Water as "time-substance": the hydrosocialities of climate change in Nepal

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Abstract

This article develops a novel theoretical framework to explain how water's situatedness relates to its political agency. Recent post-human scholarship emphasises these qualities, but surprisingly no sustained analysis has been undertaken of this interrelation. Here we do so by theorizing water as a "time-substance" to reposition human hydrological struggles (including those exacerbated by climate change) around the topologies and temporalities rather than the spatialities of water. This innovative approach opens up new areas of geographical enquiry based on *hydrosocial forms, hydrosocial transformations* and *hydrosocial information* (collectively referred to here as hydrosocialities). We contend hydrosocialities enable the tracing of human-water relations that transcend times and scales, and the matricial categories of subject and object to overcome the situated-agential binary of water. Drawing on two years' fieldwork in Mustang, Nepal, this conceptual framework is deployed to examine hydrosocialities in two remote mountain communities. We show hydrosocialities comprise diverse water knowledge-practices constituted from multiple points of proximity between the social and the hydrological in space and time. In turn, this conceptual framework underscores the importance of boundary objects in mediating water's situated-agential qualities. The article concludes that consequently boundary objects can play a crucial role in producing new practical hydrosocial politics of climate change mitigation and adaptation.

Introduction

Water as a field of geographic enquiry has a long pedigree (Thornthwaite and Mather 1955; Tuan 1968), with recent debate in the social sciences focussed on two contentions. The first emphasizes places-based and situated practices in anchoring water's production. The second

underscores water's agency, with its fluidity flowing across scales to challenge human primacy in decision-making, for example by bestowing "tool-power" on infrastructures such as dams and reservoirs (Meehan 2014, 215). Both contentions are linked in their assertion of the indivisibility of the hydrological and the social, or the 'hydrosocial', encapsulated in concepts such as the hydrosocial cycle (Linton and Budds 2014).

Moreover, both contentions invoke water as transcending time to create "a material linkage between past and present" (Barnes and Alatout 2012 485), exercising power over/power through the social (Dombrowsky 2003); a substance with multiple ontologies, fusing nature and culture together over time in innumerable ways (Morrison 2015); and most recently as a protean force with beneficent and minatory qualities, manifested strongly in the Anthropocene through hydrologically-related climate change effects (Braun 2015). It is evident therefore that water not only inveigles multiple social spaces and places, but also permeates multiple times. Yet despite these complementarities between situated and agential perspectives, current social science scholarship does not offer the analytical tools to scrutinise this crucial interrelation or the manifest ways in which it shapes contemporary studies of water. Resolving this difficulty would we contend permit fundamental new insights into the imbrication of the hydrological and the social.

This paper fills that gap. We do so by drawing upon topological understandings of space and time to develop an holistic account of water's situatedness and agency, arguing that such insights enable hydrosocial space and time to be more easily apprehended, opening novel possibilities to comprehend the hydrosocial as co-evolutionary patterns of human-water relations. Drawing on a range of sociospatial and sociotechnical literatures, we develop a novel theoretical framework, deriving inspiration particularly from the philosopher Michel

Serres. Across a voluminous output, Serres foregrounds the topologies and temporalities rather than spatialities of matter. We contend this offers analytical purchase on the question of water's situated and agential properties. Specifically, Serres's conception of matter percolated by time enables exploration of the permeable boundaries of human ordering of water/water ordering human activities.

We illustrate this approach using novel empirics derived from two year's fieldwork in two remote mountain communities in Nepal, where place-based practices and customary institutions position water as simultaneously situated and agential. Mountains inflect these relations by connecting low and high altitudes and diverse climatic, geologic, social and political identities (Balsinger and Debarbieux 2015) to yield complex water knowledges and practices. Nepal is a pre-hydraulic society in Wittfogel's (1957) sense, where the daunting challenge of projecting a national political presence among over 120 ethnic groups means the state is only now articulating with centuries-old community water institutions. Simultaneously, these institutions are being stretched by rapid social, demographic and climate change. Yet as we show, a topological perspective confirms water as always overflowing and potentially transformative.

The article first outlines situated and agential accounts of water in geography. We then introduce Serres's work, arguing that his topological perspective offers a promising means of overcoming the situated/agential binary that characterises so many studies in the contemporary social sciences on water. We show how the resulting novel theoretical approach provides fresh ways of thinking through the multiple forms and transformations of water, not only furnishing insights into its properties, but also shedding light on pathways to more politically progressive climate change adaptation and mitigation strategies for water.

Reconceptualising geographies of water: from spatialities to topologies

A wealth of geographical literature demonstrates how place matters to the social construction and practices of water (Perreault 2008; Gamble *et al*. 2010). This work derives from anthropology and political ecology debates that are sceptical of universally applicable knowledges (Shapin 1998; Forsyth 2003), maintaining instead the significance of material-geographic settings in which actors make competing water claims. These studies attest to the ways water is locally produced and given effect (Fonstad 2013; Laver and Aswani 2009; Wilson 2014). Thus, Hoogesteger and Verzijl (2015) show how community practice underpin political consciousness and human agency over water, with recent work from this perspective foregrounding the role of "hydrosocial territories" in everyday water management (Boelens *et al*. 2016).

At the same time, geographers have emphasised water's forcefulness that transcends places to challenge human primacy in decisionmaking (Bear and Bull 2011; Linton 2014). Scholarship from this viewpoint has adopted a variety of approaches to examine water's quasi-agency. For example, Meehan (2014) explores how human reliance on water infrastructures to produce the Mexican state confers power on these structures. By contrast, Schmidt (2014) demonstrates that in the US in the 19th century civil engineers implicitly recognised water's vitality in planning the country's abstraction needs.

Of course, water's agency is often rooted in its situatedness. This is neatly conveyed in Strang's (2014, 140) observation that "Water's core meanings as a life-generating, life-connecting source…recur so reliably in different cultural and historical contexts that there is little choice but to conclude that its material properties are relationally formative".

Edgecombe (2014) and Davies (2014) concur with Strang on water's agency complementing its situatedness, but there is less clarity among these authors on how to make sense of the ways the hydrological and the social interrelate.

Situated and agential perspectives thus offer broadly consonant epistemologies of water as hydrosocial. However, we argue there are crucial gaps in our understanding of how these perspectives interrelate with which geographers should engage. First is how shared concepts of water and the social – notably the hydrosocial cycle – can be advanced from dialectical tropes to a more holistic footing. Second is to provide a more forensic account of geohistorical relations between water and society, which have been critiqued as insufficiently nuanced (Schmidt 2014). Third is resolving satisfactorily how diverse water knowledges derived from different worlds of relations (eg. indigenous, modern, scientific) connect. This article seeks to advance hydrosocial debates on all three fronts. To do so, Banister (2014, 208) suggests a productive way forward in commenting that "to explore water flow at those points where humans come into close contact with it is to understand such points as fusible hydrosocial links between different scales". This flags water transcending spaces, scales and levels, suggestive of analytical consideration from a topological viewpoint.

We argue Michel Serres's work provides the foundations for such an approach. Serres (1982, 1991, 1994, 1995) claims solids, liquids, gases and plasmas are primal states of matter that both embody and propagate history: that is, in Connor's (2004, 108) felicitous phrase, matter is a "time-substance[i]": "Matter is not just sunk in and subjected to time, but is internally riddled with it. Time is stored in and emitted by matter, rather than matter being buried in...time" (Connor 2009, 5). As matter percolates time, it is vested with multiple possibilities. Two consequences follow. First is that matter's physical state and social relations are continually evolving. In effect, matter comprises bundles of 'knowledge-practices' that

propagate through time to create new information. We use the semantical construction of 'knowledge-practice' here to convey the inseparability of human understanding from action as it relates to matter (cf. Barad 2003). Secondly, the knowledge-practices bound into matter at any one moment are widely distributed across space and time, transcending geographic and temporal scales.

To understand the resulting dynamic, Serres (1994) foregrounds three aspects: matter's physical *form*; its capacity to *transform*/to be *transformed* by human practice; and the multiplication in *information* about matter that arises through time from transformative acts, and which in turn shapes future transformations. Understanding matter's myriad possibilities therefore requires careful attention to its networks of relations and how these 'pull' places together (drier, wetter, remote, central), as much as to its in situ properties. We argue this topological understanding of matter provides a promising way to reconcile the situated and agential qualities of water. As "time-substance", matter's situatedness is rendered meaningful by human knowledge-practices and networks that are spatially dispersed; while through "time-substance" being simultaneously matter *and* information, limits are imposed on human governability of matter.

Serres identifies water as not simply a liquid but as matter capable of sudden change in physical state. Thus it is an unstable "time-substance" uniquely suited to transformation and to encoding information, as each of its multiple physical states/*forms* (including ice, snow, liquid, aerosol (spray, cloud) and gas (steam)) has myriad associated knowledge-practices. Moreover, through human acts Serres claims time is bound into matter to create distinct histories and development arcs, with potentially *transformative* effects on human societies leading to new *information*.

This approach connects with recent geographical scholarship recommending greater attention be given to the geohistoric, as well as the need to foreground the forms and presences of matter through the material turn. Anderson and Wylie (2009) for example call for work examining the full range of forms, states and phases of matter. Not least, such an approach offers new insight into how the "modern constitution" (Latour 1993) of matter as nature and culture comes about. More specifically the pressing need for work on the geohistorical in water debates is made clear in recent analyses of how water and society imbricate temporally and spatially. Thus Schmidt (2014 230-231) comments on the explicit dangers of ahistorical accounts of hydrosociality: "…water histories matter…we should confront theories of the hydrosocial that see earlier [historical] perspectives…as initially devoid of hydrosocial content", while Braun (2015 240) in a wider consideration of socio-ecological change notes "Although in the Anthropocene time might come toward us from the future…the past continues to haunt the present and [to] ignor[e] this leaves us poorly equipped to address….how we face the future".

We contend that "time-substance" provides a valuable corrective to these absences, by demonstrating how water absorbs and catalyzes societal change: from the 'hard' of (ice-snow) matter, through ripples of social transformation, to the 'soft' of water information. Crucial to this transformation for Serres is *folding*: the act of using physical effort or cultural enactment to render matter as a human resource. Thus water's everyday "projective spaces" (Serres 1982, 44) fold together past and present hydrosocial forms and transformations. In turn, these projective spaces are changed through encounters with different knowledge-practices of the same matter. For Serres, 'outside' (global) knowledge-practices are particularly important here, bending topological time and space to the point where they are

brought into contact with these 'inside' (local) projective spaces, in the process *pleating* or making multiple folds in the knowledge-practices these local spaces are constituted from.

A "time-substance" approach thus offers geographers four ways to elaborate current thinking on hydrosocialities. First is by furnishing topological analytics of form, transformation and information to disaggregate water's spatial complexes. Secondly, matter as "time-substance" enables the geohistorical specificities of water to be captured, addressing shortcomings of current hydrosocial approaches; so 'past times' are retained through place-based artefacts and social arrangements that constitute human adaptation to hydrological events, while these artefacts condition water's emergent social and political transformations. Crucially this differs from conventional historical accounts by being post-human, emphasising things and matter as equally agential to humans; and by emphasising many cyclical times co-existing, rather than positing a singular linear conception of time. Third, "time-substance" offers a novel perspective on water's agency: instead of being vitalist (Bennett 2010), this emerges because of water's thermodynamic capacity to assume different physical states, each of which store information in specific ways, so complicating its governability. In a similar vein, Barry (2015) shows matter's capacity to alter networks of relations by obliging new human practices of measurement, thereby exerting agency through imposing 'limits' to scientific understanding. Lastly, the possible knowledge-practices and networks of relations that inhere in matter as "time-substance" are a source of emancipatory power, potentially leading to more progressive water futures. Thus by conjugating the physical, hydrological and the social, "time-substance" affords new insights not only into primal, but also into the practical politics of water and society (Agnew 2011). Notably, new analytical means are opened to explore hydrosocial resourcefulness to change, for as Barad (2003, 816) comments "The

future is not what will come to be in an unfolding of the present moment; rather the past and the future are enfolded participants in matter's iterative becoming".

Examining water as "time-substance"

Primary research on water as time-substance was undertaken in two Himalayan villages, Dhakarjong and Phalyak, in central Mustang. These villages were selected as representative of growing water availability issues confronting mountain communities in Nepal, and ethnographic methods were used during 2013-2015 to unearth past hydrological events and to identify contemporary practices and likely future challenges affecting them (see Figure 1). The villages share a stream and are experiencing decreased precipitation and increasing conflict over community-allocated water 'shares'.

Fieldwork was undertaken in phases by two Nepali researchers, one with local family connections. In the first phase, researchers spent four months building understandings of water use in everyday life with people in both communities. In the second eighteen-month phase, data collection was undertaken though five interlinked qualitative methodologies as follows, with all discussions conducted in Nepali.

First, open meetings were held to which all villagers were invited to discuss water use, and challenges to current practices. Secondly questionnaire surveys were circulated to all 81 households in Dhakarjong and Phalyak to establish domestic and agricultural water management. Thirdly two mixed gender platform groups were convened in each village of 10-12 people per group, to enable wider discussion of water histories, and to identify personal views and perceptions of water under climate change. These platform groups were advertised to ensure as wide a cross-section of people as possible attended. This was backed up by

purposive identification and involvement of 'hard-to-reach' low income households. Fourth, eight semi-structured interviews were held in each village with office holders (village headman (*ghempa*), the chair of the village council and councillors, and the headman's advisors (*rolo*)), to follow up on findings from the platform groups. Interview questions were open-ended to allow discussions to develop as informed conversations.

<Figure 1 here>

Lastly these activities were supplemented by participant observation over the two-year period by researchers of the everyday water practices of villagers in households, *khets* (irrigated terraced fields) and *baris* (irrigated domestic horticultural plots). The aim was to develop rich qualitative data on historic and contemporary water use. The role of Nepali colleagues throughout the research was crucial in providing grounded interpretation of water practices, especially how situated norms conditioned day-to-day community activities. Researchers also compiled extensive field notes which yielded invaluable insights into the co-evolution of the hydrological and the social in this part of the Mustang *himal*.

<Figure 2 here>

Water in Mustang

Nepal covers *c.*147,000 square kilometers and is divided geographically into three zones: the southern plains or *terai,* the hilly midlands (*siwalik*), and the mountains (*himal*) (see Figure 2). South-north elevation rises from 70 meters to over 8000 meters in just 190 kilometers, with climate ranging from sub-tropical to arctic. Mustang is on the country's northern frontier bordering Tibet. It is located within Nepal's largest protected area, the Annapurna Conservation Area Project (ACAP), and is one of 16 districts classified as remote (*durgam*)

and mountainous (NTNC/ACAP 2009). A popular trekking destination as well as an important pilgrimage site for Hindus and Buddhists (NTNC/ACAP 2009), Mustang's settlements (all villages) are situated at 2900 – 3600 meters above sea level. Despite legislation abolishing caste in 1962, social distinctions remain, expressed in individuals' eligibility for community leadership roles and in marriage restrictions (Haimendorf 1966; see Table 1).

Fieldwork was undertaken in the Kagbeni Village Development Committee (VDC) area. VDCs are Nepal's smallest political units, dependent on the next tier of the state, District Development Committees (DDC), for government funding. Dhakarjong (3220 meters above sea level (m.a.s.l) and Phalyak (3120 m.a.s.l) are situated on a spur above the Gandaki river. The predominant land use is subsistence cropping, mainly barley, buckwheat, potatoes and apples, while vegetables are grown for household use. Water availability has always been difficult in this arid region, and consequently ponds, reservoirs, irrigation channels and seasonal streams and springs play a vital role in community life (see Table 1; Figures 3 and 4).

<Table 1 here>

Dhakarjung and Phalyak share water from a single stream, the Lumbhuk, which originates in mountain snow fields some 1950 meters above the villages. The stream flows due south, carving a deep gorge to the Gandaki river a kilometer and a half away. Water sharing is organized through an inter-village agreement that operates on a day-turn basis, although this is still insufficient to irrigate all agricultural land. Under the agreement Phalyak (with 48 households and 54 hectares (ha) of agricultural land) has exclusive access to the stream for

three days, and Dhakarjung (33 households, and 24 ha) for two days. Phalyak's irrigated area is 30 hectares, with 20 hectares in Dhakarjong. Farmed land area averages 1.12 ha per household, though this masks significant variation in holding size from 0.05 ha to 4 ha in area. In the 2013-14 growing season, 87% of both villages' agricultural land was cultivated, with 13% fallowed. Decreased water availability since 1999 has resulted in land abandonment; in 2013-14 this amounted to 40 hectares, with 0.15 hectare *per* household in Dhakarjung, and 0.4 hectare *per* household in Phalyak abandoned over the last fifteen years.

From 5pm to 5am, the Lumbhuk's water is directed along a main canal, averaging 40-50cm in height and width, to *tsingu* (reservoirs) on higher land above both villages, where it is stored and distributed in day time to irrigate fields via a secondary channel network (see Figures 2 and 3). There are many tertiary channels in both villages feeding individual fields, though some distant plots require water portage. The canal networks are over 100 years old: the exact date of construction is unknown. Originally made of mud, the main canals were partly cemented in 2014. Dhakarjong's tsingu is now also cemented (*c*. 378 square meters), while Phalyak's larger reservoir (1815 square meters) is still the original stone and mud construction.

Households are all entitled to irrigate, but their quota/access varies per inherited rights rather than the land area owned. In practice, households have water access for between 3 to 12 hours a day, receiving their 'turn' once every 30-35 days. There are two cropping periods annually, from mid-April to mid- June and from mid- August to mid- September, for winter and summer crops respectively. Winter crops (naked wheat and barley) are irrigated 3-4 times, with summer crops (mainly buckwheat) needing 4-5 irrigations. Where the canals run

out before reaching khets, villagers must carry water in 5-35 liter barrels up to 100 meters; in general men are responsible for irrigating farmland, but all household members assist.

Women are also expected to manage household water use. This includes water portage (typically in 5-10 liter containers) from community tap stands to households, and managing water for drinking, washing and cleaning, as well as providing for domestic livestock. The agricultural survey showed average water consumption for each household in both villages of 165 liters per day.

<Figure 3 here>

<Figure 4 here>

Decreasing water availability over the last decade has resulted in the villages experiencing supply problems. Shortages are acute from March to May, because of declining winter snowfall and rising year-round temperatures. During 1982-1996, the average annual mean temperature increased by 1.5°C, with an average increase of 0.06° C per annum (Shrestha, Singh and Nakamura 2012); this warming trend is likely to continue (Xu *et al.* 2009). These difficulties have led to people leaving the villages to move to Kathmandu or to emigrate (chiefly to northern India). Both village councils have responded by organizing community works to dig new storage ponds and reservoirs.

Water in both villages is maintained through the *mukhiya* (Nepali: 'principal' or 'main') system of common pool resource management, which dates back about four hundred years (Pun and Pun 2013). Under mukhiya, the village headman (*ghempa*) determines community

water provision. More than that, however, the villages' social structure is defined by mukhiya's place-based water knowledges: so the ghempa is considered the *de facto* village leader, assisted by a group of rolo who have day-to-day advisory and communication roles (Dhakarjong and Phalyak have one and two ghempas, and three and four rolo respectively). This includes fixing dates for crop harvesting, settling agricultural calendars and other field-related activities, as well as enforcing and monitoring water rules.

A pivotal indigenous[ii] water knowledge-practice under mukhiya is the *dhongba.* This is a composite land-water-household-community concept, referring simultaneously to a household's land and water entitlement and to everyday irrigation practice. Dhongba 'binds-in' time, because it is an inherited right – typically, the eldest son is heir to land holdings, becoming 'Dhongba' of the household (sons who do not inherit property are referred as *Farang*, and daughters as *Marang*). Referring to irrigation practice, dhongba denotes water allocation (actual quantities are worked out based on crops grown, with more days for potatoes and less for buckwheat), and to the order ('turns') in which farmers access that water. In addition, dhongba also designates apportioning community work responsibilities to maintain water infrastructure; so based on their water share, dhongba households are assigned a work quota to maintain irrigation channels and reservoirs. Consequently, these households have more community responsibilities than *farang* or *marang,* but wield much greater influence in water management.

In Dhakarjong and Phalyak water is distributed from one land subdivision to another, with farmers irrigating plots turn-by-turn from top to bottom. Ghempas determine dates, time and frequency of irrigation. Farmers misusing water or allowing overflow into neighbouring fields face fines, with the ghempa deciding the exact amount imposed. In this way,

indigenous knowledge-practices underwrite community life by regulating water's handling as a 'resource'. Dates and turns for irrigation are settled for households in advance. Household water access and rights are granted only if members contribute to community work. This varies and, depending on its type, the ghempa, in consultation with rolos, decides whether to involve all households (*lengyi* is community work that applies to all able-bodied villagers between 18-60 years of age) or only *dhongba* (repair tasks associated with irrigation systems implemented by dhongba households).

Village councils in Dhakarjong and Phalyak (in which all households are members) are the main rule-making arenas for mukhiya. These act as customary legislative bodies with responsibility for nominating ghempas and rolos and fixing their terms and conditions (in both villages, these officials serve a one-year term). Through this forum, ghempas adjudicate intra-village disputes over water use. Decisions made at the village councils are read out and recorded. Applying customary law is usually by unanimity, and in extreme cases includes expulsion from the village or terminating household water rights.

Mukhiya could therefore be viewed as demonstrating the value of a situated account of water. But water's agential effects are also apparent. Indeed, it can be argued that in Dhakarjong and Phalyak, water, as much as mukhiya, stores bundles of knowledge-practices over time. Arguably water governs social relations and human rationalities through mukhiya as much as being regulated by it, for it demands effort through everyday community activities, seasonal calendar practices, and infrastructure upkeep. Dhongba is also topological as it links households, property, water rights and decisionmaking across time and space. Moreover, the Annapurna/ Dhaulagiri massifs can increase, reduce or deny Dhakarjong and Phalyak precipitation, highlighting water as a sphere of limited human governability. Water then is as

much topological as situated. Consequently, we contend a more nuanced account of water in central Mustang is possible if it is examined as a "time-substance" transcending history, scales and levels.

Reappraising water as hydrosocial form, transformation and information

Serres's account of matter enables reappraisal of water's situated and agential properties. Its application to Mustang shows mukhiya as not simply a system of place-based social ordering, but instead an ensemble of people (*ghempa, rolo,* and *dhongba* and *farang* farmers), practices (households, irrigation turns and changes) and objects/things (irrigation channels, reservoirs) that sustain a precarious *hydrosocial form*. Here we begin to disaggregate these situated complexities of water using Serres's conceptual framework of matter as *form, transformation* and *information*.

Hydrosocial form

Through its varied physical states water has percolated for millennia through the Annapurna and Dhaulagiri massifs, and these mountains have percolated through water. This is evident in water's hybrid forms, such as rock-ice, ice-air (snow/sleet/blizzard), soil-water (mud), air-water (rain), and even fire-water (hot springs). Water's 'superposition' – this ability to communicate two matter states simultaneously, and to switch gradually or abruptly from one to another – has made it an unpredictable quantity in human activities, alternately benign (eg. gradual snow thawing permitting spring/stream recharge), or dangerous (eg. hybrid forms 'overflowing' as avalanches and landslides). This has given rise to changing hydrosocial form: the nexus of knowledge-practices that constitutes human attempts to respond to and/or control water's physical states. Here we draw out these changes in hydrosocial form, based upon triangulation of primary data sources including oral testimonies of elders and leaders in

the two villages, consulting ancestral water rights documents, and conducting physical field surveys around Dhakarjong and Phalyak. These enable us to piece together pre-existing hydrosocial forms and the ancient projective spaces of water in the upper Lumbhuk khola (see Table 2).

<Table 2 here>

Anecdotal accounts suggest climate in central Mustang in the 18th century was wetter than at present, so more favorable for livestock farming. At that time Dhakarjong occupied a site on higher ground to the northwest of its current site, and ancestral stories suggest it relied on two water *foldings* (ie. human physical/cultural acts imposing control on water by turning it into a resource). First was community harvesting of snow melt, and second impounding high altitude springs and entraining water to small storage ponds. Sometime in the 19th century, the community moved to its current location to take advantage of the Lumbhuk *khola* and the more fertile land on lower mountain ridges. From oral testimonies, a 4-5-kilometer-long gravity-fed canal was constructed at this time to bring waters over a pass from the adjoining Shyang watershed to irrigate fields. Canal maintenance required substantial community effort, not only because its lengthy mud walls were easily damaged by landslides, but also because soil porosity resulted in high seepage. Certainly major labor commitment and community organization was needed, and at some stage in the 19th century the canal was abandoned. Traces of its alignment from Shyang to Dhakarjong were found during the field survey.

During the 19th century, Phalyak village was established below Dhakarjong's new site, and its farming and domestic communities began making riparian claims to the Lumbhuk. Platform

group discussions revealed this claims-making eventually triggered a major inter-village dispute, which was finally resolved in the c.1920s as an inter-village water sharing agreement. According to one respondent, Jhyabling Gurung, an elderly Phalyaki farmer, an influential merchant named Thak Prasad Subba was "crucial" to implementing this agreement. Gurung described how Subba moved to Phalyak in the 1920s, and on his arrival advocated water sharing between the villages, based on alternating exclusive riparian rights. Interviews with Dhakarjhong's village council corroborated this, but added further detail. Subba seems to have held influence with 'outside' state actors, using his position to persuade Phalyakis to grant him land in exchange for facilitating increased water allocation for their village, above that of Dharkarjong's quota; this was written up as a legal deed. In any event, faced by 'outside' formalized legal sanction over 'local' customary rights, Dharkarjong was obliged to accept the resulting 3 day Phalyaki /2 day Dharkarjong water sharing pact that remains in force today. While the village accounts vary, the role of the 'outside' in reshaping prevailing 'inside' water-knowledges is clear, with Subba's state contacts crucial in coercing Dhakarjong's council to reach agreement.

From a time-substance perspective, these accounts demonstrate the human limits of water governability (with the abandonment of the Syang canal), and how water folds human activities as much as human activities fold water, to the point where water's transformational power altered Dhakarjong's physical location. Crucially, these narratives are also revealed as more than conventional historical accounts 'of the past'; rather they confirm the enduring presence of earlier hydrosocial forms in shaping water's contemporary projective spaces.

Water has thus shaped diverse spaces and multiple times to make these two remote mountain communities, and refashioned indigenous water knowledge-practices. One example is the

continual need for community work on *tsingu* (reservoirs). In both villages, water and community identities are remade through reservoir maintenance – digging out land, sealing the bed to prevent seepage, filling and then cleaning/dredging regularly to prevent silting up. Likewise, gendered relations of domestic water use are particularly evident. In homes, women are directly responsible for folding water's potential agency to domestic uses through their physical effort (carrying water back from the Lumbhuk to households), and their organizing water storage and its release using cans, pots and cooking utensils. Elsewhere, water's messiness – its tendency to spill – shapes other lives, with the thick flushes of grass that grow around reservoirs used as livestock grazings before the monsoon. It is in these mundane ways that water's agency materializes. This often occurs subtly; so, during platform meetings in Phalyak with the ghempa and rolos, crops grown, management practices and, crucially, khets' physical location were all recalled by respondents reciting from memory the water allocation of each dhongba household, and painstakingly drawing these as a map to provide a focus for our discussions (Figure 5).

<Figure 5 here>

Countless water foldings over time thus materialise as irrigation practices, channels, ditches and reservoirs, and the customary law of Phalyak and Dhakarjong's village councils. It has also enabled a social class (dhongba) to emerge in Mustang society, whose resourcefulness is reflected in community water discourses and practices. Similarly, the Lumbhuk khola is the focus of a shamanic religious festival or puja performed twice yearly at its headwaters, presided over by a lama (priest) to seek divine intercession for plentiful snow and rain and productive harvests. Taken together, these mundane secular and religious acts have established the cords between hydrology and community life, fashioning development arcs

for the two villages. Hydrological form becomes indistinguishable and inseparable from the social: it is hydrosocial, "a network of multiple bonds where all things, congruent, conspire and consent; a web tied, by a lattice of relations, to the…human fabric" (Serres 1995, 111).

Hydrosocial transformation

In elucidating *hydrosocial transformation*, Serres draws attention to how matter as 'inside' knowledge-practices is subject to deformation from 'outside' knowledge-practices. Platform group discussions in Dhakarjong and Phalyak revealed people now experience increased 'stretching' of community water institutions in response to two recent transformational events, connecting the 'inside' (local) with the 'outside' (global). First is encroachment of the Nepali state into mountainous Mustang, through assertion of national water rights (HMGN 1992). Second is increasing temperatures and decreasing water availability arising from climate change in the Mustang himal, exacerbating volatility in the hydrosocial cycle. As Gobinda Bista, a young farmer from Phalyak, told us "if the Lumbhuk's water level remains like this, then we'll face a loss in summer production of 20 to 25% a year from now on". Deforming pressures are thus being exerted on topological time and space focused on mukhiya, heightening the potential for hydrosocial transformation, as the following examples show.

While villagers have always been wary of state involvement, this had tended to lessen recently because of problems with mukhiya. One example is community work activities (dhongba and lengyi) to cover irrigation maintenance and repairs and pasture and apple orchard management. Minor works are usually sorted immediately. However, in platform groups respondents noted that over the last five years major works had taken longer to arrange, chiefly because of outmigration of younger people. This difficulty, and the

adjacency of state and civil society organizations including an active VDC, the Annapurna Conservation Area Programme and non-governmental organisations (NGOs), means villagers increasingly look to the 'outside' for help. Approaching state bodies is further encouraged by major works being eligible for part-funding by DDC. Yet despite DDC, VDC and ACAP working with mukhiya, customary water practices are also tested by this process. For from a topological perspective bringing the 'inside' and the 'outside' together causes tension between water knowledges, warping the particular conception of time folded into water through mukhiya. Two recent cases shed light on this process.

In 2008, working with the ghempa, a group of farmers in Dhakarjong sought to organise rebuilding of water channels, the village meeting room and a small *gompa* (temple). Funding was initially sought from villagers but more money was needed, which was partially met from emigrés and from ACAP; in total, around 4 million rupees was raised. However, Dhakarjong's ghempa was unaccustomed to finding alternative funding, noting that this was "irksome…and used much time". Further hold-ups arose while additional funding was requested from DDC. Notwithstanding this external support, the cyclical time of mukhiya proved incompatible with the linear time of 'outside' project financing. Interrupted funding has made works difficult to complete, with construction still unfinished seven years later.

Similarly, a leading NGO, CARE Nepal, provided assistance to Dhakarjong to improve the supply of potable water. This comprised installing an 'outside' technological solution – PVC pipes – to bring spring water from the escarpment above the village to distribution points near its center. This 'outside' solution did not however take account of the high Calcium Carbonate content of the spring. The pipes furred up, with many respondents complaining of "irregular" supplies or reduced water flow. Villagers are now compelled to draw on irrigation

supplies for drinking and to alter their daily patterns of collection, confirming that water is always an active subject. The dependent boundary of hydrosocialities extends even to the molecular scale.

Deforming pressures on mukhiya also arise from climate change. From a topological viewpoint, this materializes as a hypercomplex assemblage of water interaction with transformative power, twisting extant cordings of site, people, albedo, the thermodynamics of snow melt and ablation rates, wind eddy effects, and H_2O to propel Mustang from water shortage to water uncertainty[iii]. In effect, hydrosocial form is being stretched.

Thus virtually all platform group respondents in Dhakarjong and Phalyak commented on the drastic decline in snowfall quantity and duration over the last five years, reducing the Lumbhuk's flow. Less water has caused land abandonment, while unseasonable, often torrential, rainfall is more common. Phalyak residents for example are experiencing sudden rainstorms of such intensity to cause extensive damage to traditional mud and clay buildings, while water scouring exacerbates soil erosion in fields. Not all effects are detrimental though, with higher average temperatures allowing apple cultivation by many dhongba households. Reflecting on these changes, one farmer commented: "The amount of rainfall has increased in the last two years, but it now comes at different times, while the snow's melting much faster. Sometimes we experience rainfall when we were expecting snow. This leads to crops ripening more quickly, but yielding less, and the occurrence of pests and diseases we've not seen before. But we've also been able to grow new crops, fruits and vegetables – that's a bonus".

Topologically, climate change thus manifests in Dhakarjong and Phalyak as a Möebius strip bringing together the 'inside' and the 'outside' as a continuous surface of change possibilities. This is also evidenced by climate change–induced outmigration of the young (men especially) – there are very few jobs in either village, and increased water shortage is making farming more difficult[iv]. In turn this places more agricultural work responsibilities on women, alongside their onerous domestic duties that are crucial to stabilise mukhiya; continued outmigration is thus liable to fray the gendered cords of this institution (Bhattarai, Beilin and Ford 2015). Stretching is evident, too, in how indigenous water knowledges are viewed intergenerationally: older people are characterised by the young as illiterate and 'trapped in the past', while conversely the young are regarded as lacking knowledge of the customary practices needed to sustain mukhiya.

Another indication of hydrosocial form being stretched is the recent rekindling of conflict over the inter-village water agreement. The dispute has been reawakened by diminishing snowfall, but seemingly water knowledges of the Lumbhuk from the past are also flowing through both villages to initiate conflict in the present. Thus 88-year old Phalyaki farmer Pema Sitar commented: "my grandfather and mother lived in Phalyak. Back then, the village relied on water drawn from springs further up the hill; the location and shape of the old storage pond they used is still visible at the top. Nowadays, even in the monsoon, the old spring sources don't appear. So Phalyak's totally dependent on the Lumbhuk. And the Lumbhuk is ours, it's Phalyak's property and the water rights over the Lumbhuk belong here".

Inter-village discussions on the water allocation agreement are now ongoing, and show indigenous knowledge-practices in transition: talks are held in an old school building midway

between Phalyak and Dhakarjong, so respecting villages' own territories and water gods, but significantly are conducted by younger villagers rather than the ghempas. Some villagers have suggested a joint approach to DDC to settle the dispute. Clearly transformation is underway in water knowledge-practices, catalysing the emergence of new *hydrosocial information*.

Hydrosocial information

For Serres, "time-substances" absorb transformations over time to create a variegated knowledge surface (Serres and Latour 1995). Applied to Mustang, this encompasses water foldings and hydrosocial transformations, which in turn shape the myriad hydrosocial information sets that can be in future. Given its adjacency to two modernizing sets of hydrological information, transformation of the centuries-old water knowledge-practices of mukhiya now seems inevitable.

The first is intrusion of 'outside' hydraulic knowledges into Mustang through the Water Act (HMGN 1992), under which ownership of all water sources is assigned to the Nepali state, so placing it at odds with 'inside' customary institutions. So far, villages have petitioned the Ministry for Agriculture via VDC and DDC to take back riparian management as a common pool resource, but this arrangement may not last (Lord 2016). Designating water as a national "hydropower" resource (Lord 2016 147) marks another attempt by the state to consolidate its shaky presence in this remote area, following the introduction of DDCs and VDCs (in 1991) and the incorporation of all of Mustang into ACAP (1993). This hydropower narrative seeks to reposition mukhiya as 'traditional' and outdated[v].

The second information set is 'big science' approaches to hydrology, based on quantitative modelling to provide future projections of water availability under climate change. This scientific corpus redefines availability as 'scarcity' through acquisition of data sets at high scales of spatial resolution, indirectly downplaying the qualitative everyday projective spaces of community water use. As Connor (2009, 5) reflects, "[information] is associated with the operations of codes and the transmission of signs". Big science's signature "codes" and "signs" – its algorithms, maps, and spreadsheets – effectively demarcate 'outside' (state/hydropower) water knowledges from 'inside' (mukhiya); in turn, this makes what happens at the intersection of these 'inside' and 'outside' water knowledges especially important.

Here we argue the concept of boundary objects is crucial in understanding this intersection. Boundary objects are artefacts promoting stakeholder interaction across interfaces (Gieryn 1983; Star and Griesemer 1989), giving them significance in knowledge exchanges. Accordingly, mukhiya conveys water as "time-substance" through boundary objects such as documents encoding water rights and records of deliberation between ghempa, rolo and village councillors. Customary norms, including pujas honouring water gods where lamas intercede between the human and the divine, also demonstrate a boundary – spanning quality (cf. Basnet 2007; Barua *et al*. 2014).

In the past, community resourcefulness in Dhakarjong and Phalyak has derived from using these objects to bridge between indigenous knowledge-practices and the challenges posed by water availability through developing novel adaptation strategies (eg. construction of the Syang canal). Our discussions showed this translational process is now playing out again in central Mustang. Thus platform group respondents in both villages asserted strong support for

the dhongba allocation model, but little enthusiasm for 'outside' solutions to tackle water availability; in fact, no household in either village believed water availability would improve if VDC or DDC were more closely involved. Emphatically this was not a denial of water's increased volatility as climate change takes effect in Mustang. Many recognised this volatility and the need for new hydrosocial information from 'outside', but wanted this to supplement rather than supplant the indigenous knowledge-practices of mukhiya. This was apparent in their identifying practices to address availability that brought together the 'inside' and 'outside' through combining local know-how and external technology, such as drip irrigation for crops, drought-resistant crop varieties, and improved rain collection.

Certainly in Nepal it is assumed that climate change adaptation will be underpinned by fusing scientific and indigenous knowledges (eg. GoN 2015; cf. Rice, Burke and Heynen 2015). A topological perspective suggests this is not so straightforward however, as "time can be schematized by a kind of crumpling, a multiple, foldable diversity…an object…with multiple pleats" (Serres and Latour 1995, 60). It follows that indigenous water knowledge-practices have multiply-folded topologies, derived from innumerable past human-hydrological interactions. As we have seen, these knowledge-practices interpenetrate: hydrosocial knowledge is thus simultaneously cultural *and* scientific, practical *and* theoretical. For 'big science', such indigenous knowledges are difficult to discern and their subtle imbrications hard to disentangle (Valdivia *et al*. 2010, Briggs 2013).

As we have seen, the notion of crumpled knowledges captures well the geohistorical complexity of hydrosocial relations in Dhakarjong and Phalyak (table 2), a complexity mirrored by 'outside' (including climate) changes. Serres's topological perspective suggests these 'inside' and 'outside' complexities might be used to create a new "pleat" in the local

and global. For rather than pleats arising through state fiat or historical contingencies, we argue they need to be reinterpreted as intentional acts to bring the 'inside' and 'outside' together for specific purposes in particular places (Serres and Latour 1995 60). Viewed in this way, global climate change might be 'pleated' with the local as nexus of practices, materialities and knowledges that potentially can attend to its challenges. By doing so, we discern water's complexity not simply as patterns, trends and 'tipping points' in hydrological data, but also as enabling networks of human-nature relations, objects and things, extant and emergent.

Serres (1995, 2006) provides a means of taking this forward in arguing for a "natural contract" between humankind and nature. Applied to fashioning new hydrosocial information, this suggests that to successfully translate the 'inside' and 'outside' requires a *locally-configured* natural contract[vi], that recognises the inseparability of the situated and the agential, the human and the hydrological. Such a contract would assert more holistic understandings of water's fugitive nature by generating new types of hydrosocial information. Combined with the role of boundary objects discussed here, this offers one way of envisioning a 'natural contract' for practical hydrosocial politics of climate change mitigation and adaptation, derived from pleating different water knowledge-practices.

Thus the focus for a locally-configured 'natural contract' for water under climate change in Dhakarjong and Phalyak should be upon 'boundary crossings' (pleatings) between 'inside'and 'outside' hydrosocial information sets. This requires new boundary objects for data collection that enable networks of relations for mitigation and adaptation, while also empowering social relations: for example, by collating and disseminating climate-sensitive hydrological information across communities. A priority for boundary work could therefore

be grassroots information and communication technologies (ICT) that curate and disseminate new forms of hydrological information in ways sensitive to and appropriate for all community members (Zulkafli *et al*. 2015). Moreover, a locally-configured natural contract for climate change facilitates boundary crossing between what Stengers (2005) terms cosmopolitics – recognition of a global/universal collective of human and non-humans – and indigenous knowledge-practices. It does so by creating a space where the ideas underpinning multiple water knowledge-practices across multiple times can be brought together, potentially enabling progressive politics to be developed to address local climate change challenges. Such an approach opens practical ways to grapple with what Haraway (2013) and Cadena (2010) terms 'indigenous cosmopolitics' – that is, making the worlds of relations that structure different knowledge-practices of the same matter cohere and coexist in place.

Developing a local natural contract based on ICT applications thus requires critical reflection on future water needs from *all* community perspectives, to ensure a genuinely reflective co-design process. Referring to Dhakarjong and Phalyak, the aim of these novel boundary objects would be to democratise decisions on water quantity and quality, to make hydrosocial information more accessible, and to recast indigenous water knowledge-practices as not simply an asset of the dhongba class, but a community right. By doing so, we begin to problematize how hydrosocialities are produced, for whom, and for what purpose(s). Of course, dangers arise in translations between indigenous water knowledge-practices and hydrological science. But using ICT to underwrite a natural contract for water would undoubtedly create opportunities for new hydrosocial dialogues. Given the rapidity of change in Mustang, the future of remote communities now depends on such dialogues taking place.

Conclusions

In this article, we have developed a novel theoretical framework that relates the situatedness of water to its political agency through the lens of matter as "time-substance". We have argued that topological analytics can enrich hydrosocial understandings by enabling the tracing of tangled hydrosocial forms, transformations and information that transcend times, geographic scales and levels. We used this approach to examine hydrosocialities in two remote mountain villages in Nepal, demonstrating how the triptych of *form, transformation* and *information* is constituted from folded water knowledge-practices bringing together proximities among actors in space and in time. We contend that attending to hydrosocialities in this way provides a powerful means of conjugating the physical, hydrological and the social to decipher past, contemporary and emergent politics of water.

While recent work on the hydrosocial cycle has convincingly demonstrated the social construction and production of water (Linton 2014), surprisingly there has been little engagement with its situated and agential qualities. By conceptualising matter as a "time-substance" we have addressed this deficiency to explore how change in human knowledge-practices arises from water's constant repositioning of subject:object, object:subject categories, limiting its governability. Water as "time-substance" thus draws our attention to capturing constantly changing situated-agential relations; water connects, encloses, and embraces the social to create a sense of (im)permanence. 'Time' emerges as the intersection between synchronous and asynchronous assemblages of watery forms, powers, knowledges and social arrangements, distributed widely across space. A sense of 'local time' thus arises from dissonance between multiple possible times embedded within, and emitted by, multiple watery spaces. We illustrated the resultant reorderings in Dhakarjong and Phalyak through the ways water-society interrelations are played out in everyday seasonal experiences, and the microgeographies of power that reside in inter-village histories, where traditional water rights

and agreements are stoking contemporary hydrosocial rivalries. A "time-substance" approach hence offers multiple ways of enriching existing scholarship on water.

The case study foresees the inevitable transformation of the mukhiya system through entanglements with 'outside', including climate change, and the encroachment into Mustang of state-based hydraulic water knowledges. These developments demand attention be focused urgently on how extant hydrosocialities can be refolded in relation to these new challenges, for "time-substances" are dynamic states of matter. As we have shown, negotiating water transformations in the past has relied on the creative reinterpretation of historic hydrosocial forms, embodied in boundary objects, to chart a course for emerging hydrosocialities. In this way, progressive hydrosocial politics are founded upon recognising that water and societies are confronted by change, and are also full of potential for hydrosocial transformation to address these changes. "Inside" hydrosocialities are thus crucial to unlocking the complexities posed by climate change as "hyper-object" (Morton 2013) – namely its uncertainties (by influencing human adaptation/flexibilities) and interdependencies (through co-generating new human capabilities and resourcefulness).

Our analysis of "time-substance" in Mustang provokes reflection on its wider applicability in water scholarship. Water as time-substance foregrounds multiple hydrosocial cyclical rhythms of time, through form, transformation and information and their intersection within specific places. These materialise as water's everyday projective spaces. A progressive water politics, Serres would contend, will thus not emerge from 'out there'; rather it will be formed from careful reappraisal of 'inside' indigenous water knowledge-practices that have broad-based community support such that they address contemporary needs. Practical water politics are then grounded in re(in)forming community institutions through new experimental

practices that blend the 'inside' with the 'outside', while being prepared for "new mutations of understanding" (Connor 2004, 8) that water's unruly relation with humans always obliges. Central to this is the role of boundary objects in folding the local and the global together in new knowledge configurations, requiring place-based contexts that are open to and supportive of grassroots experimentation.

More critically-informed studies are now needed to extend this conceptual framework. One line of enquiry is to 'zoom in' on aspects of "time-substance": for example, interrogating the 'fluid line' between the topographic and the topological provided by form (the 'desire' of water to run from high to low; from surface to depth); transformation (how different water knowledge-practices and experimental community designs offer manifold patterns of alternative water use); and information (from simplicity to complexity via local capacities for translation). Another promising avenue for research is greater interdisciplinary engagement with the wealth of indigenous water knowledge-practices globally that are analogous to mukhiya. Detailed analysis is needed to critically analyse how these knowledge-practices inflect indigenous hydrosocial politics, particularly how water rights are conceived, enacted and empowered. Thirdly, rather than assuming scientific and indigenous water knowledges will somehow integrate over time, we urge careful examination not just of their compatibilities but also the gaps and absences in these water knowledges as they relate to the same places. We contend the notion of water as "time-substance" is central to each of these endeavors; in doing so, it furnishes a promising analytical category to take forward post-human debates on water across the social sciences.

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End notes

[i] 'Matter' is defined in the *Oxford English Dictionary* as "constituent material", while 'substance' is "the material of which a body is formed *and in virtue of which it possesses certain properties*" [emphasis added], implying attributes exceeding "constituent material".

[ii] A particular type of situated knowledge, defined by Briggs and Sharp (2004, 662) as "knowledges of the people resident in particular places".
[iii] In Nepali, 'climate change' translates as *jalbayu parivartan* – literally changes in water and air.
[iv] This is over and above seasonal migration from both villages after the agricultural harvest, when many women and young people travel to find employment in northern India (chiefly the cities of Gauhati and Dehradun), while some livestock farmers head to Dolpa, an adjoining district to the west of Mustang.
[v] In fact under the autocratic regime of King Mahendra (1955-1972), *mukhiya* was abolished and replaced with the village *Panchayat*, then the smallest unit of Nepali political administration. In practice, communities in mountain regions resisted this change.
[vi] cf. Harris's (1997, 43, emphasis added) comment that "Serres's conception of the natural contract clearly does not espouse a simple championing of or return to "nature"…[instead it] implicates us in a complex set of interlocking practices premised on an urgent awareness of the multiple linkages between *local action*, global history and the biosphere".

Characteristics	Phalyak	Dhakarjong
Population	54 households (37 *dhongba*)	44 households (22 *dhongba*)
Water source and storage	Lumbhuk *khola* (stream), snow melt. 1 *tsingu* (reservoir)	Lumbhuk *khola* (stream), snow melt. 1 *tsingu* (reservoir)
Irrigation canals	3 main irrigation canals distributing water from reservoir (see Figure 2)	2 main irrigation canals distributing water from reservoir (see Figure 3)
Irrigated plots (*bari* (horticultural) or *khet* (terraced fields)	Barley, naked barley, buckwheat, potatoes (*khet*); apples (*bari*)	Naked barley, barley, buckwheat, potatoes, beans (*khet*); apple, fruit and vegetables (*bari*)
Water allocation	*Dhongba* (water allocated to household). Rotation among *dhongba* households, with farmers drawing lots.	*Dhongba* (water allocated to household). Rotation among *dhongba* households, with farmers drawing lots.
Water infrastructure and communal work	Small-scale water repairs (*dhongba*); larger scale community works (*lengyi*). Larger repairs now part-financed through VDC/DDC/District Irrigation Sub-Division (DIO), District Agriculture Development Office (DADO).	Small-scale repairs carried out by *dhongba* households; larger scale community works (*lengyi*). Larger repairs now part-financed through VDC/DDC/ DIO, DADO.
Water distribution rules	Through village council, with membership open to all householders. Women participate in village council meetings to select *ghempa*, but so far none have been elected to this post. Local administration through VDC/DDC.	Through village council, with membership open only to male householders; women are not invited to village council meetings. Local administration through DDC/VDC.
Social distinction in village	Land ownership; water access (*dhongha* and non-dhongba households); caste issues evident, with *dalits* (lowest caste) prohibited from becoming *ghempas* – can only be *rolo*.	Land ownership; water access (*dhongha* and non-dhongba households); caste issues evident, with *dalits* (lowest caste) prohibited from becoming *ghempas* – can only be *rolo*.

Table 1: Water governance in Dhakarjong and Phalyak, central Mustang

HYDROSOCIAL TRANSFORMATION / HYDROSOCIAL FORM	'INSIDE'		'OUTSIDE'	
	Knowledge-practices and water availability	**Foldings**	**Pleats**	**Water as 'time-substance'**
'Old' Dhakarjong as high altitude spring settlement	Indigenous; dry climate with low precipitation, regular rainfall pattern	Water harvesting (springs), water impoundment (*ghul*), water portage	Not known/no record	'Inside' foldings. Foldings too burdensome for community; resettlement of Dhakarjong on lower ridge above Lumbhuk stream, c. mid-18th century
Dhakarjong as canalised interbasin settlement	Indigenous; dry climate with low precipitation, regular rainfall pattern	Construction of interbasin canal from Syang watershed to Dhakarjong; water abstraction from Lumbhuk; water harvesting from springs; storage ponds for irrigation, water portage	Founding of Phalyak village close to Dhakarjong Water knowledge-practices in the villages come into conflict over water allocation; moderated through similar mukhiya system	Pleating of inter-village water knowledge-practices. Interbasin canal laborious to maintain; abandoned in c. 19th century.
Dhakarjong and Phalyak as canalised irrigation settlements	Indigenous and state-based; climate changing from dry to arid, diminishing precipitation, irregular rainfall pattern	Construction of *tsingu* (reservoirs) and canals feeding *khets/baris*; increased water abstraction from Lumbhuk	Pleating of knowledge-practices through Subba's inter-village water sharing agreement	Intrusion of outside state-based water knowledge-practices through legal water sharing agreement
Water sharing between Dhakarjong and Phalyak	Indigenous-hydropower-scientific; arid climate with diminishing precipitation; highly irregular rainfall pattern	Excavation of more storage ponds; enlarging of reservoirs; introduction of limited piped water systems	Multiple pleats of 'inside' and'outside' water knowledge practices, eg. State: emerges with VDC/DDC structures; consolidated through water law (1992), ACAP; Civil society: CARE Nepal piped system for drinking water	Multiple complex pleating of inside-outside water knowledge practices, warping mukhiya system; outmigration and agricultural decline

Table 2: Hydrosocial form/transformation in Dhakarjong and Phalyak, c.18th-21st centuries

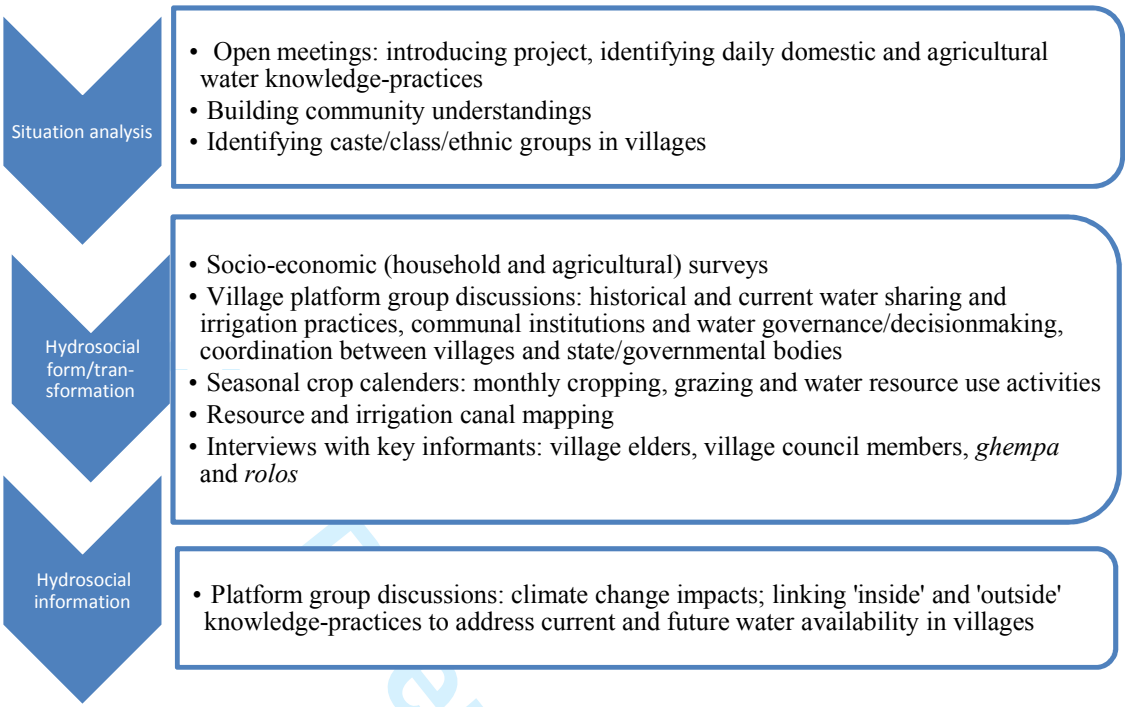

Figure 1: Research design and methodology

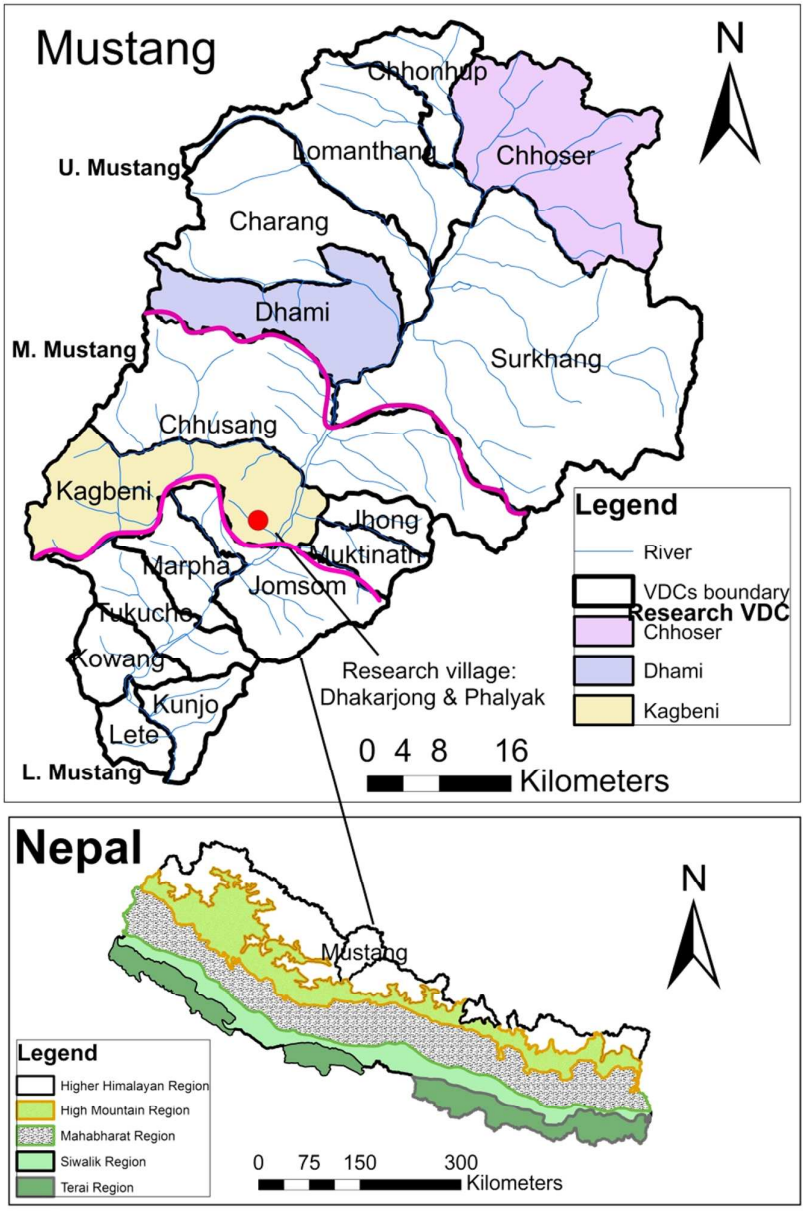

Figure 2: Nepal and the case study area

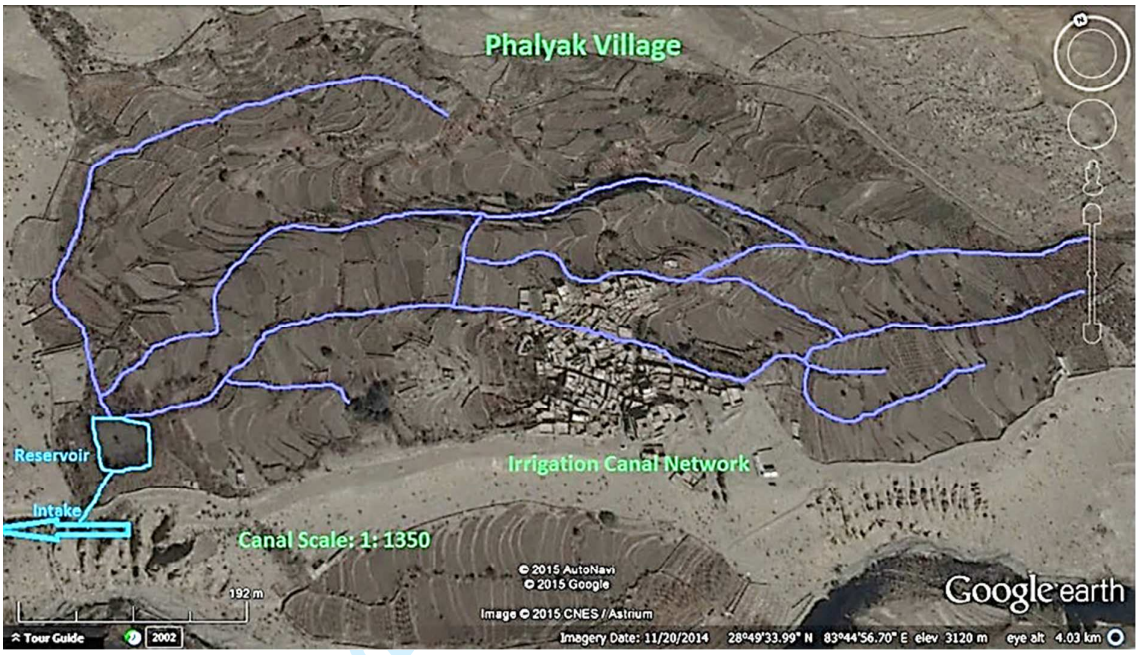

Figure 3: Irrigation canal map of Phalyak

Figure 4: Irrigation canal map of Dhakarjong

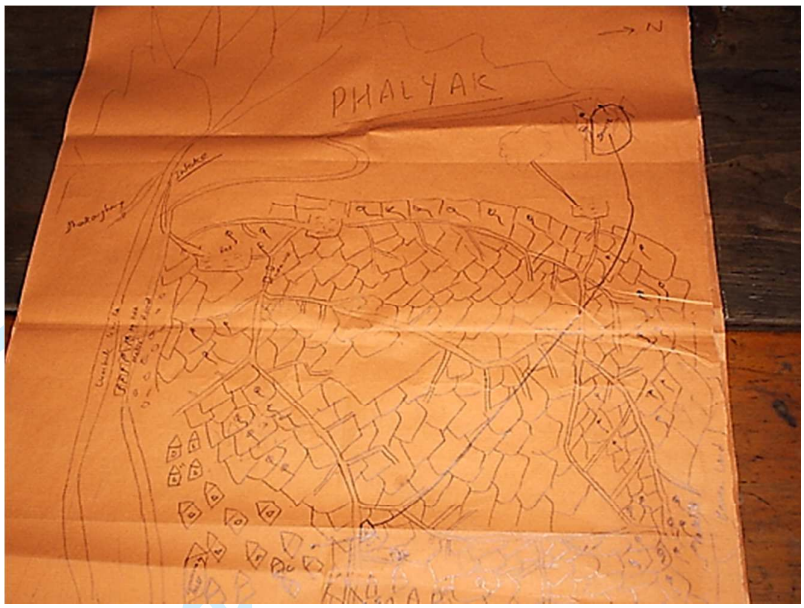

Figure 5: Ghempa's map of khets in Phalyak