Two Days in the Life of a River: Glacier Floods in Bhutan

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Abstract: An analysis of glacier lake outburst floods in the Bhutanese Himalayas in 1994 and 2015 demonstrates the social importance of the temporality of water, understood as the variability in its flow and its capacity to disturb human activity. The ways in which social institutions and cultural meanings change and influence the perception, understanding and modes of interaction with water are examined here, to indicate how the relations between people and a river are neither stables nor in flux, but rather in ongoing reconfiguration. The importance of these social institutions and cultural meanings are demonstrated by a comparison of two types of buildings which are vulnerable to the floods: the traditional temple-fortresses and the new hydroelectric power plants.

Keywords: Bhutan, floods, Buddhism, disasters, temporality, water

Résumé : L'analyse de crues glacières soudaines dans l'Himalaya du Bhutan en 1994 et en 2015 démontre l'importance sociale de la temporalité de l'eau, à savoir la variabilité de son débit et sa capacité à perturber l'activité humaine. Les manières dont les institutions sociales et les significations culturelles changent et influencent la perception, la compréhension et les modes d'interaction avec l'eau sont ici examinées, pour mettre en évidence comment les relations des gens à la rivière ne sont ni stables, ni en flux, mais plutôt continuellement reconfigurées. L'importance de ces institutions sociales et significations culturelles changeantes est démontrée par une comparaison entre deux types de bâtiments vulnérables aux inondations: les temples-forteresses centenaires et les nouvelles installations hydroélectriques.

Mots-clés : Bhutan, inondations, bouddhisme, catastrophes, temporalité, eau

On 6 October 1994, a vast quantity of water burst out of a lake high in the Himalayas of Bhutan and came rushing down a river canyon. As it reached a lower section of the valley, a zone of dense human settlement, it destroyed houses, bridges, and fields and killed livestock and several people. A similar event occurred on 28 June 2015. This second release of lake water travelled down the same valley, and it too was very destructive, though it did not take any human lives. These two floods offer an opportunity to consider the relations of natural and social worlds. What approaches can be taken to characterise and analyse the engagements that join together a society and a river – in this case, Bhutan and the Po Chhu River?

The interval between the first flood and the second, just over two decades in length, permits an examination of temporal aspects of these mutual engagements. It is long enough for the society to have reacted fully to the first flood and developed several responses to it and short enough that the first flood remained fresh in many people's minds when the second one came. Moreover, this interval corresponds to an important period in the history of Bhutan, when the country opened to the global economy, introduced new political institutions, and underwent profound changes in media and communications. The similarity of the two events creates an opportunity to assess the continuities and changes in the river, in the society, and in the relations between the two.

More broadly, these events permit a discussion of the temporality of the relations of nature and society. Rivers are particularly well-suited to these discussions (see the article by Naveeda Khan in this issue). This aptness does not stem merely from their association with flow nor from their well-known mutability, which is summarised in the familiar phrase from ancient Greek philosophy that notes that one cannot step into the same river twice. As is discussed more fully below, there are two different genres – history and biography – that

have been used in recent times to examine the temporality of rivers. The Himalayan floods allow an examination of these genres, much as the genres permit a consideration of the floods.

The Temporality of Rivers

To use the two floods to examine relations of society and nature is to develop an account of a river over a period and, hence, to locate this account in relation to other accounts of rivers over time. Reviewing such accounts in anthropology, as well as in history and other allied fields, suggests that they have come largely in two types: an earlier set of river histories, some dating back more than half a century, and a more recent set of river biographies from the last decade and a half. These two types are both concerned with temporality since they tend to have firm boundaries in time and since they trace the forward movement of the actors that they describe. The shift from the first to the second was marked both by changes within anthropology and within social science at large and by changes in environmental policy and environmental movements in many countries. As will be discussed later in this article, the specificities of the Bhutanese case present some challenges to these two types of accounts; an even bigger challenge comes from the arrival of what many call the Anthropocene, since the impacts of climate change on water resources call into question the relative boundedness of watersheds, a key assumption within river histories and river biographies. Indeed, this case documents the view that the Anthropocene – the era when human activity is visible on planetary scales – is not a simple, well-defined temporal period but, rather, a category that is the subject of debate within the natural and social sciences, the humanities, and within societies around the world (Pálsson et al. 2013).

The histories treat rivers as settings on which human action unfolds, and they consider rivers as the passive objects of human endeavours.[1] They focus primarily on watersheds as the spaces in which humans influence rivers. Karl Wittfogel's (1957) *Oriental Despotism* describes several societies located in river basins. These societies rested on irrigation-based agriculture and, hence, relied on withdrawals of water from rivers. Wittfogel traces the processes by which the management of forced labour to build and maintain systems of canals led to political centralisation and domination by small elites, creating unequal political orders – the despotism in his title. In his view, the river is acted upon; it remains passive and is wholly under the control of human technologies.

Other histories offer more nuanced accounts of individual rivers but still see rivers as passive physical entities. *Yangtze: Nature, History, and the River* covers more than two millennia of canal construction and commerce (Van Slyke 1988). In this book, the river is the stage on which officials, merchants and captains, and crew of boats carry out their activities. It accommodates their efforts to use it to carry boats, to irrigate fields, and to depict it in stories, songs, and paintings. In the past century, it provided a platform for massive engineering works under Mao. Lyman van Slyke suggests that the uses that China has made of one of its most important rivers illustrate the great continuity of Chinese civilisation and indicate the possibility – which is still not fully realised at the time of the book's publication – of future transformations, which are more profound than any in the country's history.

The *Organic Machine: The Remaking of the Columbia River* traces a series of successive transformations of this river from before European settlement to the present (White 1995). Focusing on energy and technologies, Richard White discusses the steamboats, locks, fisheries, hatcheries, dams, and hydropower facilities that have succeeded in transforming the river. This book is justly celebrated for its refusal to separate nature and culture and for its insistence on examining the river as a kind of hybrid. But, though the river has become an "organic machine," as the title states, it is still an object rather than a subject, a being that has experienced a "remaking," as the title also states, but that does not, in turn, remake the society around it. Some specific people – fishers, riverboat captains – come to know the river intimately, but this knowledge has contributed to their success in controlling it.

It was at the opening of the present century that the first genuine biography was published, in the form of a book that treats the river as an individual entity whose life story can be written rather than as the object of a history (whether or not its title happens to include the word "biography"). Like the river histories, this work examines a river within the natural and social context of its watershed. *The Rhine: An Eco-Biography 1815–2000* is an academic work (Cioc 2002). It traces the unfolding patterns in the life of the river – in its course from the Alps through the lowlands to the sea – in the context of national and international economic and political trends. The growth of trade led to engineering works to straighten the river and eliminate rapids, while land clearing and pollution associated with the growth of industry and industrial towns reduced the forests of the region, contaminated the waters, and eliminated many species from the riverine ecosystems. At the same time,

the river is a powerful symbol of wild nature, celebrated in paintings and poems and visited by tourists drawn to its dramatic cliffs, its old castles, and the few remaining fishers who evoke an earlier time of legend. This symbol supports the growth of an environmental movement concerned with restoring the cleanliness of the river's water, the forests along it, and the wildlife that inhabit it. The river has responded to this environmental movement, making the most recent phase of its life one of renewal.

In the introduction to this book, the prominent environmental historian William Cronon, who is the editor of the series (Weyerhauser Environmental Books) in which the book was published, lays out the ways that it marks a break with earlier writing about rivers. Cronon indicates that Mark Cioc (2002) shows the complexity of human impulses toward rivers and toward nature. He traces the competing "visions of the Rhine's usefulness and beauty," a tension that animates later river biographies as well. He notes "these visions are among the most important engines of change in Cioc's story" (xi).

Cronon argues that the book describes interactions between a river and human society. He examines these interactions within the space of the watershed, as the river histories do, but these interactions are different since the river itself is dynamic. Its water and sediments escape efforts at human control. It is this dynamism that makes the river an apt subject for a biography, one of the "nonhuman creatures and systems that … play crucial roles in changing the course of human events" (Cioc 2002, x). Rather than merely being acted on, the river is fully an actor in this history since "the river's nature [is] not easily subordinated to human will" (xi).

A mere four years after the publication of Cioc's book, the notion of river biographies was accepted enough in academic circles that Terje Tvedt and Eva Jakobsson (2006) could use the phrase as the title of one of the sections in their three-volume connection, *A History of Water*. And, around that year, other books began to appear that shared the elements of river biographies noted by Cronon. This rapid spread of the idea may have drawn on earlier works that anticipated it, particularly John McPhee's (1987) long article on the Mississippi, which traces the centuries-long conflict between the people who sought to straighten the Mississippi, direct its course, and end its floods and the powerful river itself, its waters, and the sediments creating problems that challenge every engineering work. (McPhee has also written biographies of humans and, hence, may have been disposed to adopting this genre to natural entities.) Other books have written of the death of rivers, a framing that may have suggested the possibility of writing biographies of rivers as well (Fradkin 1984; Harden 1996; Hill 1997; see Tvedt and Jakobssen 2006, xix). This success of river biographies also stems from the resonance between the notion of rivers as living entities and other ideas within the environmental movements that writers engage with, particularly the restoration of watersheds and, more broadly, a deeper, more experiential, and more appreciative engagement with the natural world.

Moreover, natural scientists had begun to question the possibility of human domination of rivers that was dominant in the decades of extensive dam building after the Second World War. These concerns began in the 1970s and 1980s and culminated in the final decade of the century (Orlove, Roncoli, and Dowd-Uribe 2015). The geomorphologist Luna Leopold (1977, 429–30), addressing a major conference on the California drought of the mid-1970s, noted that "the river is like an organism; it is internally self-adjusting." As a result of this dynamic quality of rivers, he called for society to have "a modicum of reverence for rivers," even though he believes that "man's engineering capabilities are nearly limitless." He expanded these views in later works; his textbook on river geomorphology ends with the statement "the river is the carpenter of his own edifice" (Leopold 1994, 281). The 1990s marked the end of the period of dam building, and the emergence of integrated water resource management as a more environmentally sensitive period in hydrology.[2]

Other writers, including anthropologists, include these elements in their writings on rivers, placing them in this set of river biographies, even if they do not use the precise phrase. Covering periods of decades or centuries, they emphasise the interactions between the river and human society and show that human action is governed by multiple relations with the river, some of economic use, others of aesthetic appreciation or even worship – in Cronon's terms: "visions of usefulness and beauty." In all of these books, the rivers challenge human efforts to control them – the idea adumbrated in McPhee's 1987 article (Linton 2014). The writers generally accept the attribution of agency to rivers (and, more broadly, to nature), and they recognise as well that rivers resist efforts to control them.

These characteristics of river biographies are present in the *River of Love in an Age of Pollution: The Yamuna River of Northern India* (Haberman 2006). The book offers a narrative that broadly parallels Cioc's. Large numbers of pilgrims travel to the river that is a sacred being to them – a goddess of love – to perform individual and collective offerings, as they have done for centuries. Under colonialism and after independence,

the construction of dams and the presence of dense urban populations diminish and pollute the flow of the river. However, its symbolic and ritual importance to large communities of worshippers provides a basis for environmental movements that promote the restoration of the river. By contrast, the Colorado River in the southwestern United States is the subject of *Dead Pool: Lake Powell, Global Warming and the Future of Water in the West* (Powell 2008). The "dead pool" of the title refers to reservoirs that have been drawn down so low that the surface of the water has fallen below the lowest outlet. The bleakest of the books, it traces the construction of dams on the river and the unrealistic commitment to transfer water to irrigated farms and urban centres, some of them outside the basin. Powerful economic interests have marginalised the calls for preservation of the river, based at times on its scenic beauty and its potential for wilderness recreation and at other times on the river's capacity to provide "inspiration" (110, 151). The book closes with the recognition that significant water conservation programs are unlikely in a region built on an optimism that has characterised the expansion of infrastructure. The competing economic interests, all pushing for greater withdrawals of water from the river, impede the claims of environmentalists.

The more recent books fall between Haberman's hopeful outlook and Powell's despair. *Cultivating the Nile: The Everyday Politics of Water in Egypt* examines a country where agriculture depends not directly on the floodwaters of the Nile but instead on the more steady flow of irrigation water from barrages and dams, both smaller ones dating back to the nineteenth and early twentieth centuries and the newer, larger, and more important Aswan High Dam of 1971 (Barnes 2014). As technologies change, tensions continue between government agencies and peasant farmers, centring not only over emerging material challenges – the poor soils of newly irrigated areas and the need for drainage to remove excess water – but also over the status of the water from the river itself: whether it is a government-controlled resource to be managed or a gift from God. *Navigating Austerity: Currents of Debt along a South Asian River* traces the Hooghly River, one of the branches that drains the Ganges into the Bay of Bengal (Bear 2015). It is located in a region where trade and shipping expanded under the British and after independence and which has faced economic change in a more recent era of global debt and austerity. Shifting patterns of investment and labour have led to the rise of temporary employment in shipping and manufacturing as permanent positions and to the repurposing of facilities (barges that once served to transport goods become pleasure cruisers and warehouses are replaced by housing developments). But earlier forms of knowledge survive since river pilots and dockworkers are more familiar with the shifting channels of the river than new entrepreneurs. Their respect for the river – and their engagement with rituals – are reworked in an era of debt governance, as they had been reworked in earlier eras, keeping alive the tensions between a framework of economic calculation and a web of caring relations between humans and the river. Like Haberman, Bear offers a more institutionalised and religion-centred alternative to the second element in Cronon's polarity of usefulness and beauty – an alternative that reflects contemporary South Asian societies and the attention to ontology in environmental anthropology of the early twenty-first century as well.

These four books share the elements that Cronon discusses in Cioc's biography of the Rhine (treating rivers as active rather than passive; recognising that rivers cannot be fully controlled; stressing the mutual interactions that connect human societies and rivers; and tracing the tensions between economic and aesthetic/religious values) and an additional element that Cronon does not single out for mention: a clear narrative arc of a succession of periods. Cioc's book divides the biography of the Rhine into a pre-capitalist phase, a capitalist phase, and an environmentalist phase in which profit is challenged and ecosystems are restored. This division is paralleled closely by Haberman's periodisation. It is present in Powell's discussion of advancing environmental crisis as well, though he is less certain that an environmentalist phase will arrive. Barnes and Bear each subdivide the capitalist phase into sub-phases – Barnes along the lines of technology and bureaucratic form and Bear by periods of international finance and economic governance.

These river biographies offer some guidance for an examination of the Po Chhu River in Bhutan and its two destructive floods, separated by a period (two decades) comparable to the temporal scales of the studies by Barnes and Bear. As these river biographies suggest, the interactions between a society and a river are mutual rather than unidirectional – the river is not merely acted on by human societies but, rather, is an agent itself. To anticipate the argument developed later, there are also other ways in which the river biographies do not serve. Humans have transformed the river less extensively than in the other cases, in part because Bhutan has a strong commitment to maintaining the extensive forest cover in the country.[3] It is also difficult to divide the river's life into a set of periods or even to know whether to assign the second flood to the same

period as the first or to a new period. And it is much harder to see economic visions as conflicting with aesthetic/religious visions. In addition, climate change – a force arising outside the society – has strongly influenced the relations of the Bhutanese and the Po Chhu River. In contrast, the other river biographies have emphasised watersheds as relatively autonomous spaces in which rivers and society interact, with the partial exception of Bear, who discusses the influence of different phases of global capitalism on the ties between West Bengal and the Hooghly River. It may well be that the impact of climate change on rivers, barely discussed in the other works mentioned here, will lead to a new phase of writing about rivers, much as a series of elements (changing intellectual traditions, the questioning of dam construction, new environmental movements) has brought a shift from river histories to river biographies.

The first of these characteristics – a low level of transformation of the river – reflects the distinctiveness of Bhutan's rivers, which descend much more steeply through much more rugged, and more heavily forested, terrain than the rivers in other countries. The rivers originate in the high mountains along the northern border of Bhutan with Tibet, where peaks reach over 7,000 metres in height and descend sharply to the lowlands along the Brahmaputra River at elevations of a few hundred metres. They form north-south valleys, separated by high ridges, which are very deep and also very short; they cover this great difference in elevation in less than 150 kilometres.

The second of these characteristics – the difficulty of dividing the river's life into periods – shows the distinctiveness of Bhutan and particularly the double face of temporality within the country. The Bhutanese understand their society as one that is simultaneously unchanging, holding firmly to long-established religious and political forms, and rapidly-changing, committed to new technologies and institutions. Many nations (including those discussed in the other river biographies – Germany, France, the Netherlands, the United States, Egypt, and India) engage with this tension between continuity and change, but the pace of alteration is truly remarkable in Bhutan, a country whose isolation has been extreme. It was never conquered by a colonial power but remained an absolutist Buddhist monarchy through the middle of the last century. It was pushed toward an engagement with the wider world by the Chinese occupation of Tibet in 1951 and the Indian occupation of Sikkim, a small Himalayan kingdom to the west of Bhutan, in 1975. Bhutan had no motor roads until 1961 and no airports until 1983, but in recent decades its connections to the rest of the world have increased rapidly (Bhutan National Commission for UNESCO 2012a). This double temporality is linked to a double understanding of the land of Bhutan, one that is simultaneously a coherent system of natural elements – mountains, glaciers, rivers, forests, animals, and plants – which are imbued with meaning and often with spirits, and a tiny element in a globalised planet, whose only two immediate neighbours, India and China, offer great opportunities and great dangers.

As the following discussion suggests, the floods raise issues not only of the continuity of the river but also of the continuity in society of the political, cultural, and moral orders of Bhutan. The residents of the towns and villages along the river and throughout the country not only had to cope with the destructiveness of the rising waters but also had to evaluate their relations to each other and to the landscape and history of their country. Thinking about a major river – with its changing flows, its ability to meet basic needs and to create damage, and its relations to the built environment – can be a way of thinking about society as well.[4]

The discussion of the floods draws on a variety of sources. Fieldwork was conducted during four visits to Bhutan, each roughly a month in length, between 2011 and 2015, including one visit after the second flood. In addition, regular contact with Bhutanese in New York and Washington, DC, during this period allowed conversations in several settings, including the United Nations, the Bhutan Foundation, the World Policy Institute, and the American Museum of Natural History, as well as several meetings with Bhutanese delegates and negotiators at the 21st Conference of the Parties to the United Nations (UN) Framework Convention on Climate Change (UNFCCC) in Paris in December 2015.[5] This fieldwork was supplemented with Skype and email interviews and with research on print and online materials.

The First Flood

On the night of 6 October 1994, Luggye Tsho, a lake high in the Himalayas of Bhutan, burst its banks. This event was a glacier lake outburst flood (GLOF), which was the result of a collapse of a terminal moraine – a wall of rock and rubble pushed downslope by a glacier, which served to contain meltwater in a lake (Orlove 2009). The waters of Luggye Tsho coursed down the valley of the Po Chhu River, carrying tree trunks, rocks, sand, and mud with them, along with the materials of four bridges that lay in their path. One resident in a village along the valley tried to use a radio-telephone to reach the towns downstream, but the potential recipients of his message were not at their stations. As a result, no warning was received.

The flood was fairly slow moving. As it drew near the town of Punakha the next morning, the residents heard a deep ominous roaring – an eerie sound that they can still imitate. Many of them, fearing danger, rushed to higher ground. In some cases, it took great effort to assist elderly relatives in this evacuation. The floodwaters reached well above the river's banks and took days to recede. A team from the government travelled through the area from 10 October through 8 November. They found that the flood killed 21 people. Many fields and pastures, more than 730 hectares in area, were destroyed, either by erosion or by being covered with sediment (Watanbe and Rothacher 1996).

Residents recall the large ponds of stagnant muddy water and how boys would go down to these ponds to catch fish, which their families would eat. One man, speaking of his participation in this activity, spoke of how much fun this was for him and the other boys, who had free time on their hands because schools were closed for weeks after the disaster. He also mentioned the moral ambiguity that was involved since local Buddhist traditions consider fishing to be a serious sin (*digpa*), worse than other kinds of killing because fish are more innocent and harmless than other creatures. Moreover, there was concern that human immorality had contributed to the disaster. This conversation led him in a direction that reduced the negative nature of his former acts (or, perhaps, of his speaking about them in a joking tone): the fish were half-dead, trapped in this water so different from their usual environment. With their eyes and gills clogged with sediment, they rose close to the surface as if seeking to leave the water. This story brings the fish closer to the category of *shisha*, "dead meat," or the flesh of animals that die accidentally or are killed by animal predators – eating this meat is not a sin because no human act of killing was involved.

However, the aspect of the 1994 flood that created the deepest concern and that has been remembered most strongly was not the fishing or the school closures or even the need to assist relatives. According to Norbu Wangdi and Loen Kusters (2012, 5), who surveyed 273 households in the Punakha region in 2012, the consequence of the flood that was most frequently mentioned first was the severe damage to a particular structure, the *dzong* that was built along the Po Chhu in Punakha at its confluence with another river, the Mo Chhu. The 1994 flood severely damaged the dzong. Photographs taken just after the event show major walls that were undercut or eroded, particularly along the eastern side. Large portions of one building that formed part of the complex, the *dzongchung*, were entirely washed away, though the most important image of Buddha was saved.

Even a brief introduction to the dzongs requires a few paragraphs, rather than just a sentence or two, since these structures exemplify and shape the engagements of a society and a landscape divided into watersheds, and both embody and represent the temporality of these engagements. They are the most dramatic buildings of traditional Bhutanese architecture, widely recognised within the country and outside for the size, strategic location, striking form, elaborate decoration, and religious and political significance. They are massive fortresses, each with high defensive walls. Within these walls are courtyards surrounded by one or two floors of rooms that open onto galleries and a tall watchtower. These rooms have served as residences or offices of officials. Bhutan has nominated five of them for consideration as world heritage sites under the UN Educational, Scientific, and Cultural Organization (UNESCO), stating that the dzongs "illustrate the peak of collective architectural achievements of the people of Bhutan" (Bhutan National Commission for UNESCO 2012a).

The dzongs are all located in river valleys at the intermediate elevations of densest population; they are often close to a confluence of two rivers since they are set on sites on which dangerous spirits reside, in local understanding (Dujardin 2000), and the temples associated with dzongs can restrain these spirits from causing harm. Moreover, they are set on strategic locations for defence. Some are on hillsides near rivers, and others, like the one in Punakha, are close to the banks of a river; they all require access to water, which is important for provisioning the resident monks and other personnel and a necessity in the case of sieges.

Although a few dzongs are recent, most date back to the last three or four centuries when regional lords and their followers battled each other and when armies from Tibet or India would invade Bhutan. In those earlier times, the large number of rooms in the dzongs served as offices and courts of officials, residences, and storage facilities, allowing local populations to withstand long sieges. They also contain temples and monasteries, often with important religious images and relics. The national language of Bhutan is known as Dzongkha, combining the word dzong with the word *kha* (language). The national language is thus the language of the dzongs because it served as a lingua franca to allow communication between the different regions of the country, each with its own set for a lord and his followers.

Despite their great age, the dzongs are all actively used at present, housing provincial government offices

and monasteries. Since the dzongs are sites of secular and religious power, and because of their position as historical monuments, there is strict enforcement of the rules that require the use of traditional dress (a short robe [*gho*] for men, a long skirt [*kira*] and a short jacket [*toego*] for women) for public occasions. However, the dzongs are not museums, and it is common to see computers and cell phones in use. The dzongs are also the sites where festivals called *tsechus* are held, each on a specific date in the traditional Bhutanese lunar calendar.[6]

The Punakha dzong is a particularly important one as a result of its size and imposing features and its deep associations with Buddhism and royal dynasties, dating back to the eighth century.[7] It has retained its importance to the present. It was the site in 1907 of the coronation of Ugyen Wangchuck, the founder of the royal dynasty and the great-great-grandfather of the present king, Jigme Khesar Namgyel Wangchuck. The dzong is the seat of the Punakha dzongkhag or the provincial government and was the seat of the national government of Bhutan until the capital was moved to Thimphu in 1955. The wedding of the present king was held there in 2011.

Though dzongs are vulnerable to fire and to earthquakes because of their wooden walls and beams, the floods are particularly feared. Rivers are understood to be the home of snake-like spirits (*klu*) and mermaids (*tsomem*), who are ordinarily calm but who can become angered, particularly if they feel that they have been neglected by the failure to make appropriate offerings in the form of butter lamps, round stones, and money or if they have been offended by acts that pollute important stretches of the rivers. Bridges, too, are dangerous places, often decorated with prayer flags to balance the risk that is associated with them.[8]

The restoration of the Punakha dzong after the flood damage was conducted over a period of ten years, with donations of USD $10 million from India supplementing the expenses of the Bhutanese government. Large numbers of traditional artisans were employed to build the temples, chortens, murals, and images. The extensive ceremonies that marked the inauguration of the restored dzong took place on the auspicious twelfth, thirteenth, and fourteenth days of the third month of the Bhutanese calendar and included circumambulation led by the king and the Je Khenpo (chief abbot of the country's central monastic body), the only two people in Bhutan who wear a scarf that is saffron-coloured rather than the colours that indicate lesser ranks (Himalayas 2010).

Between the Floods

To understand the context of the second GLOF in 2015, it is useful to look beyond the reconstruction of the dzong and review the changing importance of water and floods in the Po Chhu Valley and in Bhutan as a whole in the years after 1994. In this way, the Po Chhu resembles the rivers discussed in the river histories and biographies since it has presented both hazards and economic opportunities. As the following discussion will suggest, the results of efforts to eliminate dangers and to exploit resources are both somewhat inconclusive and shifting, closer to the arguments of the river biographers than the river historians.

These changing patterns of activity, in turn, reflect the profound transformation in the country in the last two decades. Transportation and communications link different parts of the country with each other and with the rest of the world. Road networks have expanded (the number of cars in the country has increased more than 11 fold, from just over 6,000 in 1994 to nearly 68,000 in 2013), and tourism has grown, from 5,000 arrivals in 1995 to 116,000 in 2015 (World Bank 2015). A royal decree in 1999 permitted the introduction of television and the Internet, which had been prohibited until that point. The growth in telephone usage is also striking.[9] Political changes are also significant. The movement toward democracy advanced with the promulgation of a constitution in 2008, which allowed multiparty elections and which considerably strengthened the powers of the executive, legislative, and judicial branches of the government. Although the authority and influence of the king and the royal government remain considerable, electoral politics now play a major role. There was a peaceful transition from one political party to another in the 2013 elections.

Two major sets of activity in Bhutan after 1994 influenced the outcome of the 2015 GLOF: a group of projects on glacier research and flood mitigation and an active program of construction in the river valleys. The first began right after 1994, when the government, deeply troubled by the flood, recognised that the research on the country's glaciers was limited and expanded it through international partnerships.[10] This research directed attention to one lake, Thorthormi Tsho, which is close to Luggye Tsho, the lake that was the source of the 1994 GLOF. By 2001, a review by researchers from the International Centre for Integrated Mountain Development (ICIMOD), a major mountain research institute in Nepal, showed that this lake had been growing rapidly and, moreover, that the moraine that held

the lake back was shrinking since a mass of ice within it had melted and shrunk (Mool, Bajracharya, and Joshi 2001). If it collapsed, it would release its water into a third lake, Raphstreng Tsho. The combined water of these two lakes had the potential to release as much as three times as much water down the Po Chhu Valley as had come down in the 1994 GLOF.

This knowledge influenced Bhutan's engagement with the UN agencies as part of the UNFCCC. Since Bhutan's income level is low, it qualifies as a least developed country, and so it was able to participate in the national action plan for adaptation (NAPA) process, seeking funding under the Least Developed Country Fund, administered by the Global Environmental Facility. Bhutan obtained funding in 2003 to support the preparation of its NAPA. After more than two years of planning and negotiation, it submitted its NAPA in 2006. The first three activities all focused on Thorthormi Tsho: the artificial lowering of the water level in the lake, increasing the capacity for disaster risk management in the valleys downstream of the lake, and installing an early warning system for GLOFs at a cost of about USD $7 million (United Nations Framework Convention on Climate Change 2011). The LCDF supported roughly half of this cost, the other half coming from the World Wildlife Fund and Austrian bilateral aid.

To lower the lake, the government began a large public works program, sending workers to the remote high-elevation site, where working conditions were difficult.[11] By the end of the project, Thorthormi Tsho had been lowered by five metres, still leaving a dangerous amount of water behind the moraine. Moreover, it addressed the risk at only one lake. Lakes were forming at the fronts of other glaciers in the country as they retreated, and these, too, were presenting threats (Leslie 2013; World Wildlife Fund Global 2009). Nonetheless, the lake-lowering project received a great deal of attention, both within Bhutan and internationally, in part as the result of an award-winning film about it.[12]

Although this project achieved some success, no other lake-lowering projects are currently scheduled, in part from the recognition of the large cost of the project and of the large number of lakes that present risks. There is interest in other technologies for monitoring glacier lakes and assessing GLOF risk. The use of drones has attracted some attention, especially since they are being used in Nepal for this purpose (Kuensel Online 2015). However, the Department of Civil Aviation and the Army currently prohibit these technologies.

The NAPA project also included an early warning system, which cost less than half as much as the lake-lowering project. It included automatic gauges, powered by solar panels, at several glacier lakes that would send alerts via satellite phones and mobile phones if there were a sudden drop in lake level, indicating a flood event. The government set up a system of phone trees, in which participants agreed to make calls before they began evacuating themselves and their families. The gauges were also networked with sirens in high-risk villages downstream. Employees of the Department of Energy also monitored the lakes at certain periods but had difficulty in maintaining equipment in this remote and difficult setting.

If the first set of activities, connected with the NAPA, aimed to assess and reduce GLOF risk, the second set had the opposite effect of increasing the potential damage. The period between 1994 and 2015 was a time of planning and executing hydropower projects in Bhutan, and these required the installation of infrastructure along rivers with a significant flow. Several of these rivers have glaciers at their headwaters that are vulnerable to GLOFs. Bhutan's hydropower capacity in 1994 was 350 megawatts, which has grown to 1,500 megawatts by 2014, as several new projects were constructed. Four facilities that will bring another 2,000 megawatts of capacity are currently in development (Harris 2014). This would still be a fraction of the country's total estimated potential of 26,000 megawatts (Ogino and Acharya 2014).

These hydropower facilities have played an important role in Bhutan in recent decades. Hydropower represents virtually all of Bhutan's electricity production, and it is a key to the economy, both for its contributions to domestic energy use and to the income from energy exports. It accounts for 12 percent of the country's gross domestic product, 43 percent of exports, and 40 percent of government revenues. These contributions are expected to grow in the coming decades. Moreover, hydropower is consistent with Bhutan's commitment to its well-known gross national happiness framework, through its carbon neutrality and its ability to bring light and power throughout the country (Lean and Smyth 2014)

At the time of the 1994 GLOF, only the Chhukha Hydropower Project was operating. The construction of the project, funded entirely by the Indian government through grants and loans, began in the 1970s, but the project did not start producing electricity until 1986. It bears many resemblances to the three other major hydropower facilities in Bhutan that are currently in operation as well as others that are in development. The location is in a narrow valley at a relatively low elevation, below the major areas of settlement. In these steep narrow valleys, reservoirs are small, and the

facilities are known as "run-of-river" since the water supply comes directly from the river flow or from a small head pond rather than from the storage of a large reservoir. The construction, which was managed by an Indian firm, involved large teams of labourers from India under the supervision of Indian engineers, with relatively little participation from Bhutanese firms and workers. The concrete dam and other associated structures, such as the tunnels, turbines, and the switchgear, are on a scale that far exceeds other construction in the country. In the case of Chhukha, the dam is 43 metres high and 105 metres wide, and more recent facilities are even larger. Some of the electricity is distributed in Bhutan, where the percentage of households supplied with power has increased, but most of it is exported to India, where unsatisfied power demand is very large. In this way, the dam contributes to the development of the country in two ways – in economic terms, by providing exports and foreign revenue, and in cultural terms, by bringing some of the key signs of *yargey* (development), particularly lighting in the evening, television, and mobile telephone-recharging capabilities. These patterns have continued, though the projects are growing larger and the financing is changing, as loans replace grants and private capital grows in importance.

In many ways, the hydropower facilities could be considered to be structures that are as emblematic of the most recent decades of Bhutan's history as the dzongs are of Bhutan's earlier history through the mid-twentieth century when it was an isolated kingdom. To be sure, these associations are not absolute. Much as the dzongs incorporate modern Bhutanese life, with new government institutions, mobile phones, and computers, the hydro facilities similarly are sites of national culture. Buddhist rituals often take place in them.[13] Nonetheless, the contrast between them are striking indeed. Physically, the hydro facilities seem to be the opposite of the dzongs: they use imported, rather than local, materials, and they are built by foreign labourers following industrial techniques rather than local artisans who draw on long-established crafts. They are utterly different visually – the dzongs with curves, ornamentation, and bright colours and the hydro facilities with straight lines and undecorated surfaces of grey concrete or metal. Much as visitors to dzongs must wear national dress, the workers and professionals who come to the hydro facilities wear Western clothes, although some official visitors wear national dress.

Their locations also differ. The dzongs were built at the middle elevations, in areas of dense agricultural populations, often along major routes that connected different valleys. The temples, monasteries, courts, and offices ensured that many people would not merely live near them but would also enter them, especially during festivals. By contrast, the dams and powerhouses are built at lower elevations, where the river gorges are narrower and steeper, to facilitate power generation. These areas are drier and have fewer residents. Rather than being along transportation routes, these facilities are remote and difficult to visit.

Despite these differences, these two types of structures (both large and imposing, though different in many physical elements) share a narrative element as well since they suggest temporality. In their monumental scale, careful construction, and heavy materials, they point to permanence, linking the moments of their construction with long periods after them. Both refer to foundational moments that link Bhutan to areas outside (the arrival of Buddhist figures from Tibet for the dzongs, the decisions of kings and governments to bring hydropower from India). Both promise a period of prosperity and order – and of unity as well – since the dzongs construct Bhutan as a unified web of religious and political sites that people visit as pilgrims and festival attenders, while the hydro facilities construct Bhutan as a unified grid through which electricity flows from generators to towns and villages. It could be said that both are associated with light, a temporal marking of day coming after night – the dzongs with the subduing of demons who are active at night and in dark places like forests and caves, the hydropower facilities with the expansion of electric bulbs, televisions, and mobile phone screens across the country. Venturing even further, one might note a resemblance between them as nodes in networks.

Above all, both the dzongs and the hydro facilities are linked to rivers. Both must be near them to obtain the water that is essential to their operation, though for different reasons (for strategic access to drinking water and to valley lands for dzongs and at times for ritual reasons; for energy generation for hydro facilities). And both are vulnerable to floods, as the 2015 GLOF demonstrated so clearly.

The Second Flood

On 7:05 am on 28 June 2015, an earthquake of 5.5 on the modified Richter scale occurred in Assam State, India. The epicentre was 22 kilometres south of the town of Gelephu in southern Bhutan. Light to moderate shaking was reported from Bhutan, Nepal and Bangladesh, as well as India. It led to a flurry of comments on Facebook. Sonam Choden in Thimphu in western Bhutan reported on Facebook: "The earthquake rocked my husband right back on to sleeping." Sangay Wangchuk,

who lives in Jakar in central Bhutan, wrote: "Ap Naka wags its tail again." Ap Naka means "father earthquake," referring to the widely held belief that the earth is held by a giant male spirit whose movements cause earthquakes.

A glacial lake, Lemthang Tsho, located about 95 kilometres northwest of the epicentre, burst later that day, and its waters flooded down the valley of a tributary of the Mo Chhu River. This lake, also known as Shinchila Tsho, is located in Laya County in Gasa District in northern Bhutan, close to the border with China. The first people to observe the flood were collectors of wild mushrooms.[14] Several collectors used their mobile phones to send warnings of the event to Kinley Dorji, an official in Laya, the nearest county seat (Peldem and Gyelmo 2015a). He in turn called officials in Gasa, the nearest province seat, and in Punakha and Wangdue, two large provinces further downstream on the Mo Chhu. He also spoke with police, hospitals, and officials at a large hydroelectric station at Punatsangchu in a lower portion of the valley.

The provincial officials informed their superiors in the capital city of Thimphu and called the staff at the three gauges along the Mo Chhu, directing them to monitor the river levels closely (Bhutan Broadcasting Service 2015a). The staff began sounding the sirens around 6:30 pm, even though the river was about a metre below the threshold for such alarms. The staff later stated that they were concerned that the monsoon rains, which had been heavy during the preceding weeks, presented an additional risk of sudden rises. They may also have been concerned that the sun would set around 7:00 pm, and they wanted to take action before dark.

The sirens created a sense of panic among the residents of Punakha. Although the warning sound is officially intended only to serve as a signal to local residents to be on the alert for evacuation orders, many people rushed to higher ground right away. Their concern was increased by the long period that the sirens kept blaring. The staff had only received instructions for turning the sirens on but not for turning them off, and it was only after more than an hour that they finally silenced them.

From his office in the capital of Thimphu, the prime minster ordered evacuations along the Mo Chhu and Po Chhu Rivers and at the hydropower station at 9:30 pm. These were communicated by radio, phone, and over the prime minister's Twitter account. Reports suggest that these were largely complete within an hour (Peldem and Gyelmo 2015a). Patients at a hospital in Bayo, a new town for workers at the large hydroelectric station at Punatsangchu, were moved to a military hospital at higher ground. The river peaked late that evening, with high waters at Punakha a bit before midnight and at Wangdue later on. Fortunately, the towns were not damaged. The Punakha dzong, which had been badly impacted in 1994, also came through safely. The residents returned to their homes the next morning. Power, which had been cut in Punakha and other towns, was also restored.

Teams travelled through the area on 29–30 June to examine the damage. They reported that six wooden bridges had been washed out, isolating some villages and Laya town and impeding the assessment efforts (Bhutan Broadcasting Service 2015b). Several groups of mushroom collectors were stranded on the far side of the now empty Lemthang Tsho Lake (Peldem and Gyelmo 2015b). The king ordered the army to rebuild the bridges. The first soldiers began work on 30 June, and the bridges were restored within two weeks (Gyelmo 2015a).

In mid-July, Karma Dupchu, the chief of the Hydrology Division within the Department of Hydrometeorology, sent a delegation of geologists, disaster managers, and local officials, accompanied by personnel from ICIMOD, to the glacier lakes high in the Mo Chhu drainage area, to see which of them had burst and to assess the relative importance of the earthquake and the heavy rains in causing the flood (Peldem and Gyelmo 2015b). They suggested that the earthquake had not been the trigger of the GLOF but, rather, the simple failure of the moraine dam.

A larger team, representing several different ministries, travelled to the area in September to assess the risk of future GLOFs (Gyelmo 2015b).[15] They noted the possibility of floods that would entirely destroy the country's two largest hydropower facilities, located at Punatshangchu, and mentioned that the floods could extend beyond the international border into India. They suggested that the early warning systems would be insufficient to protect the hydro facilities and that the search for solutions would require additional effort in the future; one initial suggestion that they made was to propose relocating some high elevation villages close to the lakes since the possibility of harm was particularly severe there.

Two Days in the Life of a River

In many ways, the two flood events were very different from each other. The contrast begins with their arrivals in the towns along the river: the first flood announced itself with a deep roaring sound, and the second was proclaimed in advance by sirens. The first destroyed

forests, farms, meadows, and elements of traditional architecture – bridges, farmhouses, and a dzong; the second not only destroyed some of these as well but also threatened a new kind of infrastructure, a hydroelectric facility. Government responses began several days after the first flood and several hours before the second flood in the form of warnings and evacuation orders. The first led the government on a variety of projects to mitigate the hazards, including geo-scientific research, a lake-draining program, and the construction of an early warning system; the second is leading to a variety of programs, including an intensive reconnaissance program in the high glacier region that includes social scientists as well as natural scientists, and, from these, new programs are likely to emerge, possibly in the area of vulnerability reduction.

These changes all stem from the enormous shifts in Bhutan that have taken place since 1994. The communication systems that link the Bhutanese with each other and with the outside world have expanded since the introduction of television and the Internet in 1999 and the hundredfold growth in telephone ownership. The introduction of a constitution in 2005 and of parliamentary elections a few years later transformed national politics. More generally, this transformation of the river stems from the effects of human actors, both worldwide (climate change has led to accelerated glacier retreat, which, in turn, has expanded the glacier lakes that are the sources of the floods) and within Bhutan, through the introduction of new technologies (early warning systems, hydro facilities) and new institutions (NAPAs). These have contributed to emerging understandings of the river, complementing the long-established cosmologies whose hold remains firm, as knowledge of climate change expands through the country, spread in part by the national television company, Bhutan Broadcasting Services.

And yet the two flood events were very similar. Both touched off thoughts of dangerous spirits that were incompletely subdued and that could cause damage. Both created an outpouring of concern at the national level as well as at the local and provincial levels, in which there was broad public empathy for the suffering of rural and urban people along the whole course of the river valley. Both led a specific division of labour: relief and reconstruction efforts were identified with the king and were organised through the royal government, while research activities to assess and manage future risks were in the hands of administrative agencies, particularly national ministries.

These similarities all stem from the deep continuities in Bhutanese society and culture. Buddhism remains strong as a national religion and as a part of community and domestic life. The loyalty to the monarchy is a powerful force.[16] The changes – the opening of communication within Bhutan and the outside world, the transition to democracy, the development (*yargey*) associated with electricity – can be read as signs of the strength and vigour of Bhutan rather than as fundamental changes.

As was suggested earlier, these two flood events point toward the possibility of writing a biography of the Po Chhu River, as biographies have been written of other rivers. The Po Chhu is clearly an active force in its relations with Bhutanese society. Although new forms of communication contributed to reducing the impact of the second GLOF, by alerting people downstream, the Bhutanese are far from controlling the powerful rivers in their country's rugged landscape. In particular, the efforts supported by the NAPA to lower lake levels did not prevent the second flood. Indeed, the Bhutanese have sought to protect nature in the Po Chhu watershed and elsewhere, far more than in all of the other river biographies – the forests that protect slopes from erosion are far more intact than elsewhere.

However, in other ways, the river biographies do not serve very well. Two reasons for this lack of fit stem from the distinctiveness of Bhutan and of the steeply graded Po Chhu on the southern flank of the world's tallest mountain range. First, it is difficult to detect in this case the tensions between "usefulness and beauty" that Cronon sees as "engines of change" in Cioc's biography of the Rhine and that the authors of other river biographies also examine. Second, and more seriously, it is also difficult to divide the biography of the Po Chhu into a set of successive periods; the temporality of the engagements of Bhutan and the river is different from the temporalities discussed in the biographies. It would be arbitrary to decide either that the second flood was in the same period as the first or that it was in a different period. The relations of the people in Punakha and throughout Bhutan with the Phho Chu are not either unchanging or transformed but, rather, ongoing. The *naga* water spirits remain active, so that the collective offerings at the annual *tsechu* festival at Punakha dzong and the many individual offerings at shrines keep these spirits content, their energies directed to a regular flow rather than a flood, although floods may still happen. The modern infrastructures along the rivers – early warning systems, hydro facilities – are similarly maintained actively rather than installed at one time and left in place, so that they may generate electricity for use within Bhutan and for sale to India, though disruptions remain a possibility. Indeed, these floods show that Bhutan may be neither fixed in its past or settled in a new phase. It is neither an unchanged Himalayan

theocratic kingdom – the same country that it was when it was entirely closed – nor simply another developing country, headed toward a global culture of consumption and media. Rather, its relationship with its history is ongoing, a relationship of renewal and of modification, like its relationship with its rivers.

A third feature makes it difficult to fit the Po Chhu into the format of river biographies, one that cannot so readily be attributed to the social, cultural, and environmental distinctiveness of the case but, rather, is a matter of timing, a characteristic of the period in which the second flood occurred. The first such book, Cioc's biography of the Rhine, focuses on a watershed as a unit. This watershed is the geographic and social space of the interactions between the river and the nations along it. The other river biographies – of the Yamuna, the Colorado, the Nile, and the Hooghly – similarly treat watersheds as coherent units. However, the Po Chhu watershed is more profoundly influenced from outside. Climate change leads to the rapid melt of glaciers, creating an increased risk of outburst floods. Somewhat more generally, climate change undercuts the coherence of river biographies by adding a third actor, the greenhouse gases that cause warming throughout Bhutan as in nearly every corner of the world. Such external actors have only a weak presence in the other river biographies, with the exception of external economic institutions in Bear's discussion of the Hooghly.

Like so many other stories, river biographies are interrupted by the arrival of the Anthropocene, in the form of climate change and in the form of growing human awareness of climate change in Bhutan and elsewhere (Castree 2014). This arrival makes the future of Bhutan even more uncertain, though, ironically, it underscores the importance of hydropower, now understood as a source of low carbon energy as well as a source of development, and underscores the importance of the country's vigorous programs of protection of its forests, now serving as a means of sequestering carbon as well as a means of protecting hydropower facilities from sediment. The river, its watershed, and the buildings that the Bhutanese have constructed continue to acquire new meanings as the Bhutanese continue to advance toward their country's future and to seek a place in the world from which they were until recently withdrawn. The stories of this society and its rivers may no longer be histories or biographies, both of which were regional in scale, but, instead, pieces of newer global or planetary accounts, written in genres that are still emerging.

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Notes

1 A few river histories use the word "biography" in their titles, but they remain firmly within the limits of the genre of river histories. Unlike the previous works, these books are all popular rather than academic. They describe colourful characters whose actions unfold on or near the river and document the ways that these characters and other residents have used the river to express the particular cultural orientation of their region. The first to be published with this title word was *Biography of a River: The People and Legends of the Hudson Valley* (Mylod 1969), a compendium of incidents in the river's history, stretching from the earliest European settlements to the present, accompanied by historical photographs. *The Haspeth River: A Biography* (Crutchfield 1972) also offers a series of events in the history of a river located in central Tennessee and is also heavily illustrated, though with pen and ink drawings by the author rather than photographs. Both of these books were published by small presses located in the same region as the river about which they were written. Both of the authors were local writers, amateur historians rather than academically trained ones; Mylod is a fisher and a local environmental activist, while Crutchfield, after this first book, went on to a professional career as a popular writer of Western history. A third book follows this general pattern: *Mighty Mississippi: Biography of a River* (Childs 1982) was written in the early 1930s, though not published until the 1980s. The author, a journalist at the St Louis Post-Dispatch, was born in a small city in Iowa along the Mississippi and drew on his early experiences in the book, a rapid series of anecdotes of the river, particularly its central portions near Iowa; in the years after he drafted the manuscript, he moved to the Washington bureau of the newspaper and covered national and international politics. These three popular books differ from the academic books mentioned above in their lack of general arguments and in their appeal to regional readerships rather than broader ones; they share with the academic books a focus on human actors, for whom a river is a stage for action.

2 Two key moments in the emergence of integrated water resource management were the 1992 International Conference on Water and the Environment, held in Dublin, and the establishment of the World Commission on Dams in 1997 (World Commission on Dams 2000).

3 A recent study documents that over 60 percent of the country is forested, a percentage that has been stable since 1990 (Bruggeman, Meyfroidt, and Lambin 2016).

4 Erik Swyngedouw (2004) develops this point in his discussion of the city of Guayaquil, Ecuador, in relation to the river, the Guayas, that runs through it. He emphasises the temporal dimensions of the mutual engagements of a society and a river, showing that new technologies and institutions have created hopes for a positive, modern future, distinct from the past, in which adequate, secure water supply is a key and that these technologies and institutions have also created disappointments that lead to conflicts and violence. By contrast, the engagements of the Po Chhu and Bhutan unfold in a different path.

5 United Nations Framework Convention on Climate Change, 9 May 1992, 1771 UNTS 107.

6 The *tsechus*, lasting several days, draw large crowds from the region and from more distant parts of the country as well, who come to see elaborately costumed dancers, representing spirits, animals, people, and figures from the history of Buddhism, whose movements convey moral guidance. The tsechus also attract visitors because they are the only occasions when *thangkas* – religious paintings on cotton or silk appliqué – are unrolled and placed in view of the public; these textiles are usually stored, rolled up, in temples. Viewing the dances and the thangkas brings religious merit (*gewa*) to the observers. There are also secular motives for attending the tsechus since markets form to serve the crowds.

7 The Punakha dzong is tied to Guru Rinpoche, sometimes called the Second Buddha. He was a key figure in the development of Tibetan Buddhism and the one who travelled to Bhutan in the eighth century, bringing Buddhism to the country, subduing (*tuuel*) the demons who inhabited it at the time. Like other major Buddhist figures, he did not kill or destroy the demons but, rather, rendered them harmless and reoriented their destructiveness for positive ends. During one of Guru Rinpoche's visits to Bhutan, he foretold that someone with the name of Namgyal would someday travel to a hill shaped like an elephant. This kind of vision or premonition is also a common theme in Bhutan and in other Tibetan Buddhist traditions. Centuries later, Zhamdrung Namgyal, the leader who unified Bhutan into a single kingdom and consolidated the practices of the Drukpa lineage as the form of Buddhism within the country, saw the hill where the dzong is located and noted that its elephant-like form, with the strip of land between the Po Chhu and Mo Chhu resembling the animal's trunk. Zhamdrung, who led the forces that defeated an invasion from Tibet, constructed the Punakha dzong in the 1630s. It holds many important religious statues and images, which attract pilgrims from throughout Bhutan and from the refugee Tibetan communities in Nepal and India. It is also the site of a major tsechu each year, with a ritual re-enactment of the defeat of the Tibetans and a series of offerings to the *nagas* or water spirits in the river.

8 Bridges are associated with Phajo Drugom Zhigpo, one of the key figures in the history of Buddhism in Bhutan. He travelled to Bhutan from Tibet in the thirteenth century, following earlier prophecies of the founder of the Drukpa lineage of Tibetan Buddhism; he spread this lineage, which came to predominate in the country (Bhutan National Commission for UNESCO 2012b). The well-known story tells how he took his seven sons to a bridge. Calling to the spirits to determine which of his sons were demons and which would found branches of his lineage, he threw all of them off the bridge into the river. Four of them survived, and all went on to establish monasteries and temples; three of them were carried off, and their bodies were never recovered.

9 In 1994, the country had 4,609 phones – all land lines – fewer than one phone per hundred residents. Since Bhutan requires mobile phones to be registered, the number can be assessed closely; official figures list 568,527 phones in 2014, nearly all of them mobile phones, the equivalent of one phone for every inhabitant above the age of twelve.

10 In 1994, scholarship on glaciers was limited to a survey and a monograph by a Swiss researcher (Gansser 1970, 1983) and a report by the Geological Survey of India (Sharma, Ghosh, and Norbu 1986). The Geological Survey of Bhutan completed a national inventory two years after the flood (Division of Geology and Mines 1996), a rapid pace considering the rugged terrain of the country and the lack of roads. The country also established collaborations with foreign researchers into the country's glaciers, with close attention to the risk of floods (Gagné, Rasmussen, and Orlove 2014). This research required the approval and cooperation of the government, since Bhutan, unlike some other mountainous countries, requires permits for travel throughout the country. Field researchers from India (Bhargava 1995) and Austria (Haeusler and Leber 1998) began working in the early and mid 1990s, and an active Japanese program started late in the 1990s (Ageta and Iwata 1999; Iwata 2010). Building on earlier field-based research, the Japanese scientists added remote sensing and modelling to construct glacier lake outburst flood (GLOF) risk maps (Fujita, Suzuki, Nuimura, and Sakai 2008; Fujita et al. 2012).

11 The government sent workers to build a camp near the lake at an elevation of 4,400 metres. A government engineer, working in conjunction with foreign geologists, selected sites for drainage channels. Teams of workers went to the lake for the summer months every year from 2009 to 2012. Using pickaxes, shovels, crowbars, and other simple tools, they hauled boulders and rocks away. The one piece of mechanical equipment that they used was a small jackhammer, which drilled holes in the boulders too large to haul away. The workers filled the holes with a powder that expanded slowly, cracking the boulders. The group did not use any explosives, fearing that the vibrations might destabilise the moraines and also concerns that they would disturb local spirits. Two workers died of altitude sickness in the second summer; the program increased the medical services at the camp, and no further deaths occurred, though there were some injuries and uncomfortable conditions because of the exhausting work at high elevation, the cold, and the dampness of the rains

during this season. There may have been some religious sources of discomfort as well. A group of monks was established at the site; they prayed continuously while the workers moved rocks, and made regular offerings as well, to appease spirits who might look unfavourably on these changes. By the end of the four-year period, the project had difficulty recruiting workers, despite the high wages they paid, and the army sent soldiers to help complete the drainage channels.

12 A documentary film about the lake-lowering project, *The Cost of Climate Change*, was produced jointly in 2010 by the national television company, Bhutan Broadcasting Services, and the World Wildlife Fund. It won a major award in that year, the Prince Albert II of Monaco and UNCA Global Prize for coverage of climate change, and in 2013 received the best documentary film at the film festival of the South Asian Association for Regional Cooperation, a major regional intergovernmental organisation (Bhutan Broadcasting Service 2013). It continues to be rebroadcast regularly on national television in both Dzongkha and English. In addition, the UN Development Programme, working with the Discovery Channel and Arrowhead Films, an independent film company, made a documentary about the project in 2011, *Revealed: The Himalayan Meltdown* (United Nations Development Programme 2011). It premiered at the Asia Society in Washington and was broadcast in Bhutan and internationally on the Discovery Channel.

13 The Chhukha hydropower facility sponsors major Buddhist rituals, including an annual *drupchen* (multi-day meditation retreat) and a *baza guru dungdrup* (an event in which the assembled participants jointly recite a 12-syllable mantra associated with Guru Rimpoche 1 million times). Major religious figures regularly visit hydropower facilities; for example, the Dagachhu facility was visited by the country's head abbot, the Je Khenpo, on 31 May 2014; and it was inaugurated by the Lam Neten (the senior provincial monk) on 13 March 2015, at an auspicious hour on an auspicious date in the national calendar. Moreover, there is a felicitous overlap of modern technology and the various schools of Tibetan Buddhism, in which clockwise movement is seen as auspicious and appropriate, counter-clockwise movement as dangerous and disrespectful (Powers 1995). Pilgrims walk around temples and dzongs in a clockwise direction, people spinning prayer wheels as an act of devotion turn them in a clockwise direction. And, in a fortunate coincidence, the vertical turbines in Bhutanese hydro facilities spin clockwise.

14 The mushroom is the fruiting body of the fungus *Cordyceps sinensis*, known locally as *yartsa gunbu*, collected during a short period in the summer. Demand in China for this mushroom, a well-established element in traditional medicine, has grown enormously since the late 1990s because of its reputed aphrodisiac properties.

15 The team included social science researchers from the Ministry of Agriculture and Forests as well as geoscientists and hazard management specialists. The Ministry of Economic Affairs, which also participated in the research effort, has also spoken of the importance of integrating science and policy to address the effects of glaciers on Bhutan's hydropower, agriculture, and general socioeconomic development (International Centre for Integrated Mountain Development 2015). The tone of this team's findings was sombre. They commented that climate change increased the threat of GLOFs, since the glaciers in the country are melting at a rapid pace. Vulnerability is increasing as well, as populations and infrastructure in the flood zones are growing.

16 This loyalty extends both to the Wangchuck dynasty as a whole and to each of the kings as individuals. The association with the monarchy places the floods in an ongoing national narrative through the fourth king, who led the reconstruction after the 1994 flood, and his son, the fifth king, who played the same role after the 2015 flood. This continuity was underscored with the birth of the son of the fifth king and his wife on 5 February 2016, an event that was marked by prayer ceremonies in the country's dzongs and widely diffused, thanks to the country's power supply, on the national television network (Kuensel Online 2016).

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