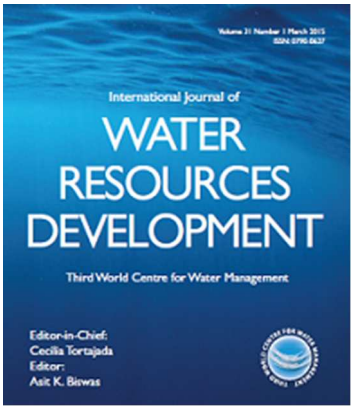

Topography and the Hydraulic Mission: water management, river control and state power in Nepal

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Abstract

We examine the Nepali state's role in water management over time and space. Using the hydraulic mission model, we use historical material, policy documents and interviews. From the 1800s, state water management concentrated on the Kathmandu valley. The 1960s witnessed the hydraulic mission launch in the lowlands through construction of public irrigation canals. Since the 1990s, a consolidating hydraulic mission climbed to the hills and mountains through hydropower development. We argue that over time, topography played a determining role in application of state power and water control through infrastructure development, and that attention to geography helps refine the hydraulic mission model.

Keywords: Water management, governance, hydraulic mission, Himalaya, Nepal.

Introduction

The control of water is widely recognised to be an important medium of power relations between state agencies and various social groups (Budds, 2009; Linton, 2010; Robbins, 2004; Swyngedouw, 2009; Worster, 1992). The relationship between state power and water control is historically reproduced and changes over time. Large bodies of scholarship have grown up around social and political implications of water use, at small and large geographical scales, in contemporary and historical contexts as diverse as the nineteenth century American West, ancient Arabia, modern Egypt, post-Soviet Central Asia, contemporary northwest China, mid-twentieth century Germany and Mexico, and the present-day globe (Akhter & Ormerod, 2015; Clarke-Sather, 2012; Harrower, 2008; Lekan, 2008; Meehan, 2014; Swyngedouw, 2009; Verhoeven, 2015; Zinzani, 2015). In South Asia, the region comprising India, Pakistan, Bangladesh, Sri Lanka, Bhutan and Nepal, there are substantial literatures that analyse hydropolitics in several major river basins, including the Indus and Mahanadi (D'Souza, 2006a; Gilmartin, 2015; Haines, 2017).

Yet the Himalayan country of Nepal has attracted relatively little scholarly attention. This is despite its geopolitical importance, which derives from its commanding position on the headwaters of the Brahmaputra, upstream of the densely-populated, water-thirsty plains of India and Bangladesh. Moreover, as this article will show, a study of the relationship between water-control and state power in Nepal offers a new perspective on the impact of topography and the idiosyncratic

development of governance in the country, which (unlike its neighbours to the south) was not formally colonised by the British, and which resisted meaningful popular political participation until at least the 1950s. We suggest that, contrary to what one might expect of a country that was long characterised by absolutist government and then by a slow development of democratic politics, the Nepali state took relatively few steps to avail the opportunity to accumulate country-wide control that has characterised hydro-development elsewhere.

We argue that the topography of Nepal – characterised by three regions including the mountains, hills and the lowland Terai - has played a determining role in the application of state power through water infrastructure development, principally by public irrigation canals but also hydropower and drinking water provision. The hills have historically been the centre of military and political power in Nepal, especially the Kathmandu Valley, but state power was based on military dominance and the ability to extract resources from peripheral areas. Over time, particularly during the twentieth century, the Nepali state turned its attention increasingly away from land and revenue and towards the assertion of its control of water resources, along with greater intervention in water resources development (Pradhan, 2000, pp. 1–3). The focus of state-led water management accordingly shifted from the Kathmandu Valley (up to the early twentieth century), characterised by very limited canal irrigation and drinking water provision; to the Terai in the mid twentieth century, where public canal irrigation systems transformed the agricultural landscape; and finally to the hills and mountains (late twentieth/early twenty first century), which have become the focus of hydropower development.

By considering the development trajectory of water management paradigms in the three topographic regions of Nepal, we highlight an understanding of the temporal and spatial process by which the state initiated and subsequently consolidated its control of water through infrastructure development in pursuit of the hydraulic mission. These shifts in water management both reflected and contributed to the respatialisation of state power, which for a long time was focused closely on

the Kathmandu Valley (eighteenth and nineteenth centuries) before travelling first downstream to the Terai and, later, uphill to the hills and mountains. While previous work on the hydraulic mission has recognised that diverse outcomes can co-exist within one national space (Wegerich, 2014), the role of topography in shaping hydraulic missions has attracted relatively little attention. In short, we demonstrate that the state's role in water management in Nepal can be understood as occupying and being shaped by the interstice between topographical contours and political history.

Paper structure

We first lay out the conceptual framework, the paradigms of water management including the hydraulic mission (Allan, 2003). We then justify our approach, introduce the three physiographic regions of Nepal, and present an overview of data sources and methods of analysis. We then offer a long-term analysis of the development of Nepali water management, governance and hydro-politics, particularly focusing on periods of change. This is divided into two parts, 'pre-modern' and 'modern' (our usage follows Allan's (2003), in order to clarify our theoretical contribution, and is not meant to imply value-laden assumptions about societies). We analyse pre-modern developments particularly during the period of Rana rule (1846-1951), but include references to earlier periods, especially that of the Gorkha kings (1769-1846). During this period, state authority revolved around raising revenue and projecting military power. Water management, like other aspects of what we might now call development activity, was left largely to local initiative. The modern period, from 1951 to contemporary times, introduced and established the national legal framework for water management, tentative steps towards greater hydro-development, the launch and consolidation of the hydraulic mission, and the introduction of participatory and integrated approaches in the late twentieth century. These shifts had important implications for the relationship between state power, society and water, reshaping it at each stage. Finally, conclusions are presented and discussed in relation to the hydraulic mission. The following research question will be examined: what has been the Nepali state's involvement in water management over time and space?

Paradigms of water management, the hydraulic mission and the role of the state

In order to critically assess the evolution the state's involvement in water management over time and space within Nepal, we apply the conceptual framework of water management paradigms, including the hydraulic mission (Allan, 2003). This framework facilitates a temporal theoretical understanding of the Nepali state's role in water management - including irrigation, hydropower and drinking water provision - within the country. It charts five paradigms that a country or region passes through during its transition from pre-modern to modern conditions. The vertical axis of Figure 1 represents water use, typically for irrigation purposes, with the horizontal axis representing time.

Figure 1: Paradigms of water management (Allan, 2003)

The first paradigm is the pre-modern, characterised by limited centralised technical and government capacity, with water being primarily controlled and managed at a local small-scale level. Modern conditions are considered to begin with the onset of the second paradigm, industrial modernity, in which the hydraulic mission is launched. The advent of the hydraulic mission can be witnessed with the onset of water resources development led by the state, characterised by extensive and intensive water capture and control through the construction of large-scale hydraulic and related infrastructure (Molle, Mollinga, & Wester, 2009). Wester defines the hydraulic mission as: 'the strong conviction that every drop of water flowing to the oceans is lost, and that the state should develop hydraulic infrastructure to capture as much water as possible for human uses' (Wester, 2008, p. 10). The hydraulic mission is considered an intended political strategy for controlling space, water and people. It is therefore an important part of everyday state formation. The third to fifth paradigms are collectively referred to as the reflexive modernity stage, a term used by Giddens (1990) to denote the questioning and potential change in direction from prior stages of development as society modernises. During this stage, the dominant approach of the hydraulic mission is

questioned by the emergence of alternative approaches. The third paradigm is that of environmental awareness or green thinking. The fourth paradigm heralds the economic valuation of water, promoting water demand management to improve water use efficiency. The fifth paradigm represents water managed as a political and institutional process, encapsulated by Integrated Water Resources Management (IWRM) approaches (Allan, 2003).

The carrier of the hydraulic mission is the state hydrocracy, a term derived from hydraulic bureaucracy, in specific reference to government ministries and water departments (Wester, 2008). Within Nepal, the hydrocracy consist of government ministries and departments who control, manage and monitor water resources. The Nepali hydrocracy is part of the iron rectangle of actors - government, infrastructure construction companies, politicians and banks - set within a larger web of interests including non-government actors, operating in the wider political economy in Nepal. Water control is crucial in understanding the hydraulic mission and the Nepali state's role in controlling water in time and space, particularly for surface water irrigation (Wester, 2008). Water-control consists of three dimensions: technical control, focusing on the regulation of hydrological processes through technical devices; organisational control, in guiding human behaviour in water use particularly that of farmers; and socio-political and economic control in which water management is embedded and that constitute conditions and constraints for management and regulation (Mollinga, 2003). Hydrocracies' resistance to reform in moving beyond the hydraulic mission to operationalise the reflexive modernity stages has been documented in South Asia (England, 2018; Mollinga, 2005; Bolding and Mollinga, 2004), as well as globally (Molle et al., 2009).

Justification

The hydraulic mission model is valuable as it schematises the evolution of water management over time, highlighting the changing relationships between state, social practices and water resources. It has been the subject of numerous related studies: in Egypt (Allan, 2003), Mexico (Wester, 2008), the USA (Reisner, 1993), the Soviet Union (Josephson, 1995), China (Shapiro, 2001), Thailand (Molle &

Floch, 2008), South Africa (Turton, 2004), Australia (Ward, 2000), Spain (Lopez-Gunn, 2009), France (Pritchard, 2004) and India (D'Souza, 2006b; England, 2018). (For a historical overview of the hydraulic mission see Molle, Mollinga & Wester, 2009).

Nepal, characterised by extreme variation in topography concentrated within a relatively small geographic area, more pronounced than the previously-mentioned countries, makes a useful contrast. Tracing the development of the paradigms in Nepal enables us to test the validity of the conceptual framework within a different physiographic context, considering the impact of extreme topographical variation over space and time.

Our deployment of the model broadly supports the phased sequence of paradigms, but highlights the importance of topography in shaping the spatial and temporal development of the hydraulic mission. In Nepal, several paradigms have tended to coexist at the same time, due to differences in geography. We therefore aim to refine the hydraulic mission model while offering an original explanation of the development of state water management in this Himalayan country

Regions of Nepal

Nepal is conventionally divided into three physiographic regions: from north to south, the mountains (including the high himal and high mountains), hills (middle mountains and Siwaliks range) and the Terai (Figure 2).

The mountain regions, above 3000m elevation, are characterised by an abrupt rise in topography, extremely rugged terrain, steep slopes and deeply cut valleys. Land cover varies from glaciers, snow, and bare soil and rock at the highest elevations, through grass and coniferous forest at lower elevations. Agriculture, often terraced, consists of rainfed potatoes, barley and wheat. Informal types of irrigation, known as Farmer Managed Irrigation Systems (FMIS), are widespread. These locally-adapted channels are characteristically small-scale, seasonal, and run-of-the-river. They include furrow and burrow structures which divert river water during high flow periods (for an

agricultural and irrigation overview of Nepal see (Food and Agriculture Organisation [FAO], 2012)). Animal husbandry is widely practised. The region had 2.5 million inhabitants in 2011, accounting for 9% of Nepal's population (Government of Nepal [GoN], 2011a).

The hills, with an elevation of 300-3000m, are characterised by areas of dense broad-leaved and mixed forest. Rainfed agriculture, often on terraced slopes, includes maize, wheat, millet, potatoes, barley and legumes. FMIS is widely practised, including run-of-the-river seasonal furrow diversion channels, and terracing for the cultivation of rice and other staple crops (FAO, 2012). Animal husbandry is common throughout the hills. As of 2011 the population of the region was 10.5 million, representing 41% of Nepal's population (GoN, 2011a).

The Terai region, with a maximum elevation of 300m, is characterised by deciduous forest, vast flood plains and extensive agriculture. Rice is the principal crop cultivated, through both public irrigation canals and FMIS, as well as wheat and maize (FAO, 2012). Animal husbandry is widely practiced. The Terai had 13.3 million inhabitants, 50% of Nepal's population, in 2011 (GoN, 2011a).

As agricultural practices indicate, the extreme differences in regional topography shape livelihoods, social systems and local culture (Gyawali, 2002, pp. 214–215). It is our contention that the relationship between water resource development and state power has not only played out across these three regions, but been shaped by them.

Figure 2: Regions of Nepal

Methods

This paper draws upon numerous primary and secondary sources.

The section 'Pre-modern: 1846 to 1951' uses a documentary history methodology, drawing on archival research conducted in Kathmandu and London. For clarity, we here give an overview of our archives, as well as citations for the specific primary sources that we used in the published version of

this article in brackets. Much of our historical data comes from the *Regmi Research Series* (Regmi, 1969-1989, and multiple references to individual volumes by year). A key resource for pre-twentieth century Nepali history, the multi-volume series is an edited collection of primary documents, mostly generated by the Nepali government, and translated into English. In the United Kingdom, the India Office collections of the British Library furnished supplementary information (Betham, 1939), as did the numerous published accounts of European travellers to Nepal in the 19th and 20th centuries (Hamilton, 1819; Kirkpatrick, 1811; Landon, 1928a and 1928b). Collectively, these accounts give snapshots of developments which were often quite localised in place and time, though some materials present a national picture. Due to the sparse nature of historical material, we analysed the data qualitatively. In Nepal, we also explored the resources of the National Archives of Nepal, located in the government's Department of Archaeology, and private collections of historical miscellanea such as the Madan Puraskar Pustakaliaya library. However, none of the primary sources that we found in these archives were ultimately included in the published version of the article. Apart from the primary sources specified above, all other citations in the section are secondary.

The section 'Modern: 1951 to contemporary' is based upon secondary data obtained from Government of Nepal policy and legislative documents from the 1950s onwards, alongside primary data from open-ended semi-structured interviews with policymakers and water experts conducted in April 2017 in Kathmandu (Table 1). Relevant data relating to government historical and contemporary plans for irrigation, hydropower and drinking water were highlighted in policies and other documents, and entered into a table to perform data reduction and display (Robson, 2002). Interviews were transcribed with relevant points and opinions concerning the state's involvement in water management in time and space entered into a table. Government involvement and plans for irrigation, hydropower and drinking water, in addition to opinions of wider governance and related issues, were then categorised upon the three-tier timeline from the 1950s onwards. Anonymity was guaranteed to all interview respondents, with data secured in a safe location. Respondents were not asked to divulge secret or sensitive information.

Table 1: Interview respondents

Results and discussion

Pre-modern: 1846 to 1951

The Nepali state's relationship to water management before the 1950s is categorized as 'pre-modern' in Allan's (2003) model. In regional context, this is surprising. Nepal's neighbour, India, experienced intensive surface-water development from the mid-nineteenth century. By the early twentieth century, major irrigation projects had transformed areas of relatively low productivity and sparse population into densely-settled agricultural powerhouses. Many of these projects used weirs to increase technological control over river flows, enabling perennial (year-round) irrigation rather than relying on seasonal river levels. Prominent examples included the canal colonies of Punjab (Gilmartin, 2015) and Sindh (Haines, 2013), the Ganges Canal, the Krishna delta and Godavari systems (D'Souza, 2006a). On the eve of its independence from Britain in 1947, India (including the areas that became Pakistan) hosted the world's largest irrigation system (Corell & Swain, 1995, p. 135). India was therefore in the hydraulic mission's industrial modernity phase, during which the colonial state and its postcolonial successors made great political capital out of their ability to reshape landscapes through water-control projects, as well as other examples of spectacular development (Roy, 2007). In Nepal, by contrast, the state did have a relationship to water management, but this is best understood as part of the broader relationship between the state, environmental resources and taxation.

Why was the development of water-resources management in Nepal comparatively slow, what was its relationship to state power, and what implications does this have for the hydraulic mission model?

In this section, we outline the development of the relationship between water and political power before and during the rule of Nepal's powerful Rana dynasty of hereditary prime ministers (ruled

1846-1951). We show that the central government in Kathmandu paid attention to water primarily when its supply was excessive (flooding) or lacking (drought), rather than through regular management, or planning systematic extensions to irrigation facilities. We then consider the severe discrepancy between water control in the Kathmandu Valley and elsewhere in Nepal that emerged by the early 20th century. Finally, we highlight the particularly distant administrative relationship between high mountain regions and the central government, which contributed to the almost total neglect of water management at higher elevations.

Before the Ranas

In keeping with Allan's characterisation of the pre-modern paradigm of water management, medieval Nepal included very few irrigation systems that were organised beyond the local level. The beginning of small-scale canal irrigation in the Kathmandu Valley has been dated to the Lichhavi period, when King Asmu Varma ordered the construction and maintenance of *raj khulos*, or royal canals, around 605 CE (Hamal, 1994, 12, 37-8). Before this it seems likely that villages relied either on rainfall, or drawing water directly from rivers, and were therefore typically situated near riverbanks in the hills and on the Terai (Sanwal, 1993, p. 60). The same continued to be true for the vast majority of the country that was located outside the commands of the handful of royal canals. But on small, localised scales, human attempts to manipulate land and water flows for agriculture had long generated the characteristic hill terraces of the middle hill region. An early-nineteenth century British traveller reported seeing canals in the Valley (Kirkpatrick, 1811, p. 65), but it is not clear whether these were major canals. Instead, another traveller wrote shortly afterwards that 'the numerous springs and rivulets that issue from the surrounding hills have been conducted with great pains to irrigate' terraced fields on hillsides, implying that these systems were minor (Hamilton, 1819, p. 223).

Such small-scale, widely-dispersed irrigation systems are unlikely to involve the kind of centralised authority and logistical capacity that characterises the large-scale, state-driven systems of the

hydraulic mission. The Gorkha kings, who conquered the Kathmandu Valley in 1769 and ruled effectively until 1846, commanded little in the way of organised administration. The Gorkha conquest of the lands that now make up Nepal had been too rapid to enable the rulers to establish sophisticated administrative systems (Höfer, 1979, p. 39). They accordingly made only ad hoc - not systematic - attempts to construct public tanks (small artificial reservoirs) and canals, alongside the upkeep of temples and construction of inns and thoroughfares (Regmī, 1961, pp. 278–279). Their chief concern was raising revenue: much of the correspondence between the crown and its local agents in the *Regmi Research Series* (Regmi, 1969-1989) concerns the levying and transmission of revenue. The pre-Rana state, in other words, was fiscal-military rather than developmental. There was little impetus towards the kind of systematic development that could initiate the hydraulic mission.

Scattered references in historical documents show that agriculture's vulnerability to variations in water availability already concerned the state. In circa 1817 CE, the King issued a royal order to one Kulananda Jha, issuing a three-year contract to manage lands in Tokha, now part of Kathmandu district, which promised to 'assess the extent of the damage and grant appropriate remissions' in case of floods (Regmi, 1984, pp. 135–136). This showed that a flexible responsiveness to climate variability was built into the system of rule.

The centralised state, however, had little interest in managing the natural environment itself. The limit of the king's intervention would be to reduce his demand for revenue after flooding or drought, not to proactively ensure favourable agricultural conditions. Indeed, the Gorkha kings sometimes exhorted their subjects to populate uncultivated lands and expand agricultural production (Regmi, 1976, p. 7), but left the actual management of the process to their subordinates. Individual tenure-holders would take their own initiative to protect agriculture. The lack of an organised approach to water-management should be understood in the context of a state where higher functions were

personal to the king, but lower functions were almost entirely decentralised. The state, such as it was, revolved around gathering revenue and keeping the king's law.

In the mountains, local administrators levied taxes on the lucrative trade with Tibet rather than on agriculture. For example, King Ran Bahadur Shah wrote to Raja Wangyal Dorje of Mustang in 1790 CE, granting him the right to collect taxes on trade (Regmi, 1970, p. 99). But there seems to have been little distinction between the other two of Nepal's three regions, the hills and the Terai, during the Gorkha kingdom period: both were fertile and potentially productive, and could produce revenue through agriculture. This focus on revenue over development continued to characterise water governance in Nepal right up to the 1950s, though as the next section outlines, some changes were afoot.

Rana period

A landmark moment in the Nepali state's evolving relationship to agriculture and natural resources was the accession to power of Jang Bahadur Rana, the founder of a dynasty of powerful prime ministers who wrested effective control of Nepal from the throne and governed from 1846 until 1951. During this period the Rana prime ministers wielded de facto power with the title 'Maharaja', while the Gorkha throne retained the title 'Maharajdhiraj'. Jang Bahadur, and his successors, took pains to centralise Nepal's revenues, reducing the granting of landholdings to intermediaries (especially in the Terai) and ensuring that payments passed through the central treasury (Regmi, 1977, pp. 119–126). Another aspect of this tendency was the passing of the Muluki Ain ('Civil Code') in 1854, under Jang Bahadur's rule. This was a sweeping legal code. It had important implications across the social life of the country, not least formalising the diverse existing collection of ethnic and 'tribal' communities into a unified, caste-based hierarchy (Burghart, 1984). The aim of this was to weld the many peoples of the recently-conquered Gorkha kingdom into a national whole, reinforcing high-caste social dominance while strengthening the Ranas' political control. It codified existing customary and Hindu law, while introducing amendments. The majority of the code dealt with social

and cultural questions such as caste rules, marriage, and crime and punishment (Höfer, 1979, pp. 39–42).

While the Muluki Ain contained relatively little on water use for irrigation, it included several clauses that sought to define the relationship between the state, cultivators, land, and environmental instability. Out of the 118 clauses that relate to landholding, 12 referred either to remissions to be granted to revenue-payers whose lands have been damaged by floods or landslides, or to punishments meted out to people who falsely claimed that their lands had been thus damaged (see (Regmi, 1977, Regmi, 1978)). These clauses were are substantial and detailed, and outlined a response to water extremes that suggested such events were a routine part of agricultural life. They took no apparent steps to implement water systems that would prevent flooding.

On the contrary, the Ranas' fiscal-administrative system was designed to mitigate the economic damage that flooding could cause, through remissions, rather than to promote environmental control. In this respect it was similar to other revenue systems in South Asia. In Odisha, eastern India, for example, the Maratha rulers (1751-1803 CE) took a proportion of agricultural produce in kind, while the colonial British administration (1803-1947 CE) made fixed cash demands but granted remissions in case of damaging inundations. The former system automatically shared losses between agricultural producers, the Maratha rulers, and their intermediaries. The latter theoretically meant that the state shared the burden of losses (D'Souza, 2006a, pp. 73-84). In Rana-era Nepal, both cash and in-kind revenue systems coexisted on different classes of land (Hamal, 1994, p. 21); the evidence of the Muluki Ain points to the Ranas' flexibility. The Muluki Ain did incentivise the expansion of agricultural production by asserting the rights of 'any person [who] through his own physical labour' dug irrigation channels and cleared forests on redistributed land (Regmi, 1977, p. 124). But, again, this merely set out the legal and fiscal conditions under which cultivators could do agriculture rather than systematically organising new cultivation.

Overall, the early Rana period heralded a slow but significant change in the state's relation to land, with a growing market for land sales coupled with a decline in the supply of new land that could be brought under cultivation as the population expanded (Whelpton, 2005, pp. 53–54). Yet the early Ranas continued the distant relationship between the state and water control that had characterised their predecessors. By the 1930s, however, the Ranas had cemented some steps towards water control, especially in the Kathmandu Valley, where the first moves towards the hydraulic mission phase of development began. The Nepali government began to diversify its engagement with water governance, through three types of water control: hydropower, irrigation, and drinking water.

Firstly, a small hydropower plant (500kW) was constructed at Pharping in 1911, which supplied power principally to Prime Minister Chandra Shumsher Rana's palace (Gyawali, 2002, p. 222). Another hydropower plant was constructed at Sundarijal in 1934 (600 kW). However, the Ranas built these two plants to supply themselves with electricity, and the general public had almost no access to it (Sharma & Awal, 2013).

Secondly, the Ranas made a first, tentative move towards the development of large canal-irrigation systems similar to those in India's Ganges and Indus basins. The first large public-sector irrigation canal system (the Chandra Nahar Canal System), with a net command area of 10000 ha, was constructed in 1922 and is still in operation. Appropriately, this canal was constructed in the eastern Terai lowlands, where the shallow gradient and large expanses of alluvial plain lent themselves to canal-irrigated agriculture. Apart from this canal, however, informal FMIS continued to prevail across the rest of Nepal.

Thirdly, by the early twentieth century, much of the Kathmandu Valley was also covered by a piped drinking water supply. Prime Minister Bir Shumsher commissioned the first such system in Kathmandu, the first Bir Dhara system (1891-1893 CE). An office for water supply, the Pani Goshowara Adda was also established. It provided private and community standpipes, initially in some parts of Kathmandu and alter in other parts of the Valley. The ruling family – apparently

primarily the women – also established water pipes in Patan in 1905 (drawing water from springs to the south of the town, and constructed by Indian-trained Nepali engineers), in Pokhara and Jajarkot in the western hills in 1921-24, and at Dhankuta in the eastern hills during the late 1920s (Landon, 1928b, pp. 196–197). In 1939, Rana generals presided over the opening ceremony of a piped water supply in Kirtipur, marking the completion of the Valley's provision (Betham, 1939).

These state-led initiatives in canal irrigation, hydropower and drinking water showed that the Rana administration was beginning to think in terms of the 'developmental state' – one which governed as much through development as through the coercive power of sovereignty (For classic discussions of the relationship between development and governance, see Escobar, 2012; Ferguson, 1994. For a critique of their ideas in South Asian context, see Daechsel, 2015; Roy, 2007). As new scholarship shows, development might have played a greater role in late-Rana discourses of statecraft than historians have recognised (Gyawali 2017). Nevertheless, Rana water projects were far smaller in ambition and impact than the high-modernist mega-projects that Scott (1998) and Mitchell (2002) have persuasively argued were often characteristic of twentieth-century statecraft. Nor did they aim at the sweeping expansion in, and alterations to, water-supply systems that would accompany the beginning of the hydraulic mission.

Rana development, then, focussed narrowly on the Valley and parts of the Terai. The other regions that made up the country, particularly the northern mountain areas, were neglected. This is partly because of the difficulty of communications: travel was slow. More importantly, though, the Gorkha and Rana regimes showed no interest in developing agricultural resources in the uplands. Regions such as Manang district, in north-central Nepal, even now mix farming on the valley floor with 'high mountain' agriculture on the surrounding slopes, where people rely primarily on raising livestock, alongside growing potatoes, barley, wheat and millet. This is a very different proposition to the rice agriculture that dominates the hills and the Terai, since the crops used require less water than rice, and farming is done less intensively. Mountain settlements were traditionally seasonal, with herders

taking cattle to higher elevations during the summer, when fodder became scarcer downhill, and coming back to lower elevations during the cold winters (see Aase et al (2010) for a contemporary perspective on Manang agriculture). Even if the rulers in Kathmandu had wanted to institute large-scale irrigation systems in Manang, the topography would have made such an effort fruitless.

Moreover, regions such as Manang and neighbouring Mustang commanded passes toward the north, and were chiefly valuable as a trade corridor to Tibet, especially for the salt trade. As a result, trade culture was more important than agriculture, and certainly better able to produce a taxable surplus. (Manangvi traders even travelled and traded internationally (Ratanapruck, 2007), which was fairly unusual at a time when most Nepalis could not easily leave the kingdom.) As a result, the Gorkas and Ranas were able to extract taxes on trade rather than on agriculture, and the limited surviving records indicate that relations between Kathmandu and mountain regions were primarily framed around the appointment of local headmen to collect and remit such taxes, with minimal intervention into mountain affairs (for example (Regmi, 1970, p. 99, 1976, pp. 6–7)).

To summarise this section, topography and the slow, piecemeal development of state capacity meant that the hydraulic mission did not develop. Even its limited evolution in the Valley could only reach a small section of Nepal's population: according to the 1920 census, the Valley had a population of only around 367,000, against more than three million in the mountains (Landon, 1928a, p. 258; Landon notes that there are some inconsistencies in the 1920 census figures, so these should be taken as indicative rather than definitive). It is not clear who conducted the census, or how. Canal development in the Terai, which had almost 2.2 million residents, had more potential to spread the hydraulic mission. But, as we have seen, only one canal system was introduced there. However, the early Rana period did begin to formalise the state's relationship to the natural environment and resources, especially though land laws, and the later Rana period laid some of the groundwork for hydro-development.

Modern: 1951 to contemporary

The Rana government fell from power in 1951 and power shifted back to the king. Several decades of political change followed, often tumultuous. The new royal government first experimented with parliamentary democracy (1959-60), then dissolved parliament in favour of a 'panchayat' system of controlled and localised democracy, and then returned to party-political democracy in 1990. However, a Maoist insurgency erupted in 1996; and, following a royal attempt to re-take absolute power in the mid-2000s, a reconstituted parliament abolished the monarchy in 2008.

The decades since 1951 have therefore witnessed considerable political instability, but all of these changing regimes at least nominally prioritised welfare and economic development (Whelpton, 2005, p. 122). Moreover, political continuity is not necessarily a requisite for the intensification of water resources development. In nearby Pakistan, for example, the hydrocracy (and the hydraulic mission) thrived under democratic government and military dictatorship alike (Akhter, 2013, Akhter, 2015; Haines, 2013). Indeed, it is difficult to map political changes neatly onto changes in water management. This echoes our analysis of the pre-1951 situation, though we did show that water management was becoming a meaningful arena for the exercise of state power by the early twentieth century. Similarly, Nepal's transition into the hydraulic mission and then the reflexive modernity stage represented the increasing entrenchment of the country's developmental state.

The state's role in water management from 1951 onwards can be broadly classified into three periods: planned development (1951-1970), intense development (1970-1985), and integrated and participatory approaches (1985-present). Each period is characterised by various policies and acts indicating the state's water management plans. As we will see, the earlier phases intensified the late-Rana period's tilt towards irrigation on the Terai lowlands, while later developments moved uphill, towards hydropower projects in the hills and mountains.

Planned development: 1951-1970

This period represents the launch of Nepal's hydraulic mission (industrial modernity stage), with the state hydrocracy, namely the Department of Canal, as the carrier. The Department was established under the Ministry of Construction and Communication in 1952 to oversee irrigation development, subsequently evolving into the Department of Irrigation in the 1970s. At this time drinking water provision as well as hydropower were under the organisational remit of the Department of Canal. Formal management and development by the state was initiated from 1956 onwards in the form of Five Year Plans, a central national planning approach of the government to drive economic and social development in Nepal. The five-year plans mirrored the practice of neighbouring India (Whelpton, 2005, pp. 125–126).

The Development Board Act (1956) was one of the state's first measures to provide planning guidance for a variety of development initiatives, including irrigation and drinking water (GoN, 1956). It is also considered to have provided a favourable environment to encourage international donor assistance in infrastructure development (Interview 1 and 5). Three acts defining the state's involvement included the Irrigation Act (GoN, 1961), the Water Tax Act (GoN, 1966), and the Canal, Electricity and Water Resources Act (GoN, 1967) (Table A1). These Acts initiated and entrenched water-management plans in the state's legal and financial regime. Limited provisions were made to involve non-government actors in the legislative and policy formation process, nor during the management of public canal irrigation schemes.

The area under irrigation grew substantially during this period, with the total area estimated at 80,000 ha by 1970 (FAO, 2012; GoN, 1988) (Figure A1). The geographic focus was concentrated on the Terai (including the Khageri, Rupandehi, Rautahat, Tinau and Dhanusha irrigation systems), the Kathmandu valley (Tika Bhairav, Mahadef Khola, Pashupati and Budhanilkantha systems), and the Pokhara valley (Viyayapur system), and a small number of sites in the hills. By contrast, the vast majority of farmers, particularly in the hill and mountain regions, were engaged in small-scale FMIS,

receiving limited technical and financial support from the state. The lack of capacity to undertake water infrastructure development prompted the state to seek bilateral assistance, with engineers from India and funding and technical support from the USA, focusing on the construction of public canal irrigation systems, hydropower and water control structures. The most significant project, the Koshi flood control barrage, was completed in 1963 with Indian capital and technical expertise, geared primarily towards Indian benefit (Government of India, 1961, pp. 50–52).

The pace of hydropower development during this period was relatively slow. The Panauti hydropower plant (2.4MW) was the first to be constructed in 1965, followed by the Tinua (1MW) and the Trishuli (25MW), both constructed in 1967. These hydropower plants were the first to provide electricity to Nepali citizens, since previous plants had supplied electricity exclusively to the ruling elite (Interview 1, 4). By 1970, cumulative hydropower generation capacity was around 40MW (Sharma & Awal, 2013) (Figure A2).

Coverage of government-installed piped drinking water focused on urban areas (Kathmandu and Pokhara) and some district headquarters in the Terai and hills, but not the mountains. The vast majority of rural communities in the Terai, hills and mountains were dependent on other sources, such as groundwater springs and rivers (Sharma et al., 2016) (Interview 1). Piped drinking water coverage at the national level was 6% by 1970 (GoN, 1970).

In summary, during this period the legal framework defined a centralised and top-down role for the state in water management, primarily concentrating on the construction of public irrigation canals in the Terai region in order to maximise yields and economic returns. The administration's choices regarding water development had wide-ranging impacts, including on the country's demography. During the 1950s and 1960s there was substantial migration from the hills and mountains into the Terai (Whelpton, 2005, p. 123). While most people moved on their own initiative rather than due to official relocation schemes, the development of irrigation and associated livelihood opportunities in the Terai was a pull factor (Interview 1, 4, 5). Yet such irrigation development largely over-looked the

majority of farmers practicing FMIS and population concentrated in the hill region, as well as the mountains (Gyawali, 2003) (Interview 2, 9). While the hydraulic mission had begun, it remained selective, focused on the Terai region.

Intense development: 1970-1985

This period is defined by the acceleration of Nepal's hydraulic mission, characterised by a rapid rate of public canal irrigation construction in the Terai. Multilateral assistance – significant loans and technical advice from the World Bank and Asian Development Bank – financed expansion. This was justified as needed to stimulate economic growth, expand agricultural production to achieve national food security, and enhance rural livelihoods in order to reduce poverty (Interview 2, 6, 8, 9 and 10). Such state-led infrastructure development aligns with the pursuit of industrial or high modernity, a vision of how the benefits of technical and scientific progress might be applied in every field of human activity (Scott, 1998). More locally, it was part of a push by King Birendra, who came to the throne in 1972, towards economic development through regional planning, resource conservation and education. Significantly for our argument, he also promoted agriculture in the hills (Whelpton, 2005, p. 126), which marked part of a shift away from the Terai's domination of public sector irrigation schemes.

The Department of Irrigation led efforts to accelerate the rate of public canal irrigation infrastructure development, and hence increase their control of surface water. This can be interpreted as an exertion of power (Foucault, 1991; Shore & Wright, 1997). During this period, according to one interview respondent (Interview 1), the Department of Irrigation would have better named the 'Department of Concrete', more interested in the amount of money spent on irrigation works than the volume of water supplied to farmers and the area of land irrigated. The state, along with private infrastructure construction companies, development banks and politicians, constituted an iron rectangle of actors, a synergistic relationship in which 'the ways flows of water are created or modified by water infrastructure [and] are intertwined with flows of power and influence, often

manifested in the form of political or financial benefits, whether private or collective' (Molle et al., 2009, p. 336).

By 1970 the total area under irrigation had risen to around 450,000 ha (FAO, 2012) (Figure A1), including Kankai, Mahakali-I and Narayani systems. The geographic focus was primarily concentrated upon the construction of public canals in the Terai, albeit with a few appropriate sites in the hills (Interview 2, 7). The pace of hydropower development quickened, with the Kulekhani I (60MW), Kulekhani II (32MW) and Marsyangdi (69MW) stations raising cumulative generation capacity to 130MW by 1985 (Figure A2).

In 1972 the Department of Water Supply and Sewerage was established. Construction of piped drinking water concentrated on urban centres (including Kathmandu Valley), district headquarters and accessible rural areas within the hills and Terai. Communities in less accessible areas of the hills and mountains were largely left to their own devices to locate and maintain drinking water supplies, mainly from groundwater springs and rivers (Interview 3, 5, 10). No statistics are available on the level of drinking water coverage for this period.

Relatively fewer acts were passed during this period, with previous legislation providing justification for the state's approach (Table A1). The Soil and Watershed Conservation Act (GoN, 1982) focusing on watershed management represented the first tentative move by government to address smaller-scale water management (Interview 3, 6, 8, 9). However, lack of government capacity and funding constraints limited its effectiveness, with plans representing policy statements of intent lacking effective implementation (Thomas & Grindle, 1990). Towards the end of this period based on pilot project experiences initiated by international actors (e.g. UNICEF participatory water supply and sanitation projects, and USAID-supported irrigation management projects), disconnect between government water service provision and majority community needs began to become apparent (interview 1, 5, 8, 9). Furthermore, public awareness campaigns highlighted negative environmental and social impacts of large dams in the Himalaya (Interview 5, 8) (Dhawan, 1990). Owing in part to

pressure from international actors, Nepali non-governmental organisations and community groups, certain sections of the government realised that environmental impact assessments of large-scale water projects were required, in addition a more participatory and integrated approach to water management (Interview 1, 3, 7, 9) (Gyawali, 2003). This represented embryonic movements that initiated the reflexive modernity stage of water management paradigms from 1985 onwards.

In summary, the construction of large-scale infrastructure was considered the primary solution to meet growing demand for water, in order to increase agricultural production and promote economic growth. However, the results were far from satisfactory, as witnessed by inter-sectoral and inter-regional riparian conflicts, in addition to insufficient water provision for irrigation and drinking water, particularly in the mountain region (Interview 1, 4, 5, 9, 10) (Gyawali, 2013). The rapid expansion of both the physical water infrastructure and institutional framework consolidated state control over an increasingly important economic and political system.

Topography remained an important determining factor. Drinking water initiatives continued to focus on urban centres in the hills, especially seats of regional government, echoing the previous focus on Kathmandu. Meanwhile, irrigation development focused on the Terai, where public canal systems could bring large tracts of land under agricultural production. The influx of foreign capital and technology enabled the state to sponsor an increased pace of development, which helped to create a similar planning-centred developmental state that India had developed thirty years earlier.

Participatory and integrated approach: 1985-2018

This period witnessed a paradigm shift in the state's policy and legislative approach towards the reflexive modernity stage of water management paradigms (Allan, 2003). Acts and policies were passed that encouraged environmental assessments of infrastructure-based water projects (the third paradigm identified by Allan), economic valuation of water (fourth paradigm), and stakeholder participation in the development and management of water projects, encapsulated by IWRM

principles that recognise political and institutional dimensions (fifth paradigm). Throughout this period the state has remained committed to implementing the hydraulic mission, whilst at the same time, introducing reflexive modernity paradigms as statements of intent.

Aligning with participatory elements of the Soil and Watershed Conservation Act (GoN, 1982), the Basic Needs Program (1987) recommended greater farmer participation in managing irrigation schemes at all levels. The restoration of democracy in 1990 helped galvanise efforts to promote more inclusive approaches. While the conflict with the Maoists in the following years hampered notable progress (Interview 1, 2, 4, 5, 9), the link between democratisation and the need for a new water-management approach demonstrated the extent to which the latter was embedded within the broader political context.

From the early 1990s onwards, legislation and policies promoting paradigms of reflexive modernity included the Water Resources Act (GoN, 1992), Water Resources Strategy (GoN, 2002), and Irrigation Policy (GoN, 2003), and more recently, the climate change orientated plans and policy (Table A1). On paper, if not necessarily in practice, the state had moved towards a more participatory approach to water management. This is partly in line with the emphasis that major international donors such as the World Bank placed on the decentralisation of development processes since the 1990s, in addition to the World Commission on Dams Report (2000) which highlighted detrimental social and environmental effects of large-scale water infrastructure projects (Interview 1, 3, 4, 5, 6, 9) (Dixit & Gyawali, 2010).

Continuing irrigation differentiation between regions highlights the triangular relationships between state, farmers and water resources. By 2007 an estimated 1.2 million hectares was under irrigation in Nepal (Figure A1) (FAO, 2012). Government-managed public irrigation schemes focused on the Terai (an estimated 31.9% of irrigated land), with minor presence in the hills (5.9%) and mountains (1.9%). Conversely, independent FMIS still dominated in the hills (75.1% of irrigated land) and mountains (78.9%), significantly less than in the Terai (33.2%) (Table A2). Independent FMIS are considered to be more efficient than public irrigation schemes (Joshi, Ostrom, Shivakoti, & Lam, 2000).

The pace of hydropower development was significantly hampered by political change in early 1990s with the restoration of democracy and the Maoist movement, in addition to environmental protest movements (Interview 3, 4, 5, 9). However, since the late 1990s, the relative pace of development has increased with the state consolidating its role, in part a result of opening the sector to private investment and foreign construction companies. Hydropower stations such as Kali Gandak A (140MW) and Middle Marsyangdi (70MW) completed in 2002 and 2008, significantly increased national generation capacity, standing at 750MW[1] in 2015 (Sharma & Awal, 2013) (Figure A2). Over 80 projects with a total of 1500MW generation capacity are in various stages of planning and construction in the hills and mountains (Interview 1, 3). These projects are funded by donors and development banks, engaging private sector construction firms. Further plans for hydropower development are earmarked in the hills and mountain regions (Interview 1, 3, 5, 6, 8, 10). The state is consolidating the hydraulic mission in a new medium of water infrastructure. However, Nepal is often cited as under-utilising its 83,000 MW of hydropower potential, owing to technical challenges associated with rising terrain, compounded by financial, political and regulatory difficulties (Sovacool, Dhakal, Gippner & Bambawale, 2011) (Interview 1, 3, 5, 7, 8, 9, 10). The vast majority of hydropower plants are run-of-the-river, impounded year-round reservoir storage with hydropower capacity is rare in Nepal.

A clear urban bias still exists regarding the provision of piped drinking water. The World Health Organization estimates that 45% of urban areas and 2% of rural settlement had access to piped water in 1990, rising to 50% and 18% respectively by 2015 (World Health Organisation [WHO], 2015). Urban settlements are concentrated in the Terai, the Kathmandu Valley, Pokhara and accessible areas of the hills, relative to the mountains. While the technical challenges of topography and types of settlement influences the government's provision of piped drinking water, an effect of these discrepancies is that the state maintains strikingly varied hydraulic relationships to its citizens.

Perhaps the most important feature of this variation is that the state tends to play a planning and management role on the Terai, but frequently operates in a responsive mode in the hills and especially in the mountains. In Dannevig's study of water development in two villages of Manang district in the high mountains, for example, respondents told him that *de facto* control of irrigation systems had always remained with users, despite the existence of a bureaucratic mechanism for planning, approving and constructing new irrigation works (Dannevig, 2005, p. 64). This contrasts with the above examples from the Terai, which involved an intensive planning and construction process, managed by the state. Nearly seven decades after developmental rhetoric emerged in Nepali politics in the 1950s, water-management efforts still pool downhill.

Conclusion

By considering the development trajectory of water management paradigms in the three regions of Nepal, we highlight an understanding of the spatial and temporal process by which the state initiated and subsequently consolidated its control of water through the hydraulic mission. These shifts in water management both reflected and contributed to the respatialisation of state power. We have demonstrated that the state's role in water management in Nepal can be understood as occupying and being shaped by the interstice between topographical contours and political history.

Topography has defined the state's involvement and choice of water management infrastructure over time. During the pre-modern paradigm the state's involvement in water was historically focused on Kathmandu Valley, characterised by the construction of limited canal irrigation and piped drinking water serving the needs of the elite who resided in the valley (eighteenth to early twentieth centuries), with the remainder of the population reliant on small-scale traditional irrigation systems and drinking water from springs and river sources. Travelling downstream to the Terai in the 1960s, the state initiated its control of water through the launch of and acceleration along the hydraulic mission. The construction of public canal irrigation systems transformed the agricultural landscape. At the time, the Terai offered the most viable option for the government to expand its involvement in water management beyond the Kathmandu valley, with the flat-lying terrain conducive to the construction of public canal irrigation infrastructure. However, as the available area in the Terai became increasingly utilised by public canal irrigation, the state began to look upstream to continue infrastructure development. Moving uphill to the hills and mountains, the state has consolidated the hydraulic mission in a new medium of water infrastructure, through hydropower development since the late 1990s. Although the state intended to rapidly develop hydropower in the hills and mountains within recent decades, the pace of development has been hindered by topography and associated technical construction challenges with rising elevation and extreme terrain. Topography can therefore still be seen to be a defining factor in the state's choice of water management and pace of infrastructure development over time within Nepal.

At the same time the institutional landscape, which embodies the hydraulic mission, has proved a powerful influence on state water management since the 1960s. The hydrocracy - set within the iron rectangle of actors including politicians, banks and infrastructure construction companies – resists fundamentally changing its primary focus on large-scale infrastructure development, and hence diminishing its control of water and power. Reflexive modernity paradigms promoting reform, participation and integration, introduced by policies and acts from the mid-1980s onwards, have largely remained symbolic, constituting statements of intent without effective institutions and

organisational capacity to transform them into practical reality (Merrey, Meinzen-Dick, Mollinga, & Karar, 2007).

Until the late twentieth century, water management in the mountains was largely a local affair; in the twenty-first, it is becoming increasingly nationalised, as national-level agencies take on upland flood-control and hydropower projects. State power has not only become more *intensive*, through the increasing intervention into day-to-day life that is the hallmark of modern states (Foucault, 1991), but also more geographically *extensive* as Kathmandu has expanded the areal extent of its de facto authority. Over time, political power has travelled uphill in order to meet the water that travels downhill.

The hydraulic mission model has proved helpful in explaining the phased development of water management in Nepal, but our study also offers an opportunity to reflect on the theory itself. It was originally developed in contexts of semi-arid and geographically larger countries, where topography was relatively more conducive to large-scale canal irrigation systems, particularly in the flat-lying deltas of large rivers. The fact that we can apply it in Nepal's extreme topographical variation demonstrates the theory's value and versatility. We have shown the extent to which the model needs to account for geography as well as temporality. In Nepal, the early phase (historical) focused on valley and hills, later phase on Terai, and the most recent phase climbing uphill to the hills and mountains. Pronounced topographical differences proved as important a variable as time.

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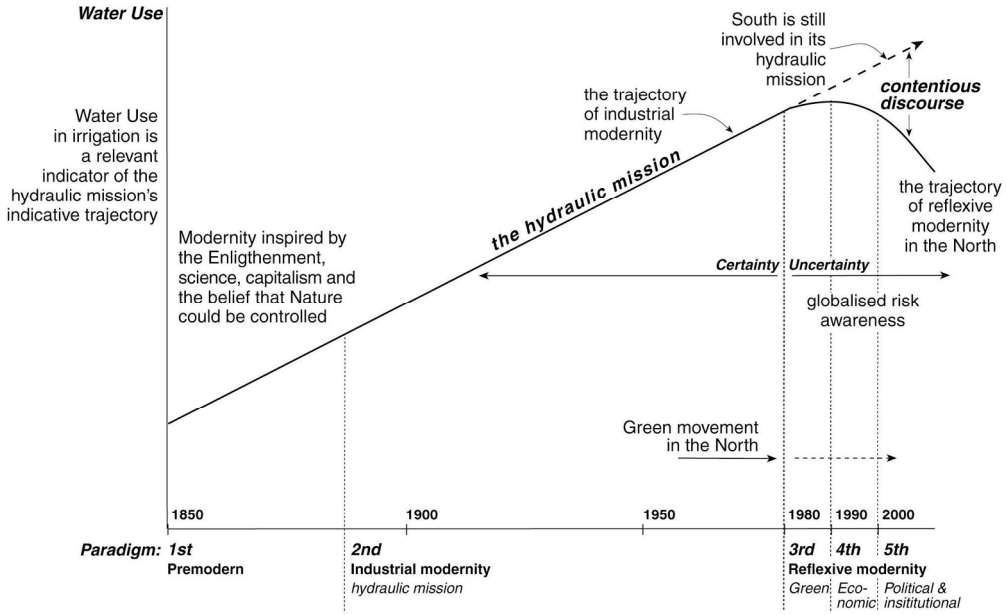

Figure 1: Paradigms of water management (Allan, 2003)

530x332mm (96 x 96 DPI)

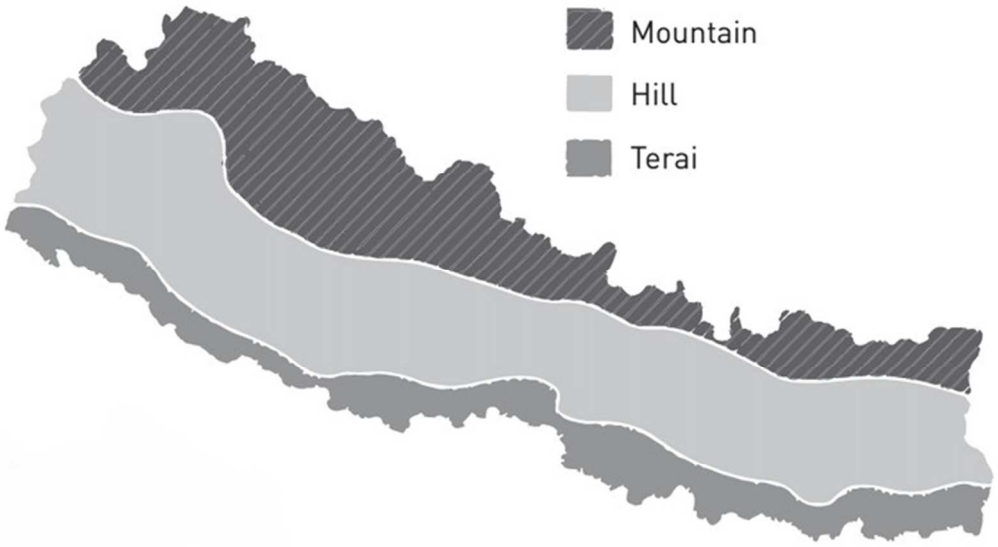

Figure 2: Regions of Nepal

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Table 1: Interview respondents

	Type of Organisation	Job title	Number of interviews
1	Nepali Government	Former Irrigation Minister	One
2	International Organisation	Water and irrigation specialist	Two
3	Nepali NGO	Water specialist	One
4	Academia	Natural resources specialist	One
5	International donor	Livelihood development adviser	One
6	Academia	Water policy specialist	One
7	International Organisation	Agriculture specialist	One
8	International Organisation	Water and development specialist	One
9	Nepali NGO	Livelihood Development Advisor	One
10	International Organisation	Water management specialist	One

Supplemental material

Appendices

Table A1: Government of Nepal legislation, 1961 to 2011 (GoN, 1961; 1966; 1967; 1982; 1992; 1999; 2002; 2003; 2005; 2010; 2011b; 2011c).

Legislation	Salient points
Irrigation Act (GoN, 1961)	• Encouraged the construction and maintenance of irrigation channels; plans for the construction of drinking water supplies and sewerage networks; collection of water charges for irrigation and drinking water. • Legal provisions made for water users, emphasising the importance of irrigation development to promote agricultural production and enhance national food security.
Water Tax Act (GoN, 1966)	• Water taxation and licensing for all users, including drinking water provisions for large urban areas including Kathmandu and Pokhara.
Canal, Electricity & Water Resources Act (GoN, 1967)	• Legal framework including definition of water taxation and licensing, with an emphasis on irrigation and hydropower.
Soil and Watershed Conservation Act (GoN, 1982)	• Represents first tentative move to address small-scale local management issues. • Focus on watershed management, promoting greater user participation in designing and managing water and agriculture projects.
Water Resources Act (GoN, 1992)	• Comprehensive legislation bringing all water users together for the first time. • Endowed ownership of water resources to the state, ranking eight water user groups in priority order, with drinking water considered top priority, followed by irrigation. • Stressed the importance of developing hydropower capacity. • Legal recognition given to Water User Organisations, enabling Farmer Managed Irrigation Systems (FMIS) and public irrigation systems to collect fees from users to finance cost recovery, including operation and maintenance costs. • Economic valuation of water use and allocation.
Water Resources Regulation (1993) (GoN, 1993)	• Delegated power to District Water Resources Committees, consisting of multidisciplinary government and non-government stakeholders and users to resolve disputes, sanction permission for water use and issue licences. • Advocated the formation and registration procedure for Water User Organisations.
Irrigation Regulation (GoN, 1999)	• Provided legal and technical guidance on Water User Organisation registration, responsibilities and rights under licence fees. • Set rules on management transfer of public irrigation systems to local users including joint management.
Water Resources Strategy (GoN, 2002)	• Advocated integrated water resources management, identifying concepts and practices of holistic management between stakeholders at the river basin level. • Environmental assessments for water infrastructure projects.
Irrigation Policy (GoN, 2003)	• Expanded upon concepts of decentralisation, particularly autonomy of farmers in financing and managing irrigation systems in order to transfer pubic systems. • Focused on FMIS and called for a strengthening of capabilities of Water User Organisations for the participation of users in planning, construction and management of irrigation systems. • Advocated the strengthening of institutional capacity and improving inter-ministerial and department coordination within government. • Importance of developing year-round irrigation, both during and immediately after the summer monsoon.

	• Called for the development of storage facilities (at all scales) for the provision of water during the dry season.
National Water Plan (GoN, 2005)	• Detailed the framework to implement the Water Resources Strategy (2002). • Set of short, medium and long-term action plans detailed for programme and project activities, investments and institutional aspects.
National Adaptation Programme of Action (GoN, 2010)	• Overview of potential anthropogenic climate change impacts across sectors, including water resources and agriculture. • Sectoral adaptation responses for water and agriculture.
Local Adaptation Programmes of Action (GoN, 2011b)	• Developed involving community members in pilot project areas across Nepal, identifying livelihood vulnerabilities and adaptation responses for the water and agriculture sectors.
Climate Change Policy (GoN, 2011c)	• Detailed adaptation and mitigation objectives, identifying vulnerabilities across sectors. • Identified capacity building requirements to increase resilience of communities. • Called for a strengthening of government institutional structures and procedures. • Provided a financial needs assessment. • Adaptation responses for water and agriculture including disaster risk reduction, particularly for floods and droughts.

Table A2: Regional division of irrigation type in Nepal (FAO, 2012)

Irrigation type and area (Ha)	Mountains	Hills	Terai	Total
Irrigable area (total under government public canals and FMIS)	52,000	253,000	786,000	**1,091,000**
Government managed systems (public canals)	1,000 (1.9%)	15,000 (5.9%)	251,000 (31.9%)	**267,000 (24.6%)**
Government assisted FMIS	10,000 (19.2%)	48,000 (19%)	274,000 (34.9%)	**332,000 (30.4%)**
Farmer Managed Irrigation System (FMIS)	41,000 (78.9%)	190,000 (75.1%)	261,000 (33.2%)	**492,000 (45%)**

Figure A1: Historical growth of irrigation area in Nepal (public canals systems and FMIS) (FAO, 2012)

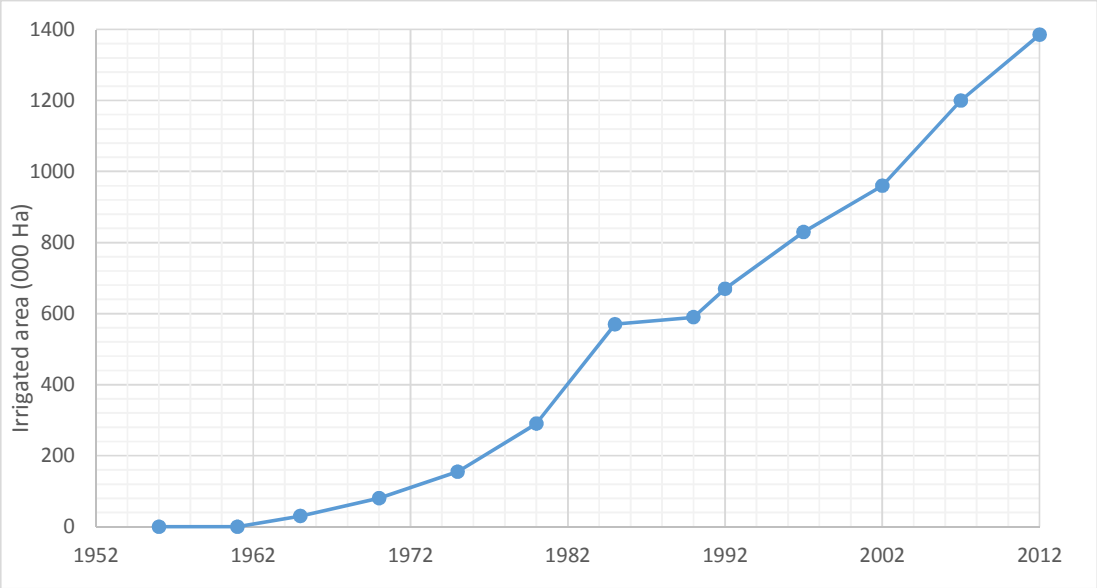

Figure A2: Historical development of cumulative hydropower generation capacity in Nepal (adapted form Sharma and Awal, 2013)