To meet basic livelihood, if these systems are poor the quality and services that communities get is poor they become highly vulnerable.
Broader	Transport and Mobility, Communications Livelihood (Agriculture, Water, Forestry)Shelter Markets (tax-base), Financial services Health system, Education Social networks, Non-farm production systems	Enable individuals, households and communities switch strategies when faced with hardship while pursuing their daily lives.

Thirty two indicators related to above elements were collected (Dixit et. al., 2015)

supported entry, transfer and management of data using smart phones, which made it possible for the researchers to simultaneously check the consistency of the data while the enumerators conducted surveys. Both the researchers and enumerators discussed issues related to water use, irrigation, disasters, agricultural production, literacy, and communication with local community leaders, government officials, non-governmental organizations and other stakeholders. This was done in order to understand the communities' capacity to respond to floods and other shocks, to assess their awareness of transboundary water development, and to learn how waterlogging, inundation, bank erosion, and degrading of water commons affected them.

The study also assessed the status of local ecological and human-built systems in each VDC. Using questionnaire surveys and VDC data on energy use, access to drinking water, access to irrigation, food sufficiency, literacy, communication, transportation, financial status, livelihood, health, sanitation, the number of community-based organizations and the presence of government agencies and development organizations were collected. This information helped determine the current vulnerability of the wards in the studied VDCs.

Data related to 32 indicators representing exposure, sensitivity and adaptive capacity was also collected. Composite values of the indicators were calculated to assess the vulnerability by wards in each of the 10 VDCs. Vulnerability was assumed to be directly proportional to exposure of physical and ecological systems to hazards and to the sensitivity of these systems to external shocks. It was assumed to be inversely proportional to people's adaptive capacity, for example, better access to benefits from ecosystems or human-built systems meaning lower vulnerability. The data was presented in a GIS platform.

The platform helped communicate the findings to various stakeholders as well as discuss the assumptions made in the assessment. This process further helped in developing a shared understanding on the community's perspectives on the treaties, the state of the water use, water commons and their conservation. The baseline and maps were useful in framing strategies to reduce vulnerability and promote conservation and management of water commons and other natural resources.

Even though the focus was on a specific region of Nepal's Tarai, the study broadly examined the water commons (rivers, wetlands, ponds, and groundwater) within the context of the Chure range. Forests and their biodiversity were also taken into account because the services they provide support the livelihoods and well being of the region's inhabitants.

Paddy harvest in Kanchanpur - Women perform much of the tasks in farming

3 The Study Area

This chapter describes the regional and local contexts of the study region, including climatic, hydrological, demographic and socio-economic characteristics.

Regional Context

Precipitation

As in the rest of Nepal, rainfall during the monsoon season is the main source of water in the study area. The monsoon rain contributes to 80 per cent of the annual rainfall while the winter Westerlies and the pre-monsoon showers contribute the remaining 20 per cent. Rainfall between November and April is, on average, less than 50 mm/month, but the intra-basin variation, both monthly and annually, is high. Monthly rainfall in the monsoon, extending from June to September, ranges from 150-300 mm. The actual distribution of rainfall depends on the orographic effects of the mountain ranges as well as the windward and leeward effects.

In Nepal the Eastern region receives more rainfall than the West and Far West Nepal in the monsoon. For example, the summer monsoon contributes to only 70 per cent of the rainfall. Certain meso-level characteristics of rainfall are also evident in Nepal: the rain shadow region of Jomsom in the north of the Annapurna-Dhaulagiri range receives an annual rainfall of just 269 mm while Lumle in Pokhara, south of the same range, receives about 5,288 mm. The national average rainfall is 1,869 mm. A similar variation is also seen around the Arun Valley in East Nepal. In small valleys, micro-level variations in rainfall are common but there is no distinct pattern of distribution from the hilltops to the valley floor. Even in the Tarai, where the topography is flat, rainfall does vary spatially.

Most of the rainfall comes in short spells. It is not uncommon, for example, for 10 per cent of the annual precipitation to come down in a single day or half of the season's total expected rainfall to be concentrated in a mere 10-day period during the monsoon. A storm of high intensity usually lasts for a short time and often covers a small area, while low-intensity rainfall may cover a large area and last for several days. Short duration and high-intensity bursts have become more frequent in recent times[5].

TABLE 6

Snow-fed and non-snow-fed rivers

River	Basin Name	Tributary in Nepal	
		Snow-fed	Non-Snow-fed
Himalayan	Mahakali	Chamelia	Surnaygad
	Karnali	Seti West, Humla Karnali, Mugu Karnali, Tila, Sinja, Thuli Bheri, Bhudhiganga	
	Narayani	Kali Gandaki, Seti, Marsyangdi, Modi, Ridi, Chepe, Daraundi, Trishuli, Budhi Gandaki, Madi, Dordi	Andhikhola, East Rapti, Lothar, Manhari, Badigarh
	Koshi	Indrawati, Bhote Koshi, Sun koshi, Tama Koshi, Dhudh Koshi, Arun, Tamur, Khimti	Rosi, Trijuga
Middle Mountain/ Mahabharat	Babai		Babai, Sharda
	West Rapti		Mari, Jhimruk, Arung, Lungri
	Bagmati		Bagmati, Bishnumati, Kulekhani, Main, Kokhajhor
	Kamala		Kamala
	Kankai		Kankai, Mai Khola
Chure	Tinau, Rohini, Khutia, Kasaria, Mohana, Banaganga, Birahi, Aurahi, Manusmara, Sir-sia, Jhim, Hardinath, Khando, Bhundi, Lohan-dra, Bering, Ratuwa, Lal Bakeya, Lakhandehi. Kusum, Dobhan, Sisne and Jhumsa		Jharahi, Dhanewa, Sadbudri, Bhaluhi, Bhumahi, Mahau, Baghela,

Rivers

The river network of Nepal boasts more than 6,000 rivers, which stretch to a total length of about 45,000 km, and are dense at 0.3 km/km^2. While this figure indicates that the channels are very close to each other, it does not capture the diversity of Nepal's topography, which can render an upland landscape dry even though a major river flows through it. Steep terrain, dissected landscape and ruggedness are characteristics of upland watersheds while the lowlands have meanders, wetlands and marshes. Thus, along with the density of the rivers, analysis must also take into account spatial features (e.g. elevation differences) of the landscape.

The river basins of Nepal can be classified into three types based on their dry season flow: the snow-fed Himalayan (first-grade) basin, the non-snow-fed Mahabharat (second-grade) basin, and seasonal Chure (third-grade) basin (Table 6; Figure 5). The snow-fed rivers, from east to west, include the Koshi, Gandaki, Karnali, and Mahakali, all of which originate above the snow line but are also fed by non-snow-fed tributaries, which drain the Middle Mountains. The second-grade rivers originate below the snowline, drain into the Mahabharat catchments and are fed by direct runoff and groundwater from this region. The third-grade rivers originate in the Chure range. The catchment

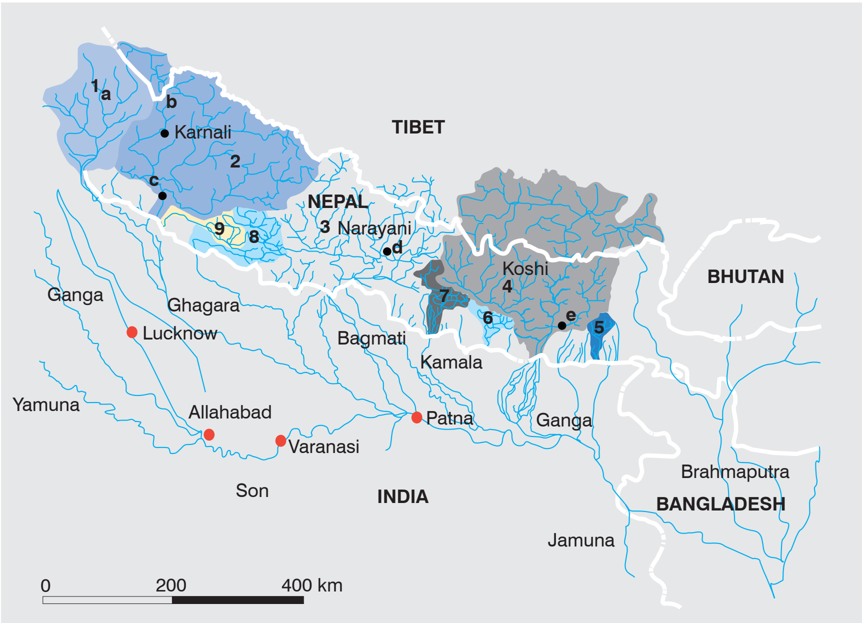


Figure 5
River basins of Nepal

areas of a few third-grade rivers also extend to the Southern slopes of the Mahabharat range.

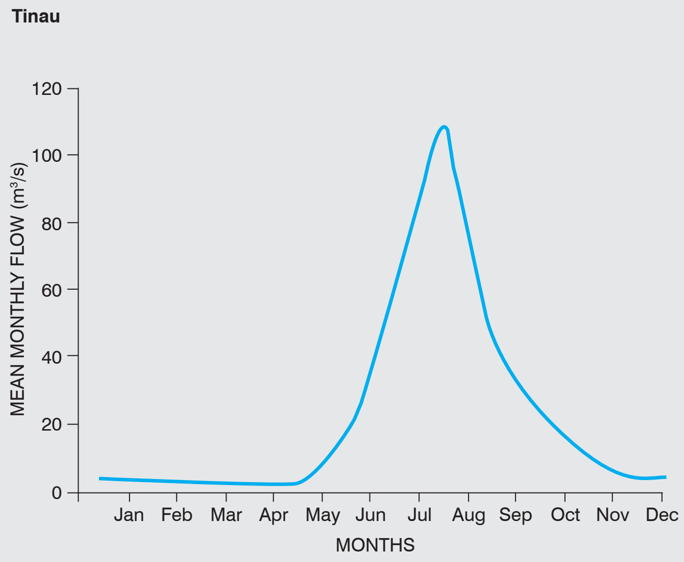
The Mahabharat rivers-Kankai, Kamala, Bagmati, West Rapti and the Babai - collectively have a catchment area of 17,115 km^2. The Chure rivers drain an area of about 18,860 km^2 in both the Chure range and Nepal's Tarai though the catchment of an individual river may be generally less than 350 km^2 in area[6].

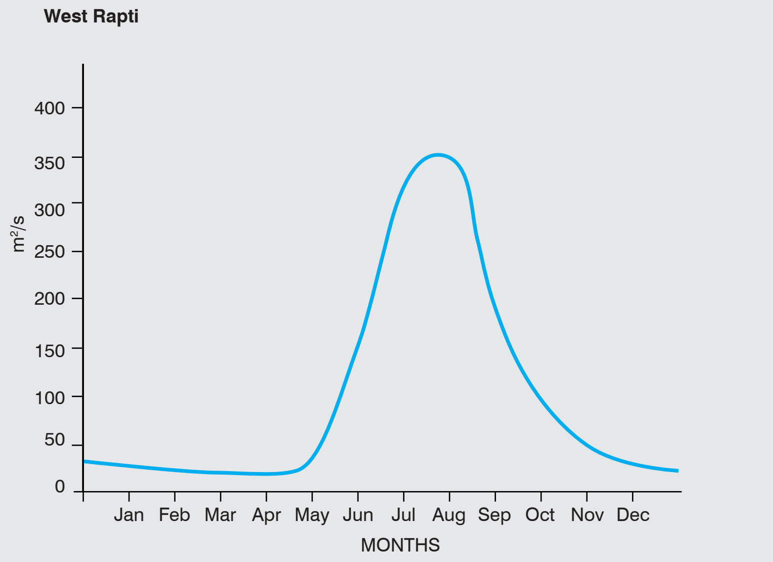
Hydrology

Snowfall and rainfall determines the hydrology of rivers, including their temporal and spatial flow characteristics. The mean annual flows of the four first-grade rivers, i.e. Koshi, Gandaki, Karnali, and Mahakali, are 1,500 m^3/s (Chatara); 1,583 m^3/s (Narayanghat); 1,392 m^3/s (Chisapani); and 658 m^3/s (Sharada Barrage). For these four rivers, flow is usually highest in July/August and lowest in February/March, just before the snow starts to melt. The flows also fluctuate dramatically; the ratios of the maximum to minimum flows in the Koshi, Gandaki and Karnali rivers are as high as 14:1, 19:1, and 13:1, respectively.

When instantaneous flows are considered, the ratio of maximum monsoon to minimum dry-season discharge is much higher. In the Karnali River, for example, this ratio is as high as 130:1[7]. Snow and glacier melt contribute to dry-season flows of the Koshi, Gandaki, Karnali, and Mahakali[8]. Their discharges rise with the arrival of the rainy season in June. The higher and more widespread is the rainfall, the higher is the concentrated flow in each flow record. For example, in 1954 and 1968 the Koshi River at Barahachhetra recorded a flow of 25,000 m^3/s and 26,000 m^3/s respectively. These peak floods were outcomes of widespread monsoon rainfall produced due to the influence of low-pressure weather systems over the Bay of Bengal[9].

The combined mean annual run-off of the rivers that originate in the Mahabharat range is 566 m^3/s. Their hydrology depends on the time distribution of rainfall, the land use, and land cover in the catchment. The dry-season flows of these rivers are low and individual discharge peaks are





influenced by rainfall in the headwater. In fact, their flow is very low when there is no rainfall, and upper river reaches may remain dry even during the monsoon without rainfall. As the rivers run downstream, groundwater and base flows add to their discharge. The discharge of the rivers in Chure basins is not measured systematically and indirect estimates suggest a combined annual run-off of 456 m^3/s[10].

Rivers in Nepal function as drainage waterways and transfer large volumes of water from the upper catchments to the plains of Tarai and eventually to the Bay of Bengal. The flows of all the rivers of Nepal comprise 71 per cent of the natural historic dry-season flow and 41 per cent of the total annual flow of the Ganga River at Farakka[11].

The rivers also transfer a huge amount of sediment created by upland erosion, landslides, glacier processes, bed and bank cutting to the lower reaches. The transferred amount is prodigious during an extreme flood, as it is created when a glacial lake or landslide dam breaches. In the mountains with have steep sloped rivers, sediment transport and bank cutting dominate[12]. As the rivers reach the plains, their capacity to transport sediment decreases and sediment load begins to get deposited, causing the rivers to meander and alter their courses. In the plains, the discharges of first-grade rivers mix with those of second- and third-grade rivers. And though this mix exacerbates flood damages, this phenomenon is poorly acknowledged and documented.

Local Context

This section describes the physical features, the climate and the socio-economic characteristics of the inhabitants in the three study areas, Kanchanpur, Parasi and SapSuM (Figure 6). These characteristics are

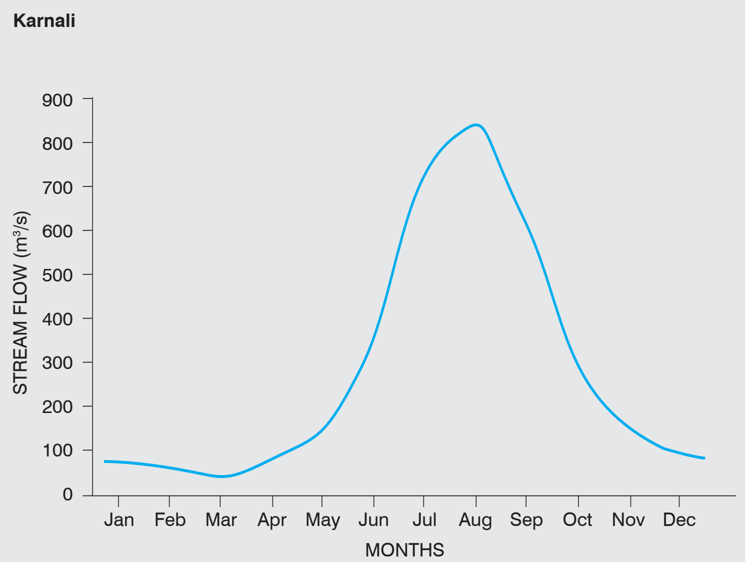


Figure 6
Hydrology of the rivers

important to understand because of the impacts of the transboundary river projects at the local level.

Geology and soil type

The three study areas are part of Chure-Bhabar-Tarai landscape. The Chure range lies along the Main Central Thrust (MCT) fault. Composed of fluvial deposits from the Neogene age, the entire range is in an active stage of tectonic movement. The Chure range about 8-10 km in width, is the youngest mountain range of the Himalayan system and its elevation ranges from 150 masl to 1,600 masl. In places, the Chure range is separated from the Mahabharat range by the inner Tarai; in others, by the Doon Valleys. Elsewhere, Chure merges with the Mahabharat range, making it difficult to distinguish the two. For example, there is no Chure range east of the Koshi River, but, west of the Gandaki River, it exists as a separate range with an elevation of almost 2,000 feet.

The Chure range rises abruptly from the Tarai plains with a slope of more than 50 degrees[13]. The range is composed of unconsolidated mass of loamy skeletal soil which is prone to erosion and landslides even though its slopes are covered by forests at places. Its geological composition includes clay, sandstone, conglomerate, dolomite, and boulders. Colluvial formation is common on the hill slopes and foothills, while alluvial (residual) soils are found along the ridge tops, on spurs, and on the southern plains.

Next to the Chure is the narrow stretch of Bhabar belt, a region dominated by thick layers of gravel and boulders along with layers of thin loamy soil on the top. Numerous large and small landslides, soil creep, deep gullies, scarp, and rock falls on the southern slope of the Chure, brought down by fluvial processes, contributed to the formation of this zone. Because of its' high porosity, much of the recharge of deep groundwater aquifers in the Tarai occurs through this zone.

Climate and rainfall

All of the areas studied have tropical climate, though they do vary slightly, with the southern half of the Tarai being hotter than the north. Average summer temperature in the north ranges between 25°C and 40°C, which occasionally climbs as high as 40°C in the southern flank of Tarai in May and June. The months of October and November have a pleasant weather. The winter is mild and dry in which the mercury hovers between an average minimum of 6°C and a maximum of 25°C. Fog in winter is common throughout the Tarai plains. After January, the coldest month of the year, the temperature begins to rise from a minimum of around 0-3°C until it peaks before the onset of monsoon season in early June.

With the arrival of the monsoon, humidity increases. The relative humidity ranges from about 60 per cent in the pre-monsoon months to more than 90 per cent during monsoon, which can vary depending upon temperature and rainfall. Humidity also fluctuates during the monsoon months as rainfall breaks periodically. The lowest humidity is recorded in April and May, when the weather is hot and dry.

Monsoon winds from the Bay of Bengal bring rainfall to SapSuM, Parasi and Kanchanpur. Monthly rainfall is usually higher on the foothills than on the Tarai plains. Along the Chure range, the normal annual rainfall is 2,000-2,200 mm. Morphology of the watershed, including soil formation, vegetation, slope, shape and drainage density affect the flow pattern of the streams originating from this region. However, such influences have not been examined in greater detail.

The monsoon usually starts in the second week of June and lasts till late September. Sometimes rain is scanty and drought conditions prevail. Cloudbursts used to be typical during the late stages of the monsoon a few years ago but recently they occur even during the earlier stages. Rainfall is usually greater along the foothills than in the southern plains, though this too varies spatially from East to West. October and November are usually dry. Westerlies, which bring rain from the Mediterranean, reach Nepal in their dying stages during December and January. The influence of this weather system is stronger in western Nepal than in the eastern parts. Pre-monsoon rain is active after March, which is also accompanied by strong winds and substantial variations in day- and night-time temperatures.

Groundwater resources

Recharge of the deep aquifer systems in Nepal's Tarai region occurs through the unconsolidated formation of the Chure-Bhabar region. In the GRB, the aquifers also have a transboundary character which has not been properly mapped as of yet. In the Bhabar zone, groundwater is recharged rapidly, with the permeability of the formation as high as 50-200 m per day. The water table in the Bhabar region is deeper than that in the Tarai region that lies south of the Bhabar zone, which has thick alluvial formation and plentiful groundwater. The groundwater table in the Tarai varies seasonally, but is normally 3-10 m below the surface during the dry season and rises during the monsoon[14]. When the monsoon is over, the groundwater starts to recede again until it reaches its lowest level in the pre-monsoon months between March and June.

Recharge of groundwater results from a combination of rainfall and an inflow from rivers. The groundwater aquifers of Nepal's Tarai as well as of the northern plains of GRB are recharged through the Bhabar as well as through in-situ rainfall. However, the actual amount of recharge, in shallow and deep aquifers, from the two sources has not been fully assessed. On-going environmental and land use changes caused groundwater table in pockets of Tarai to deplete. Some of the aquifers in the Tarai are artesian but in the last few years hydrostatic pressure has lowered due to over-extraction and lower recharge rates[15].

South of the Bhabar, variations in soil characteristics govern the recharge rates from local rainfall. A recent study has developed a typology for aquifers that were traditionally considered to be a single homogenous system of comparable properties at the basin-scale. The typologies show significant spatial differences in aquifer properties, recharge potential and chemistry, even within a single basin[16].

There are many ponds and wetlands in the Tarai region that function as buffer against floods and also support groundwater recharge. And even though the interaction between the surface and groundwater in the Tarai area is significant, it has not been scientifically documented. As a result, the extent to which groundwater contributes to surface flow, and vice versa, is far from clear. The lack of systematic data further creates a challenge in managing groundwater, which is the major source of water for irrigation and domestic uses within the study VDCs.

Environment and ecology

The Chure-Bhabar-Tarai complex supports diverse ecosystems that are home to a variety of flora and fauna. Of the 7,000 vascular plant species recorded in Nepal, 22 per cent (1,570 species) are found in this region. Until the 1960s, the entire region was under a dense forest, called chaarkosejhadi, which was the habitat for a variety of trees, vegetation and wildlife[17]. This region had sparse human settlements due to the prevalence of malaria. With the eradication of malaria, the region has turned into one of the most densely populated areas in the country, and much of the forest area was cleared to acquire land for agriculture and human settlements. The three study areas are close to three natural reserves (national parks) that promote biodiversity conservation.

Koshi Tappu: An area of 175 km^2 in the flood plain of the Koshi River, about 9.3 km upstream of the barrage, was declared as the Koshi Tappu Bird Sanctuary in 1976. This area is home to wild buffaloes and other flora and fauna, and, is also an internationally important Ramsar site. For the local community, the area is a source for fishes, medicinal plants, fodder, and firewood. In the last 34 years, due to the shifting river and human encroachment, the land use around Koshi Tappu has changed, as has the quality of its ecosystem services[18].

Chitwan National Park: The eastern part of the Gandak barrage is close to the Chitwan National Park, which spreads over an area of 932 km^2 in the districts of Makawanpur, Chitwan, Nawalparasi and Parsa. Established in 1973, and declared a World Heritage Site in 1984, the park encompasses landforms in the Chure-Bhabar-Tarai landscape and in the Doon Valleys. Sall (*Shorea robusta*) trees are the climax vegetation covering more than 70 per cent of the area. The park is also a habitat for diverse flora and fauna, including birds and mammals, such as the Indian one-horned rhinoceroses, Bengal tigers, and leopards. As a tourist destination, the park is a source of revenue for the government and also provides tourism-related employment for the local population. Contiguous to the Chitwan National Park is the Valmiki National Park in Bihar's Champaran District in India.

Suklaphanta Wildlife Reserve: This 305 km^2 wildlife reserve consists of grasslands and forests consisting of *Shorearobusta* (sall) and *Terminalia elliptica* (Asna, Saj or Saaj). The reserve is home to numerous species of swamp deer and the Bengal tiger[19]. Encroachment and degradation of this reserve has had adverse consequences, particularly on the forest and water ecosystems and, as a result, on the livelihoods dependent on such ecosystem. In areas where sall trees have been heavily felled, invasive vegetarian have dominated. South of the Reserve, along the Sharada River in India, lies the Dudhwa National Park, an important tiger reserve in Uttar Pradesh. Gangetic dolphins are found in the stretch of the rivers flowing through this park.

Wetland and ponds

The study regions have numerous independent and oxbow lakes, wetlands, and natural ponds. Altogether, these water bodies cover an area of 15,711 ha[20]. Ecologically sensitive commons such as forests and grasslands are sources of some of the key products that support the livelihoods of people in the region. Kanchanpur's Ghodaghodi Tal, which is home to 34 species of mammals, 140 species of birds, 27 species of fish, and 244 species of flowering plants, is one such sensitive ecosystem, but conservation efforts to preserve this as well as other lakes have been insufficient. Such water bodies have been subjected to accelerated human encroachment in the recent past. The same is true of forests, whose cover has declined as encroachment has led to a high rate of tree felling. Between 1950 and 2000, for example, the forest area in Kanchanpur District declined rapidly with dire implications on national vegetation and wildlife.

Socio-economies

The early 1950s, endemic malaria prevented the establishment of large-scale settlements in the region, but once DDT was sprayed under malaria eradication program, the scrooge of malaria-causing mosquitoes was minimized and human settlements gradually increased. Older settlements are located in the southern areas, while migrants have created ribbon settlements along the East-West Highway as well as in the junctions of the main highway and secondary roads. In 1971, these districts had a combined population of just 1,052,967; forty years later, in 2011, the population had tripled to 3,462,897[21]. Migration and natural population growth have increased competition for limited land, forest, water and other natural resources.

Though fair-weather roads connect most of the VDCs, accessibility is still limited in many cases. Accessibility is especially problematic in the rainy season when river flow becomes full, rendering the settlements isolated for months. Of the total road of 985 km in the districts, about 600 km of roads are blacktopped.

It is estimated that about 88 per cent of the population in the study areas have access to cellular mobile phones and landlines. According to the 2011 census, 67 per cent of the population in the districts are above five years of age. Literacy and access to education is very low though differences do exist across the three areas. Local communities earn their livelihoods by raising livestock and growing sugarcane, vegetables and crops such as rice and wheat.

The Koshi region was Nepal's first industrial corridor. The Biratnagar jute mill, which processes jute grown in the area, was established in Rani, a town by the Nepal-Bihar border. So were the Morang sugar mills. In 2011 alone, 425 industries in SapSuM employed 44,704 workers. In Sunawal of the Parasi region the Lumbini Sugar Mills was established in 1984 as one among the six large sugar factories in the country which has ceased operation.

Kanchanpur District has very few industrial establishments, and

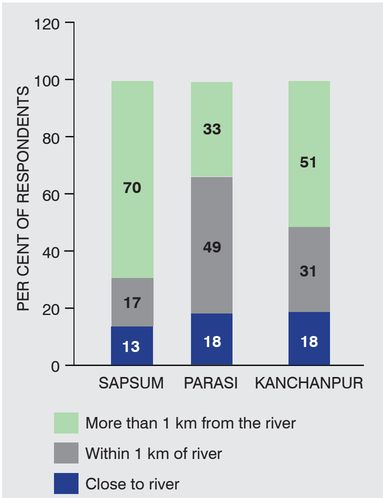
TABLE 7

Mean monthly rainfall in the study area

	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max 24hr
SapSum	1569.88	9.56	13.59	14.41	57.29	159.03	253.37	501.39	346.43	246.53	78.57	8.04	12.13	270
	2203.42	11.28	17.23	24.00	75.26	172.59	351.04	567.99	445.05	366.57	149.94	14.58	7.67	352
	1970.67	11.57	13.50	14.54	62.74	176.72	341.39	567.09	375.69	293.78	92.28	8.47	7.70	405
Parasi	1764.58	13.39	32.98	18.83	35.09	89.21	300.95	534.55	402.73	261.60	70.58	5.27	14.90	355
Kanchanpur	1664.95	23.10	34.06	16.92	16.01	47.29	245.26	482.31	463.76	270.48	49.42	4.33	13.69	352.90

Data source: DHM, Data duration 1973-2013

Figure 7
Distance from rivers



employment is more concentrated in the civil services, trade and commerce, and wage earning in construction works. Many, including youths, seek employment in foreign countries. The general economic condition of the residents in the study areas is low compared to the national figure. Additionally, exposure to annual flood hazards undermines the socio-economic condition of the people.

Demographic characteristics: The average household size in the three study areas ranges between 4.5-5.5 persons, with SapSuM's household size the lowest at 4.5, followed by Kanchanpur at 5, and Parasi at 5.5. Tharus, Kevat, Mallah (Sahani), Chamar (Harijan), Nau, Yadav, Majhi and Kahaar are the occupational caste groups in the area. Muslims constitute 4.7 per cent of the respondents. Of the total respondents, 79 per cent were male and 21 per cent were female. More than 70 per cent were aged 30-60 years and more than 91 per cent were married (See table 8).

At the three study locations, a large proportion of respondents lived near riverbanks: 13 per cent in SapSuM and 18 per cent each in both Parasi and Kanchanpur. These people were highly vulnerable to floods and riverbank erosion. In Parasi, almost half of the respondents (49 per cent) lived within one kilometer of the river, while in SapSuM, the majority (70 per cent) lived more than one kilometer away from the river and were thus not immediately affected by flooding (See table 7).

Education: Of the surveyed households, 56 per cent of respondents were literate, and only 10 per cent had completed their high school education. Of the literate, only 14 per cent were females. SapSuM had the largest percentage of illiterate respondents, and about 53 per cent were unable to read and write. In Parasi and Kanchanpur each, 42 per cent of the respondents had less than a high-school level education. Education among women was low as well.

TABLE 8

The socio-economic profile of the respondents (per cent)

Basins	Age			Sex		Marital Status			Education		
	<30	30-60	>60	M	F	Married	Unmarried	Divorce/ Widow	Illiterate	Below High School	Above High School
SapSuM	9	71	20	79	21	93	5	2	53	33	14
Parasi	8	74	18	84	16	94	3	3	32	42	26
Kanchanpur	13	70	17	77	23	91	45	4	30	42	28

TABLE 9

Household income (in per cent)

	Basins					
Household income	**SapSuM**		**Parasi**		**Kanchanpur**	
House Hold Type	M	F	M	F	M	F
Below $ 20	37	86	28	85	41	84
$20 - $40	16	8	10	6	13	7
$40- $60	23	3	15	6	11	1
Above $60	24	3	47	3	35	8

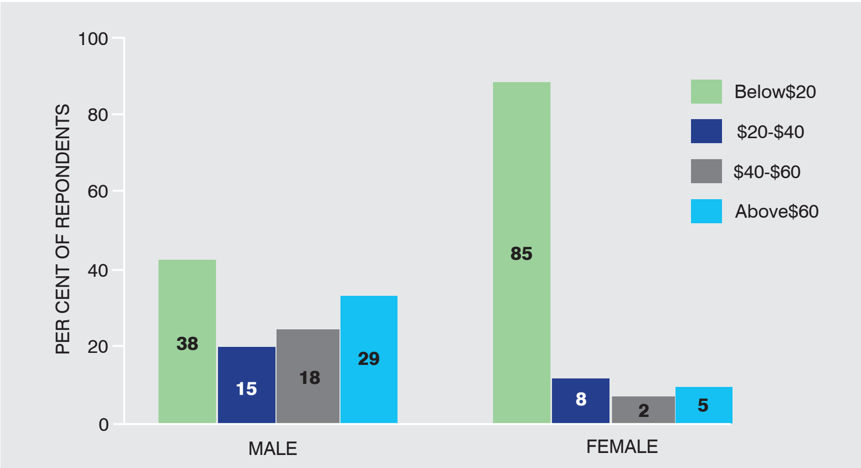


Figure 8
Monthly household income

Household income: In the three study areas women had low monthly incomes; about 85 per cent earned less than 20 USD and only 5 per cent earned more than 60 USD per month. Most women were involved in household chores, which are often not valued monetarily. On the other hand, about 38 per cent of the male respondents earned less than 20 USD per month and 29 per cent more than 60 USD. Kanchanpur had the highest percentage of male respondents earning less than 20 USD, a fact that highlights the high rate of unemployment and the lack of diverse income sources in the area. Parasi was better off than the other two locations; 47 per cent of male respondents earned more than 60 USD per month (See table 9 and figure 8).

Landholdings: The majority of the respondents in the three study areas—98 per cent in Kanchanpur, 82 per cent in Parasi and 80 per cent in SapSuM—owned homestead and/or farm land (See figure 9). Of the total households, only 62 per cent owned a farmland and those settled along roadside or on public land possessed barely enough land to build a house and were generally without a land title. Those settled on untitled lands faced the risk of evacuation. These families made a living either working as daily wage farm workers or as sharecroppers or contract farmers. Those who operated as contract farmers faced risks from flooding, as they were required to pay fixed rents to landowners and were uninsured.

Crop production: Nearly 41 per cent of the respondents depended on farming (crop and livestock) as their primary source of income. Villages within the commands of the canals received water for irrigation, while others depended on groundwater pumping.

Figure 9
Landholdings among the surveyed households

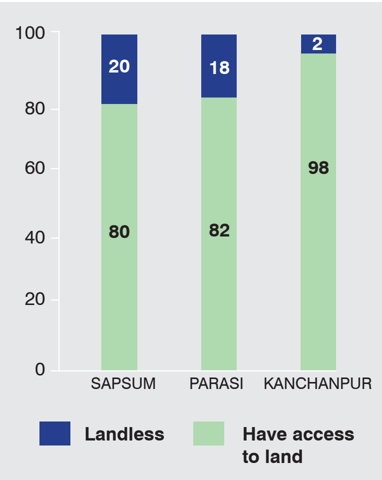


TABLE 10

Occupations of respondents

Main Occupation	SapSuM	Parasi	Kanchanpur
Artisan	1	3	0.4
Boatman	0.43		
Business	5	10	7
Day labor	33	5	10
Farmer	29	62	50
Fisherman	0.44		
Ghatial	0.13		0.1
Housewife	13	7	13
Rickshaw puller	1		
Service holder	4	5	10
Student	1	2	4
Unemployed	6	1	4
Other	6	5	1.5

Groundwater irrigation was accessible only to those who owned their own pumps and tube wells, and those who could not afford a pump had no other option but practice rain-fed farming.

Paddy was the main crop, followed by wheat, sugarcane, maize, and mustard. Potato and seasonal vegetables were also grown. Horticulture was practiced, but the land under commercial scale horticultural production was small. Villagers' access to improved seeds, fertilizers, plant protection and market was limited, therefore crop productivity was low. Raising animals was an integral part of farming. Most of the households owned livestock, including cows, oxen, and buffaloes. Livestock rearing has a substantial input to household income.

Rice and, to a lesser extent, wheat demands reliable irrigation for successful crop production. Therefore, only those lands located within the command area of the irrigation canals were available to the locals for cultivation of summer paddy. In any case, the productivity of the land still depended on monsoon rains, which also determined the volume of water available in the canals to meet irrigation demands. Families in the northern region of the study areas grew maize, beans and lentils because year-round irrigation was not available. Farmers suggested that operations of the barrages and canals often did not meet their irrigation needs.

Livelihoods and sources of income: Approximately 62 per cent and 50 per cent of respondents in Parasi and Kanchanpur respectively were farmers. In SapSuM, however, only 29 per cent were farmers while 33 per cent were daily wage labourers. Interestingly, boatmen and fishermen were found only in SapSuM, and they comprised of only about 0.43 and 0.44 per cent of the respondents, respectively (See table 10).

Some households operated small tea and liquor shops while others sold small amounts of fruits and vegetables in the local market. A few were ironmongers who repaired kitchen utensils and agricultural tools. Some families collected firewood from nearby forests and sold in local markets or adjoining townships. Others collected thatch and sold them for covering roofs. Few individuals, with professions like carpentry and masonry works, also practiced off-season farming. A few were engaged as part-time workers in repairing roads and canals. Tailoring and working in hotels or as guards in Nepal or India were other sources of employment. It was clear that families continuously sought alternative opportunities to supplement their income from farming.

4 Perceptions of the Changes and Lessons

This chapter describes the perception the respondents regarding the treaties that paved development of transboundary water infrastructure. It also captures their views regarding benefits and the consequences of recurrent flooding, inundation and the degradation of water commons. Some of these impacts are caused by the infrastructures built in the three rivers.

About treaties: Local people professed to having mixed view about the three projects. Almost all the respondents felt that India had benefitted more than Nepal; 96, 98, and 99 per cent held this view in SapSuM, Parasi, and Kanchanpur, respectively. They also claimed that the three water systems provided irrigation water to much larger areas in India than in Nepal, which they perceived unfair and unjust.

People held such perceptions because the canals supplying water to the Indian states of Bihar and Uttar Pradesh are much larger than those supplying water to Nepal. Around 88, 76 and 82 per cent of the respondents in SapSuM, Parasi and Kanchanpur revealed that they had not read the treaties and knew nothing of the arrangements between the two countries that led to the development of the water projects.

TABLE 11

Local consultation before the treaty and during project construction (in per cent)

Basins	Yes	No
SapSuM	10	90
Parasi	24	76
Kanchanpur	14	86

Use of water: Respondents (24, 51, and 42 per cent in SapSuM, Parasi, and Kanchanpur, respectively) identified irrigation as the major use of river water. In addition, 21 per cent of the respondents in SapSuM used river water for other domestic uses, such as cleaning, bathing and animal watering. Fishing was common in Kanchanpur and SapSuM where 23 and 13 per cent of the respondents, respectively cited this use of the river. Furthermore, larger proportion of the respondents in SapSuM, i.e. 10 per cent compared to the 2 per cent in Parasi and 1 per cent in Kanchanpur, accorded religious significance to the river water.

TABLE 12

Causes of changes in rivers

Causes of change	Basins		
	SapSuM	Parasi	Kanchanpur
Improper treaty with riparian countries	14	11	19
Construction of different river valley projects	13	25	14
Less water availability	14	28	41
Frequent change of course by river	18	5	7
Massive river bank erosion	27	2	5
Improper governance / management system	12	25	10
Other	2	4	4

In all the three locations, respondents suggested that they had observed changes in river behaviour over the past two decades. People also held different perceptions regarding the cause of these changes. As many as 27 per cent of the respondents in SapSuM maintained increased incidences of riverbank erosion in the past two decades and as many as 14 per cent of them blamed the improper treaty of the Koshi River for increased erosion, flood damages and inundation. In both Parasi and Kanchanpur, 25 and 14 per cent of the respondents opined that projects and infrastructures built in the rivers were responsible for reduction in river flow and increased incidences of damaging foods. About 25 per cent of respondents in Parasi argued that poor governance and management of the water infrastructures were responsible for increased incidences of flood damages (See table 12).

The changes in the river, as a result of the development of the water projects, have had a variety of impacts on the people of the area. About 40, 36 and 21 per cent of the respondents in Parasi, Kanchanpur and SapSuM revealed that they did not receive water for irrigation on time though they were close to the river and the canal system (See table 13). Wards 6, 7 and 8 of Sreepur VDC of Kanchanpur District, which are situated in the irrigation command of Mahakali Irrigation Canal (MIC) did not receive water when needed. Farmers of Ward 4 of Suda VDC revealed that they had not received irrigation water for the past five years. Respondents also maintained that availability and access to drinking water had become scarcer and attributed it to changes in the local hydrology. As many as 20, 22, and 24 per cent of respondents in SapSuM, Parasi, and Kanchanpur, respectively, maintained that water infrastructures built in the rivers had resulted in loss of their livelihoods, both due to the changes in water flow and also due to increase in flood and bank erosion events. Floods and bank erosion were also responsible for damages to agricultural land and homesteads as well. About 39 per cent of the respondents at SapSuM perceived that the river had become more aggressive with increasing frequency and intensity of damaging floods and bank erosion. (See table 14)

Many respondents maintained the belief that incidences of flooding, bank erosion, inundation and waterlogging had worsened after the

TABLE 13

Changes observed in river system

Changes in river water	Basins		
	SapSumM	Parasi	Kanchanpur
Irrigation availability lower than needs	28	37	23
Not getting water on time	21	40	36
Non-availability of drinking water	10	2	9
Low availability of water for daily chores	4	2	5
No access to water for rituals	4	2	0.5
Less fish available	3	3	5
No/unsafe means of transport	8	3	4
Increased frequency of riverbank erosion	12	3	5
Creation of new land (braided river course with islands)	1.5	1	0.5
River water has become polluted/murky	7	2	4
Other	1.5	3	8

TABLE 14

Impacts from changes in the rivers

Impacts	Basins		
	SapSuM	Parasi	Kanchanpur
Loss of land for homestead and farming due to bank erosion	39	8	10
Loss of crop	20	34	30
Conflict on the ownership and access to newly created land	7	2	8
Less livelihood opportunities	20	22	24
Extra effort to get safe drinking water	7	1	5
No support for religious-cultural activities	1	0.6	0.5
Loss of livelihood of fisher folk			0.8
Reduced food variety	2	21	5
Unsafe and expensive mobility	4	11.4	8
Other			8.7

barrages and embankments were constructed. The structures built, they claimed, had blocked natural drainage, inundated agricultural land, and caused waterlogging. These perceptions indicate that construction of water infrastructures alone did not necessarily guarantee assured services. These infrastructures were built without necessarily considering the needs and priorities of those in the vicinity. The respondents, in the three study areas, revealed their frustration against the government and the project authorities who were not responsive to their longstanding grievances.

Loss and damage: Damages caused by floods in the studied areas were of three forms: inundation, riverbank erosion, and deposition of sand. Unregulated sand extraction from the river-bed aggravated bank erosion at many locations. Respondents also suggested that the haphazard and unplanned growth of settlements had led to drainage congestion, thus increasing inundation during monsoon. Respondents held different views on factors that lead to flood disaster.

Most respondents revealed that flooding was the key hazard that was responsible for recurrent losses and damages. About 93 per cent of the respondents in Parasi and 53 per cent in SapSuM identified flooding as the major hazard. As many as 32 and 23 per cent of the respondents in Kanchanpur and

SapSuM named flash floods as the second most common form of disaster, while as many as 20 per cent in SapSuM revealed river erosion as the third most common hazard. Some respondents also identified that the occurrence of fog during winter months was becoming more recurrent over the past decade, causing damage to winter crops (See table 15).

TABLE 15

Types of disaster

Major disaster	Basins		
	SapSuM	Parasi	Kanchanpur
Flood	53	93	53
Flash flood	23	5	32
River erosion	20	1	4
Fog	1	1	9
Sedimentation	3		2

TABLE 16

Perceived causes of natural disasters

Causes	Basins		
	SapSuM	Parasi	Kanchanpur
Construction of water infrastructures	21	25	10
Improper management of water	24	15	14
Poor governance and ineffective policies	7	14	2
Conflicts between countries	9	7	2
Climate change/variability	24	8	43
God's wrath	13	24	28
Others	2	7	1

At many locations in the three study areas, people faced additional suffering from the death of family members, injuries and asset losses due to flooding and bank erosion. Others faced loss of crops and degradation of farmlands due to erosion and coarse sand deposition. About 26 per cent of the respondents in SapSuM shared that floods had damaged their houses while another 25 per cent said they suffered damages to farmlands due to flooding and sediment deposition. About 34 per cent of the respondents in Parasi and 31 per cent in Kanchanpur also reported facing damages caused to their farmlands

About 25, 21, and 10 per cent of the respondents in Parasi, SapSuM and Kanchanpur, respectively, suggested that construction of the hydro-engineering infrastructures such as barrages and embankments was directly responsible for increased incidences of flooding and inundation in the area. Similarly, as many as 43 per cent in Kanchanpur and 24 per cent in SapSuM identified climate change as the trigger for increased incidences of flooding and inundation. 28 and 24 per cent of the respondents in Parasi and Kanchanpur, respectively, maintained that increased incidences of flood disasters were acts of God (See table 16).

Widespread inundation was common in the three study areas. Before barrages and embankments were built, floods did affect human settlements in the studied districts as well as those in Bihar and Uttar Pradesh across the border. Floodwater would drain out within a few days in such cases. However, new infrastructures have caused flood-water to remain stagnant for longer periods now.

In Parasi, for example, streams flowing south from the Chure were responsible for inundation in the villages of Balarampur, Machhargaun and Jagdishpur in the monsoon. Though the Gandak Barrage project did not include flood mitigation as an objective, embankments were built along Khajura, Dhanewa, and Jharahi rivers. These embankments did, in fact, prevent the spreading of flood-water in the settlements, but they also aggravated inundation. For example, embankments built to protect Rupaulia, Daunnedevi, Jamuniya and Pratappur VDCs in Parasi were responsible for inundation of Rampur Khadauna VDC every monsoon[22]. The VDC's wards remain under water for almost three months a year. In some years the period of inundation may extend for up to five months. The following story highlights the plight of the villagers:

The construction of the Gandak Canal began in 1962 and was completed in 1967. Gradually the water seeping from the canal banks began to accumulate because at many locations toe drainage had not been provided. A few years later, a check dam was built in the Jharahi River and similar intervention was also made in the Dhaneba River. These two rivers, flowing from the Chure range, flank the VDC from two sides and again confluence in the south of the VDC.

Due to proximity to the river, about 667 ha of land, homesteads, water bodies, drinking water sources (dug wells and shallow tube-wells) are flooded for three to four months every year. Livestock movement is affected and schools are closed. People use boats to commute. Pregnant women, elderly people and children face great difficulty, as do those unable to afford a boat. Commuting to the health post and local market is difficult.

Similar interventions in natural watercourses in Nepal as well as India have led to the people living along the Nepal-India border to suffer from inundation and submergence of agricultural land and homesteads during monsoon.

Water that seeps from the MIC also inundates parts of the four VDCs in Kanchanpur, i.e. Rampur, Bilashpur, Rauteli-Bichwa and Belagi settlements of Sreepur. After the eastern embankment of Tanakpur Barrage was built, bank-cutting around Brahmadevmandi was prevented, but rainfall-induced inundation affected parts of Chandani-Dodhara VDC. The VDC also faced threats from the direct flooding of the Mahakali River.

TABLE 17

Conditions of protection structures

Condition of protection	Basins		
	SapSuM	Parasi	Kanchanpur
On the embankment	1	1	1
Inside	2	31	31
Outside	97	60	68

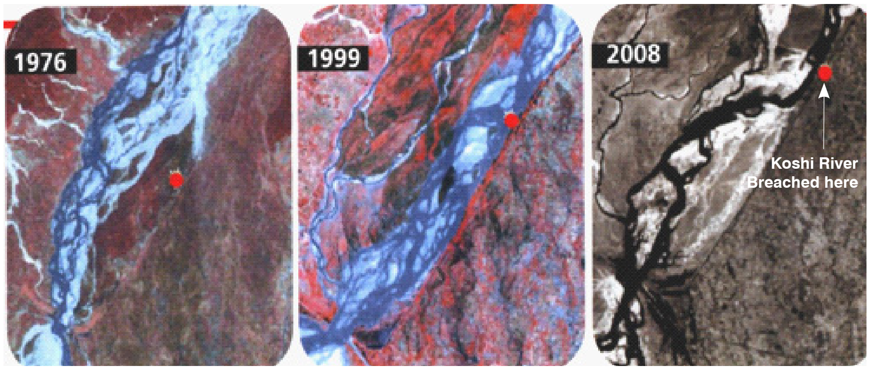
TABLE 18

Immediate support during disasters

Agencies	Basins		
	SapSuM	Parasi	Kanchanpur
Government	19	43	16
Community	19	0	5
INGO/NGO	6	0	27
Private/Corporate	2	10	0
No support	54	47	52

In Parasi, farmers revealed that the Gandak West Canal blocked the south-flowing streams, increasing instances of inundation. To facilitate drainage, aqueducts were built in sections where the canal crossed a tributary. In the monsoon, however, sediment and debris brought by the floods in these rivers gets deposited in these aqueducts, blocking the waterways. Thus, water accumulates in the upstream side and inundates agricultural land and settlements. Crops are damaged and the grazing areas of livestock lost. Schools are closed and used as shelter by those who face inundation. People use boats to commute to the local market and to take sick people to health posts[23]. The incidences of inundation and submergence are more dramatic in SapSuM than in Parasi or Kanchanpur.

The Koshi River used to move from east to west, but its behavior began to change after the embankments and the barrage were built. The sediment load of the river was deposited upstream of the barrage with the river moving more capriciously within its embankments[24]. Starting 1987, the river started flowing from west to east along the Koshi Tappu Wildlife Reserve. Because the riverbed is a few meters higher than the adjoining lands, it became a source of seepage and also increased the chances of an embankment breach. Upstream sediment deposition also reduced the capacity of the barrage to handle discharge smaller than its designed peak flow of 23,990 m^3/s. The Barrage operators today have to be more cautious even when the water flow is lower.



Changes in land form of Koshi river upstream of the barrage

Source: CSE (2009)

Figure 10
Changes in river within embankments

The Koshi embankment has been breached many times and each breach has produced serious consequences. In the past, these breaches were treated as local disasters, and, while governments did provide small amounts of relief, victims were left to fend for themselves.

For example, the 2008 breach of the Eastern Koshi embankment at Kushaha VDC in Sunsari District, about 10 km north of Nepal's East-West Highway, produced damages of transboundary proportions. After the breach occurred, the river began to flow through the opening along its old channels towards the Ganga River and, as it hurtled south, affected 3.5 million in Nepal and Bihar. Agricultural lands were covered under a thick layer of sand, infrastructures were damaged, and people were killed. The flood affected eight VDCs in Sunsari and Saptari districts—Kusaha, Laukahi, Ghuski, Sreepur, Haripur, Narsimha, Madhuban and Basantapur.

The resulting flooding caused 40 deaths, of whom 18 were women and 6 were children. Most of these deaths occurred as a result of diseases such as diarrhoea and other epidemics. About 2,350 were injured, of whom

898 were women and 816 children. The flood damaged about 1,318 ha of cultivated land, fully or partially, and also damaged 12 km stretch of Nepal's East-West Highway. The direct economic loss due to the flood was estimated at Rs. 37.8 billion. Even today, a significant portion of the agricultural land and land plots remain covered under thick sand and are out of cultivation[25].

Displacement: In the three studied areas families were displaced when land was acquired for the project development. About 45,000 families were involuntary displaced when various elements of the Koshi Project was implemented (Pathak, 2008). People were also displaced due to flooding and this trend continues even today. Of the total respondents, about 31 per cent opined that they were displaced at least once in their lifetime. Some of the families had to move their homestead more than once because of floods, while others had to move out the area for good.

Due to land acquisition: Involuntary displacement results when private land and properties are acquired for the construction of infrastructures such as barrages, dams, and canals without the consent of the owners. When infrastructure projects are built, land is acquired for office buildings, contactors' and engineers' quarters, roads and for obtaining boulders and sand for construction materials. Such acquisition exacerbates the concerned family's social and economic contexts prior to the development of the project.

Il three cases, although compensation in the form of cash was provided, the process was delayed by bureaucratic procedures. In some cases, families displaced through acquisition in the 1950s have not yet received compensation in any form. Whatsoever may be justification for delays, the claims on compensation still remain outstanding. Even when the compensation amount was provided, it was not sufficient for the families to purchase new assets. This is yet another standing grievance of the families whose lands were acquired. However, their voices have gone unheard. In order to receive compensation, families likely to be affected need timely information. In some of the projects, access to information was limited, when the projects were planned and implemented. This has been more or less the case with most infrastructure projects.

Due to flooding: Of those displaced, 38 per cent indicated that flooding was the major reason for displacement. In the Koshi region, a majority of the respondents reported that recurrent flood damages, together with the decline in agricultural productivity, had caused people to migrate to cities. About 100 households of the Narsimha VDC of Sunsari District were identified to have migrated to Ramganga, Belgachiya, Chitaha, Tanmuna, Aurabani, Simariya, Doliya and other neighboring VDCs[26]. As many as 60 and 30 per cent in Kanchanpur and SapSuM, respectively, identified the lack of livelihood opportunities as the second most important cause for the displacement of people. In Suda and Shreepur VDCs of Kanchanpur, more than 34 per cent of households had moved at least once in their lifetime, about 60 per cent due to a lack of livelihood opportunities and a meagre 6 per cent due to flooding. However, on September 20 of 2008, a flood in the Doda River killed two children and displaced 18 households in ward 1 of Sreepur VDC. River-cutting and bank erosion displaced about 36 families in wards numbers 9, 10, 11, 12 and 13 of the Mahendranagar Municipality[27].

River erosion and inundation affected the eastern parts of Udayapur District, north of the barrage. The areas upstream of the barrage, within Saptari and Sunsari District, faced the problems of flooding and bank erosion, but the flood victims of Prakashpur, Mahendranagar and Barahachhetra VDCs did not receive any compensation for the damages they faced. Many families faced displacement more than once in their lifetime. About 84, 69 and 64 per cent of respondents in Parasi, SapSuM, and Kanchanpur maintained that they had lived in their current homestead all their lives while others had moved fewer than five times. About 26 per cent of respondents in SapSuM and 15 per cent in Parasi stated that they had moved less than five times. In SapSuM about 3 per cent had moved more than 10 times, although they shifted to nearby areas[28] (See table 19).

Indirect displacement: Respondents in the three study areas faced loss of agricultural land and crop damages every year due to flooding, but were not compensated for it. In Saptari District, of SapSuM, for example, several hectares of land are waterlogged due to the combined effects of drainage congestions and seepage along the West Koshi Canal. This has rendered the land useless. Such lands have, today, been left fallow. It is estimated that crops planted in 6-7 thousand bigha of land were affected[29].

In 1980s, flood victims in Mahendranagar, Sunsari began living near the Koshi Tappu Wildlife Reserve but security personnel dislodged them away using elephants[30]. Similarly, farmers in the south-eastern parts of West Gandak Canal have not received compensation for crop damages that they suffered due to inundation and drainage congestion even though Rs. 1.2 million had been allocated for this purpose.

Nepal did raise the issue of land compensation in the Seventh Joint Committee meeting on water resources between Nepal and India on January 24-25, 2013[31]. Unpaid compensation issues had been highlighted at the fourth joint standing technical committee meeting of September 2013 by representatives of the GoN, but officials from the GoI disagreed, claiming that the Koshi agreement made no provision for compensating land eroded by floodwater.

Community actions: In all of the three study areas, communities are taking actions to assert claims for the damages that they have suffered. While some actions were successful, others were not. Some of such community led actions are described below:

SapSuM: On January 5, 2010, the Koshi Flood Victim Struggle Committee staged a protest demanding compensation and rehabilitation. The committee was formed to voice the grievance of the families affected by the 2008 flooding. The protestors demanded compensation for the land damaged due to sand casting after the 2008 breach of the Koshi embankment, as the breach had left the land unsuitable for crop cultivation. During the demonstration a clash erupted between security personnel and agitators in Haripur VDC of Sunsari District. About eighteen protestors and four police personnel were injured[32]. After this incidence, a dialogue was held between the demonstrators and local administrators. Subsequently, the government released Rs. 150 million as the second instalment for the relief support of Rs. 1.60 billion provided by the government for assistance.

Parasi: In Parasi, civil actions still continue. The appurtenance of the Gandak project prevented natural drainage and led to undesirable inundation. Families suffering the damages consistently pleaded for support to overcome the hardship they faced, but government agencies did not respond. In 2006, residents of the area formed the *Gandak Nadi Niyantran Sangharsa Samitee* (Gandak River Control Struggle Committee) to coordinate actions and raise their collective voice against the recurrent inundation and livelihood damage

TABLE 19

Houses moved after flooding

Household shift frequency	Basins		
	SapSuM	Parasi	Kanchanpur
Never	69	84	64
Less than 5 times	26	15	34
5 to 10 times	2	1	1
More than 10 times	3	0	1

caused by the Gandak Project[33]. The Committee received intellectual and knowledge support from a local civil society-group Indreni Social Development Forum on issues related to compensation for the damages caused to standing crops, homesteads and livestock. The Committee also demanded that the canals be properly maintained and that hospitals, roads, and bridges be built. Pabitra Neupane, the vice president of the Committee, remembers:

Seepage water from the Indian Main Canal (IMC) affected our land for a long time. We didn't know what to do. A few years after it started, my father, my brothers, and I approached the Chief District Officer (CDO) of Nawalparasi District seeking support to address the problem. To my disappointment, the CDO said that these issues did not fall within his administration's purview. He advised us to contact the Department of Water-Induced Disaster Prevention (DWIDP) under the Ministry of Irrigation (MoI). When we approached the DWIDP, officials told us that the government of India controlled the operation and management of the IMC and that only Indian officials would be able to help.

Between 1993 and 1995, officials from India visited the area many times but they took no action. The seepage continued but we were not compensated for our losses. Then we decided to form the Gandak Struggle Committee (GSC) and take the matter to higher levels in the Nepali Government. Through the GSC we officially approached the CDO for compensation. The CDO again advised that we get in touch with the MoI but the officials there said that they would not be able to do anything and pointed us towards the Government of India. They told us that the 1959 Gandak Treaty entrusts the Government of India with the responsibility for looking into issues related to the damages caused by the malfunctioning or technical failure of physical infrastructures of the project.

During one of our visits to the Ministry of Irrigation (MoI), officials told us that they would discuss the issue of compensation with the CDO. Finally, we received compensation of Rs. 28,000 and the MoI allocated Rs. 110,000 for strengthening the canal and preventing the seepage. However, seepage along the canal still could not be controlled even with this intervention. This frustrated us.

In 2004, we, the members of the GSC, began digging in the IMC. The CDO came and advised us not to do so because digging Indian assets would lead to serious consequences. After that, we waited for almost a year but nothing happened.

Then, in 2005, we decide to improve our knowledge about the Gandak Project. We collected pertinent documents related to the project, including those related to the Gandak Treaty and started educating ourselves around the provisions of the treaty and the project. This helped us understand the provisions on rights and responsibilities of the Indian side with regards to operation and maintenance of the canals and other infrastructures. After this, we could articulate our demands more logically and within the purview of the provisions.

In 2008, we organized a mass protest in the IMC that continued for 34 days. On the 35th day, officials representing the Nepalese and Indian administrations came to negotiate. We signed a 21-point agreement to address our demands. Nonetheless, the government of India addressed only a few of those demands.

We then approached the Ministry of Foreign Affairs in Kathmandu (MoFA) and requested that our remaining demands be met; otherwise, we warned of another mass protest. We found out that the MoFA had informed the Government of India of our plans. Officials from Patna and New Delhi visited Kathmandu and met with us, but still nothing came out of it.

In 2011, we organized a press conference and mentioned that because India had not paid compensation for 25 years we would file a case with the International Court of Justice. Four days later, the Indian government provided Rs. 5 million to Nepal. However, the affected families are yet to receive the remaining amount of compensation that is due to them[34].

Kanchanpur: In 2012, flood victims staged a fast-unto-death in front of the CDO of Kanchanpur District, demanding compensation and rehabilitation of flood affected families. They demanded that flood-affected families be provided lands at safer places and that their rehabilitation be assured with livelihoods, education and health related components integrated into the rehabilitation package[35]. Their demands are yet to be fulfilled.

Early warning systems: The answers to the question of whether people received early warnings of any form before the floods varied across the study areas. About 97 per cent of respondents in Parasi stated that there was no warning system in place and they did not get any advisory on flood events. On the other hand, 37 and 49 per cent of the respondents in SapSuM and Kanchanpur claimed to rely on local radio and television stations for information on weather (See table 20).

TABLE 20

Early warning systems

Early warning	Basins		
	SapSuM	Parasi	Kanchanpur
Radio/TV	37	1	49
Word of mouth	3		1
Government announcement/advisory	No	No	No
NGO	No	No	No
Others forms of warning	1	2	1
No warning	59	97	49

Other forms of warnings were also mentioned, for example, the red flags that are hoisted by the operators of the Koshi barrage when the water level rises above the threshold level.

Social support and responses: More than half of the respondents in SapSuM and Kanchanpur stated that they did not receive immediate support from any agency, but a few did reveal that government agencies provided some form of immediate relief. They also revealed that government employees were the first responders to reach them during any disaster. The respondents in SapSuM and Kanchanpur added that, alongside the government, local communities, NGOs and the private sector were also involved in providing relief support of some form (See table 18).

People were asked if the community itself could play a role in responding to flood disaster mitigation. When asked if they were capable of dealing with the problem on their own, nearly 50 per cent of the respondents in SapSuM and Kanchanpur said that they could work together to address the problems. Contrarily, about 60 per cent of respondents in Parasi revealed that, without support from the government and non-governmental organizations, the local community was not equipped with knowledge and resources to deal with flood-related problems.

Bank erosion was recognized as another major challenge facing the communities in the three study locations. About 64 per cent of respondents in SapSuM and 65 per cent in Parasi stated that they were unprepared to deal with bank erosion. Even though half of the respondents in SapSuM stated that they could deal with problems at the community level, most thought that they could not do so at the household level. Nearly 52 per cent of the respondents in Parasi stated that they were unprepared to deal with floods at the household level. The respondents in Kanchanpur, however, seemed more confident as nearly half of them revealed that households did have the knowledge and the capacity to deal with both flooding and riverbank erosion.

In the study areas, it was found that farmers responded autonomously to address the deficiency of water. For example, some farmers have recently started using mechanized pumps to extract water from aquifers and open water bodies (rivers, ponds and lakes) for supplemental irrigation. For such well-to-do farmers who could afford to purchase pumps the groundwater functioned as a buffer that increased the reliability of the supply for irrigation and met their drinking water needs. Poorer farmers, on the other hand continue to depend on rain. The majority of respondents in SapSuM articulated that agricultural productivity in the areas has gone down, income from farming had reduced, and many families had migrated to cities. Some sought jobs outside the country.

Vulnerability Ranking: In the study areas people used human-built and natural ecosystems to overcome the difficulties they faced. They used such systems to maintain their livelihoods and, within the limit of their capacity, to diversify them. However, these responses are becoming more complex as new constraints emerge. New risks continuously generated by the impacts of hazards, including climate change, manifest in the local economies, and livelihoods. People also face hardships from non-climatic risks. The knowledge of the condition of local ecosystems, human-built systems and the context within which services from them are managed reveal why certain people have stunted access to the services such systems provided. This is also one the reasons why vulnerability is perpetuated.

Ranking is a useful tool for establishing vulnerability of a specific geographic area and devising plans to address them. The ranking established was presented to the local stakeholders at each study site for their validation. Locals of Suda VDC, for example, agreed that ward 9 was the most vulnerable because it faced flooding every year. In addition, inundation and poor drainage damaged electricity distribution pylons, roads, canals, and drinking water systems. In some cases, flooding was so bad that children could not commute to their schools and sick people could not travel to receive health services. Vulnerability assessment at this scale is useful to frame strategies to respond to floods and droughts as well as to the other threats emanating from degradation of water.

Vulnerability assessment can help formulate strategies that can help local communities adapt to climatic and other changes. They need to be made more participatory and transparent, so that the decisions taken have a greater chance of being successful in addressing the emerging problems (See table 21 and figure 11).

Local knowledge: In the study areas, water commons engrained in the local ecological and social contexts created multiple benefits for the people and supported their livelihoods. The

TABLE 21

The most and least vulnerable wards in the selected VDCs

District	VDC	Vulnerable ward	
		Most	Least
SapSuM	Darbesa	8	9
	Pharseth	5	7
	Banauli	8	7
	Barahchhetra	1	9
	Bhadgaon Sinuwari	7	5
	Narsimha	6	8
Parasi	Rupaulia	2	3
	Rampur Khadauna	3	4
Kanchanpur	Suda	9	1
	Sreepur	8	5

local knowledge generated, while managing the commons, is social capital that can help people adapt to emerging shocks, including those that arise due to climate change. However, this knowledge is being eroded in the quest for new knowledge in pursuance of development. Meanwhile, modern methods have failed to deliver services and also degraded water commons.

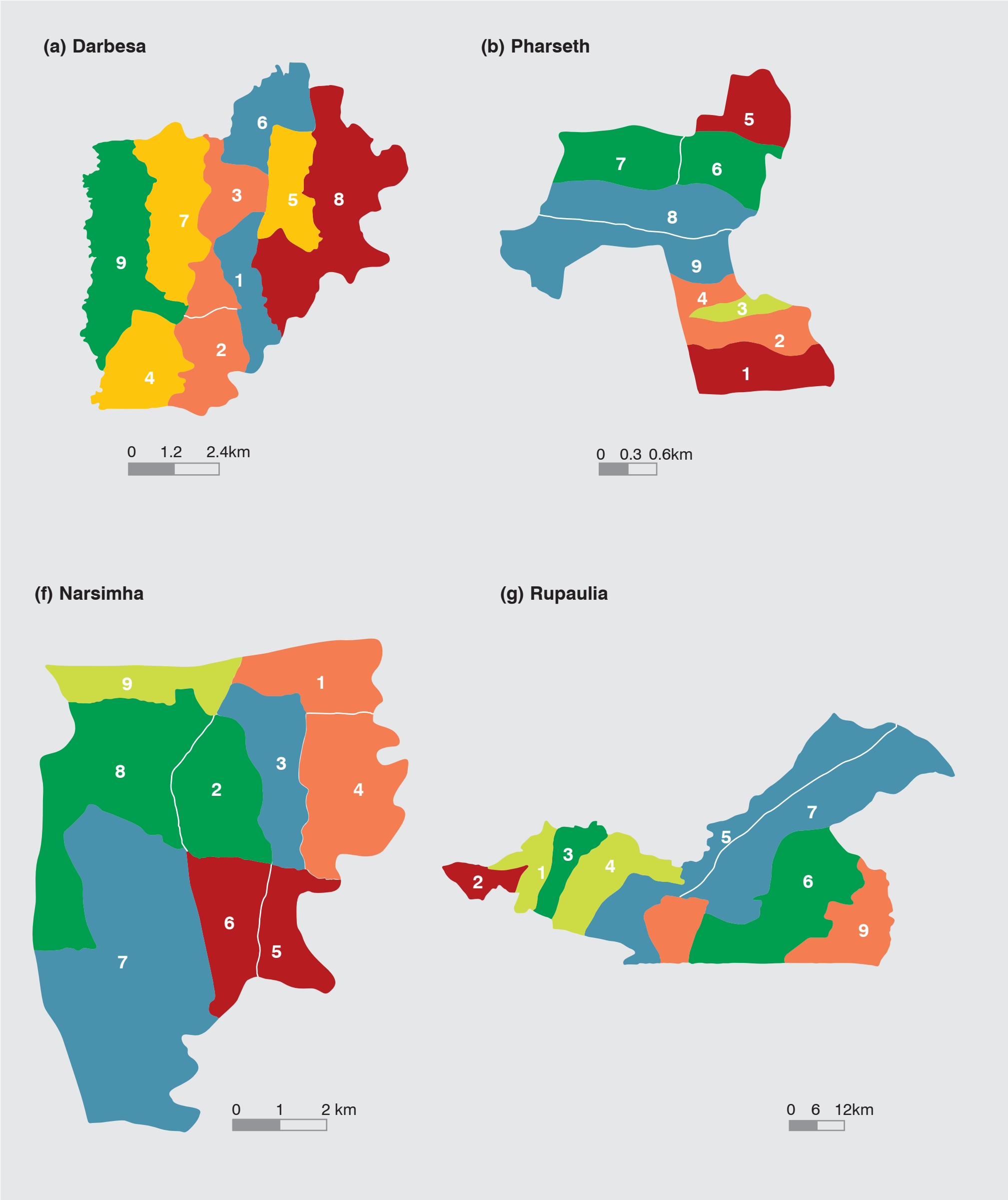
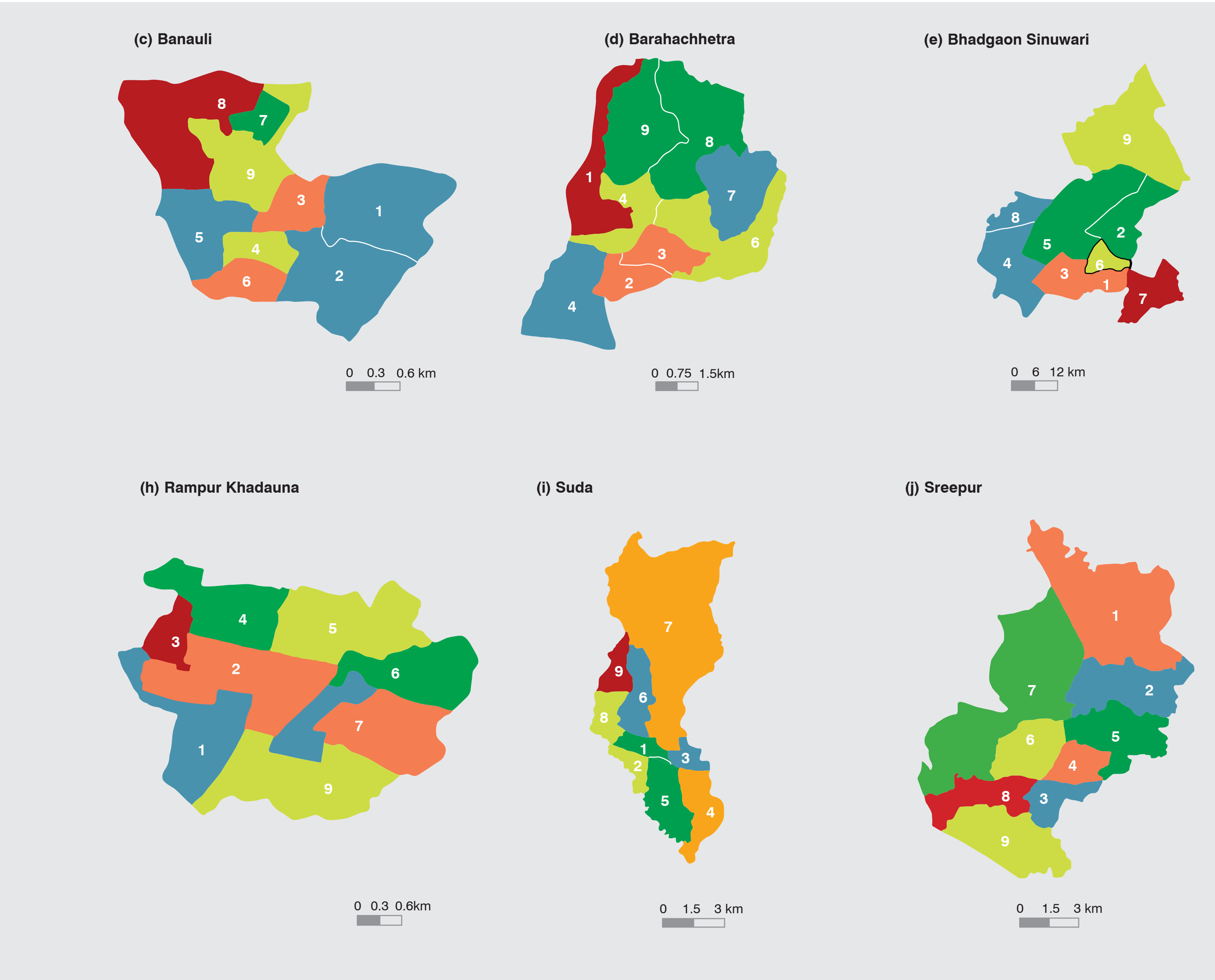


Figure 11
Ranking of the 10 VDCs in the study areas


(c) Banauli
8
7
9
3
1
5
4
2
6
0 0.3 0.6 km
(d) Barahachhetra
9
8
1
4
7
3
6
2
4
0 0.75 1.5km
(e) Bhadgaon Sinuwari
9
8
2
5
4
6
3
1
7
0 6 12 km
(h) Rampur Khadauna
4
5
3
2
6
7
1
9
0 0.3 0.6km
(i) Suda
7
9
6
8
1
3
2
5
4
0 1.5 3 km
(j) Sreepur
1
2
7
6
5
4
8
3
9
0 1.5 3 km

2008 Flood: Devastated rural homes in lower Koshi

5 Final Observations

This study has provided a broad picture of the state of water commons in specific regions of Nepal. To that end, it has used treaties on shared water between Nepal and India as lenses. The study has identified issues that affect effective use of water services for riparian communities in Nepal from projects constructed under the treaties. Signed in an era when social, economic and technological challenges were not as complex as they are today, the provisions of the treaties are insufficient to meet the emerging social and political context while maintaining health of the water commons. The treaties and agreements must be revisited and be informed by emerging lessons particularly because water induced disasters have become more frequent with serious impacts on lives, assets and livelihoods.

Increasing water needs and scarcity are also exacerbating degradation of water commons. Depleting groundwater sources and pollution are other threats that need serious consideration. Local needs must be met equitably as water is shared among different users. These efforts must build trust among various users as well as help in conservation of water commons. These objectives can be achieved by building transparent, responsive, inclusive and accountable governance.

It is not clear how these objectives can be achieved when countries enter into new agreements on harnessing of shared water resources or when they revise existing ones. This study suggests that existing treaties and proposed ones need to consider the fundamental role of water in nature and societies. Continuous dialogue among different users, managers of water and decision makers is a prerequisite for positive outcomes. These outcomes are a) health and integrity of water commons, b) minimizing pollution and degradation c) water services reaching those for whom interventions are made and d) build trust among various stakeholders including governments.

Interaction with locals of Narsimha VDC, Sunsari

NOTES

1 The projects under the three treaties also generate hydropower. These, and other projects related to hydropower development, are not covered in this study.

2 The Bhabar region extends from the foothills of the Chure range along Nepal's East-West High-way to the northern edge of the highway. The region could be designated northern Tarai while the region to the south of the highway the southern Tarai. The two regions differ in their geological structure, their underlying aquifers as well as in their social contexts.

3 In many cases, the boundary of a unit (area) that is defined politically and administratively does not match with that of a watershed. Such mismatch creates limitations during vulnerability assessment while formulating Ecosystem based Adaptation (Dixit et al 2015) as well as while pursuing water stewardship.

4 These local entities are being redesigned according Nepal's 2015 Constitution but at the time of writing of this report had not been finalized.

5 A study by Practical Action (2009) showed that the annual average rainfall of Nepal was 1,857 mm. Alford (1992), Lang and Barros (2002), Barros and Lang (2003), Barros et al. (2000), Shrestha (2000) explained the monsoon in a macro context but the behaviors at the local level are poorly understood. Interaction between topography and the monsoon creates large regional and local variation in precipitation: long-term precipitation patterns show large variations over spatial scales of around 10 km controlled by topography (Anders et al., 2006). In many places fivefold difference between rainfall in valleys and their adjacent ridges exist showing the importance of orography to convective processes (Higuchi et al., 1982, Barros and Lang 2003: Kansakar et. al 2004: Panthi et. al 2015). These studies suggest that topography and altitude play major roles in precipitation distribution over Nepal. The level of instrumentation available to monitor monsoon dynamics is insufficient to explain them and remain poorly understood. Thus, it is not easy to anticipate the impacts of climate change on the dynamics of local precipitation.

6 In 1979, Zollinger classified Nepal's rivers as Snow-fed, Mahabharat and Chure types (Zollinger 1979). Later Nepali hydrologists began examining details about the number of streams, their density and length. See Shanker (1985) for an earlier analysis. This analysis remains valid even today though the morphology at section of certain rivers has undergone major changes. One typical example is the Bagmati and its tributaries in Kathmandu. They are no longer the meandering types of the past but been deprived of sand through mining, polluted by dumping of social and liquid wastes as well as turned more into canals by erecting walls on the banks. In the past few years Kathmandu is seeing a largely state led civil group supported campaign that is clearing the river of the solid wastes on its bed banks.

7 While discharges of most of the larger rivers are measured, this is not done so with smaller rivers and tributaries. At the same time, error margins in the measured data remain (Dixit and Moench 2007).

8 Studies indicate that decreasing ice volume in Nepal's Himalaya will lower stream flow in the future with negative consequences on hydropower generation, irrigation, food security and overall well being. It has been estimated that the Dudh Koshi River, for example, may experience up to 30 per cent decline in its stream flow by 2100 as the ice volume of glaciers that feeds the river is predicted to decline]' by half during the same period. (http://www.scidev.net/south-asia/climate-change/news/water-flows-decreasing-in-nepal-himalayas.html). Gautam and Acharya (2010) found that the flow of Karnali and Mahakali rivers is also decreasing while the West Rapti River shows an upward trend.

9 This peak discharge was recorded in 1968 (GoI, 1981). According to DHM records, the highest recorded peak flow in the Karnali River was on 11 September, 1983, had a magnitude of 21,700 m^3/s and was exceeded in 2014. The peak flow in 2014 was 22,200 m^3/s. In the Narayani, a peak flow of 25,700 m^3/s occurred on August 1971.

10 Shanker (1985) has used the specific runoff value to estimate runoff from Churerivers. Most of the Chure rivers flow in the months of monsoon and this flow alone could account for as much as 90 per cent of their total annual runoff. In the upper regions, the Chure rivers may be almost dry during non-monsoon months and even during monsoon, if there is no rainfall, the rivers may not have bank flow at all.

11 Snowmelt sustains the low flow of snow fed rivers. The data on share of rivers from Nepal to Ganga River at Farakka is based on Pun (2004). In the last decade, due to increased snowmelt the flow dynamics has changed but the specifics cannot be calculated because the available data does not allow for precise analysis.

12 The sediment mass derived from the erosion of mountain slopes, beds and banks of rivers, landslides and glacial valley is transferred and deposited downstream. The flow and deposition of sediment are responsible for the formation of the fertile plain and the deltaic region of the Ganga, and other rivers. The amount of sediment that Nepali rivers transfer is high but underestimated. In the 1970s, when the Theory of Himalayan Degradation was postulated, it was mentioned that 240 million cubic meter per year of sediment was discharged from Nepali rivers (IBRD 1974). Dixit and Moench (2007) reviewed assumptions and collated existing sediment discharge data of main rivers to suggest that the combined sediment outflow from Nepal's four snow fed rivers is about 472 million-cubic-metres, which is almost double the then oft-quoted 240-million-cubic-metre total outflow from the country. When sediment discharges from the Mahabharat and Chure rivers are included, the figure is even higher. Climate change induced extreme events are likely to alter the existing sedimentation dynamics as sediment runoff is likely to be more but it is not easy to estimate what this increase will be. At watershed level making such assessment will be even more difficult because of insufficient data.

13 See Hagen (1998) and Upreti and Dhital (1994).

14 The Bhabar region is constituted of coarse-grained colluvial deposits and alluvial fan whose sediment sizes decrease as one moves south. Recharge of multiple aquifer systems in the Tarai occurs through this zone. Although direct rainfall recharge is significant all over Tarai, lateral subsurface recharge from Bhabar is important for the deeper confined aquifers. Various estimates are available for the rate of groundwater recharge in the Tarai region. The earliest estimate by Duba (1982) puts the total annual recharge at 11,598 MCM of which 2,761 MCM (nearly one-third) occurs in the Bhabar Zone and the remaining in the Southern Tarai plains. In South Asia, the use of groundwater has helped stabilize agriculture and increase household

incomes (Moench 2003). At the same time, deepening groundwater table, due to excessive pumping by large number of pumps, has also been a growing concern in some pockets. Current estimates put the total number of electricity- and diesel-powered groundwater pumps in the GRB at 25 million (Shah 2013). Unregulated groundwater use mobilizes arsenic contaminants, depletes aquifers, and creates social inequity by denying affordable water and energy services to poor farmers. The pervasive use of diesel pumps can cause degradation of groundwater ecosystem and increase the carbon footprint.

15 Once densely forested, the Bhabar belt faces rapid human encroachment for various social and economic reasons. The East-West highway, which more or less follows the southern limit of the Bhabar zone, has contributed extensively to development of almost ribbon settlement along the highway. New settlements and the associated agricultural activities have grown both legally and illegally. Industrial establishments are also flourishing after the construction of the highway. The main recharge zone is thus facing increasing threats from industrial, agricultural and other human activities. Collectively, all of these actions have consequences on the quantity and quality of groundwater recharge an important element for the health and livelihood of the Tarai population.

16 The study describes groundwater typologies for the aquifer which integrate existing datasets at a transboundary scale for the first time, and provide a new lens with which to view the aquifer system. (Bonsor et al 2016) Localized water quality degradation and groundwater depletion require careful management to sustain groundwater's role as that buffer (Alan et.al 2016).

17 These include *khair (Acacia catechu), siris (Albizzia sp.), harro (Terminalia chebula)* and *ankhataruwa (Heynea trijuga),sal (Shorea robusta), sissoo (Dalbergia sissoo),* and *saj (Terminalia elliptica)*. The major plants observed in the region are *Boehmeria platyphylla D. Don (gargalo), Colocasia esculenta, Schott (karkalo), Imperata cylindrical (L.) Raeusch (siru), Ipomoea carnea ssp., Fistulosa (Mart. Ex Choisy) Austin (besharam), Pogostemon benghalense (burm), Kuntz, (rudilo,* and *Saccharum spontaneum (kans).* The bird species are *Alcedo atthis, Ardea grayii, Ceryle rudis, Ciconia episcopus, Egretta alba, Hoplopterus indicus,* and *Hoplopterus malabaricus.*

18 The reserve's ecosystem provides an estimated annual economic benefit of around USD 16 million but there is no practical mechanism to share this benefit with local communities. See ICIMOD (2013).

19 Other associates are *Lagerstroemia parvifolia, Adina cordofolia, Terminalia belerica, Mitragyna parviflora, Hymenodictyon excelsum, Anogeissus latifolia, Syzygium cumini, Mallotus philippensis,* and *Holarrhena antidysenterica* as well as grass species like *Eulaliopsis binata, Saccharum spontaneum, Saccharum munja,* and *Imperata arundinacea.*

20 When Nepal came into contact with the modern world in the 1950s, the composite wit had a contiguous region of dense forests, tall grasses and wetlands that was the habitat of Royal Bengal Tigers, Asian Elephants, One-horned Rhinoceros, Gaurs and Swamp Deers. Such wildlife still exists but people-wildlife conflict is increasing as forest area decreases. (Ministry of Forests and Soil Conservation 2015). Adhikary (2015) provides the data on forest degradation

21 Population in both rural and urban areas of the Chure-Bhabar-Tarai composite shows increasing trend where people migrate to Tarai from the hills and the mountains expecting better living conditions and opportunities. This composite is also defined as the Tarai Arc Landscape (TAL) that spreads from the Mahakali River in the West to Bagmati River in the East. The TAL region extends to India's Yamuna River in the west linking 11 trans boundary protected areas (from Parsa Wildlife Reserve in Nepal to Rajaji National Park in India (Ministry of Forests and Soil Conservation 2015). In Nepal, the 2001 census recorded

that almost 1.5 million TAL-Nepal residents were born outside the TAL, compared to only 0.5 million in 1981 (CBS 2002). The population of the five districts involved in this study (Morang, Sunsari, Saptari, Nawalparasi and Kanchanpur) is based on census data of 2011 (CBS 2011).

22 In wards 7, 8 and 9 floodwater remains stagnant from fifteen days to three months, inundating about 542 ha of agricultural land and affecting 95 households in ward 7, 76 households in ward 8 and 80 households in ward 9.

23 This information is obtained from local level interaction in Rampur Khadauna VDC, Nawalparasi in 2013.

24 The bed level of Koshi in Bihar is higher than the adjoining flood plains (Valdiya 1985). In these areas, large tracts of lands are routinely inundated due to drainage congestion by newly built roads and embankments on the Indian side of the border. However, these local concerns are only occasionally mentioned during public discourses in Nepal or India. Drainage congestion also results due to development of roads and growth of settlements in Nepal's Tarai.

25 The flood led to widespread devastation in Nepal and North Bihar. The discussions are found in Dixit (2009), UNESCO (2009), MoHA (2011).

26 Information based on local-level interactions held in Narsimha VDC, Sunsari District in 2013.

27 Based on local-level interactions and key informant interviews held in Sreepur VDC, Kanchanpur, in 2013.

28 Information based on local-level survey.

29 One bigha is equivalent to 0.68 hectare and 1.67 acre.

30 Information based on local-level interactions held in 2013 at Sunsari District.

31 According to its minutes, 1,516 bigha of land was eroded between 1961 and 1964 and 3,948 bigha between 1965 and 1968. Officers from both sides jointly verified that an additional 2,226 bigha had also been affected. See http://www.wecs.gov.np/pdf/JCWR-VII.pdf

32 See http://us.ekantipur.com/2010/02/22/national/koshi-victims-agree-to-sit-for-dialouge-vehicular-movement-resumes-along--east-west-highway/308902.html.

33 The 21-point demand of the Gandak River Struggle Committee included issues like compensation, removal of hardships etc.

34 Information based on interview with key informants, 2013 at Parasi.

35 http://www.thehimalayantimes.com/fullNews.php/fullNews.php?headline=Flood+victims+stage+fast-unto-death+&NewsID=347243.

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ActionAid-Nepal

ActionAid is a global federation working to end poverty and injustice with thousands of communities and millions of people across the planet. With 45 national members and country programs worldwide, ActionAid focuses the majority of its resources on working with the poorest and most excluded women, men and children. ActionAid International Nepal (AAIN) is a member of ActionAid International Federation, working in Nepal since 1982.

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"A Nepal without poverty and injustice in which every person enjoys their right to a life of dignity."

Mission

"To work with people living in poverty and excluded people to eradicate poverty and injustice in Nepal"

Strategic Objectives

- Ensure improved livelihoods and build disaster resilient communities by enabling people living in poverty and marginalised people to claim productive resources.
- Facilitate political advancement of people living in poverty and marginalised people to hold duty bearers to account, develop propositions for national development strategies and deepen democracy.
- Engage with women and girls to build their active agency to challenge and take actions against all forms of discrimination and injustice against their body, sexuality and unequal burden of work.
- Support all children to attain quality education in a safe and equitable environment.

ISET-Nepal

ISET-Nepal is a research organization that conducts inter-disciplinary research and engages in policy dialogues. The organization was established in 2001. ISET-Nepal examines social and environmental challenges with the aim of contributing to building a society capable of addressing such challenges through improved knowledge and capacities. ISET-Nepal collaborates and partner with diverse national and international academicians, researchers and organizations. ISET-Nepal conducts interdisciplinary research and holds interactions on crosscutting issues involving the environment, water, technology, politics, and society with a wide spectrum of the Nepali society as well as with global actors. It generates evidence for policies on the five themes: Disaster Risk Reduction; the changing rural-urban continuum; climate, water, ecosystem, food, and livelihood Interdependence; energy system and management and public-sector governance.

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ISBN 978-9937-8519-7-8

9 789937 851978