Limits to adapting to water variability in rural Nepal: Gaps in community-based governance

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Rural communities in the low-lying plains and lower hills of Nepal remain vulnerable to changes in watershed dynamics. A range of coping and adaptive strategies are being implemented to address technical and infrastructural needs relating to agriculture, ecosystem management and disaster prevention. However, to ensure the equity and equality of these measures in relation to water, effective governance mechanisms that link different water users (e.g. upstream and downstream) emerged as an important, yet contested, component. Conflict exists between local water users (both within and between villages in the same watershed), the resolution of which has been hampered by ineffective and inactive water user committees that lack proportional representation and the institutional capacity for sufficient responsiveness. The paper concludes with suggestions for reviving effective committees at the community scale, bearing in mind the need for institutional and organizational stability, equality and sustainability.

Keywords: climate change adaptation, droughts, floods, watershed governance, institutions, Nepal

There was the first reported case of climate refugees in Nepal

In June 2010, the Kathmandu daily newspaper *Republica* reported on what they described as the first recognized case of climate refugees in Nepal. Residents of the mountain village of Dhe, in upper Mustang, were being relocated to a purpose-built 'model village' (consisting of renewable energy technology and supposedly sustainable and 'appropriate' land allocation) in the lower Mustang region. These 'climate refugees' were reportedly displaced because 'water sources had completely dried up' (Shah, 2010).

As a result of events of this kind, which occur despite the fact that Nepal is perceived to be richly endowed with water resources (Pachauri and Reisinger, 2007), attention is increasingly turning to the impacts of changes in water availability and the growing inequality of access. These impacts include the decreasing and less predictable availability of water for irrigation and sanitation, despite the increasing frequency of flash floods. Although it is the mountainous regions of Nepal that receive the majority of attention from climate change analysts,

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in the lower altitudinal zones climate change affects a larger and more concentrated population that is dependent on a bio-physical environment characterized by agricultural expansion, deforestation, rapid land-use changes and soil erosion. These processes exacerbate broader changes in soil and vegetation properties, as well as the fluvial dynamics of a complex bio-physical environment.

Anthropogenic pressures are, therefore, projected to exacerbate poor water accessibility and quality, which have a negative impact on productivity and human health (Ensor and Berger, 2009). Thus, the lives and livelihoods of those living in low-lying, agriculturally rich and flood-prone areas are being increasingly affected. As Gurung and Bhandari (2009: 91) point out, 'agriculture, the mainstay of over 80% of the Nepalese population, has been affected by both warming and uncertainty of monsoon', which compound existing problems such as a widespread lack of investment in water management infrastructure. There is a pressing need, therefore, to build empirical data on what water-related impacts people have to manage, what their management strategies are, and whether these strategies can lead to effective livelihood adaptation in the long term. Of concern here is the capacity of community-based water governance mechanisms to overcome water-related challenges.

Of concern is the capacity of community-based water governance

This paper, therefore, contributes to the literature on livelihood adaptation and the governance of water resources, principally at the local level. The research was carried out in some of the most productive agricultural lands in Nepal, located in the *terai* (low-lying plains on the border of India that reach 200 metres above sea level (masl)) and *siwalik* (a band of low hills that range from 200 to 1,000 masl). The research revealed the exposure and sensitivity of livelihoods to changes in watershed dynamics (explored below), and explored the ways in which communities that depend largely on agriculture are adapting to such changes. Analysis of current adaptive strategies leads to the question of why institutions at the local level are currently unable to ensure equal and effective watershed management across communities. The paper concludes with recommendations for enhancing community-based resource governance for more effective adaptation.

The livelihoods were shown to be sensitive to changes in watershed dynamics

Assessing vulnerability to climate change in Nepal

A participatory vulnerability assessment (PVA), developed by Practical Action Nepal as part of a project funded by the Asian Development Bank (ADB) to map vulnerability, provides the context of the research and was loosely implemented in four communities in the districts of Chitwan and Nawalparasi. In line with the Intergovernmental

Panel on Climate Change (IPCC) conceptualization of vulnerability (Pachauri and Reisinger, 2007: 89), the PVA was developed in order to quantify exposure and sensitivity to climate change, as well as the capacity to adapt at the community level. Exposure was defined as the nature and degree to which changes in water supply and/or availability are experienced (Adger, 2006), while sensitivity refers to the degree to which the socio-ecological system is modified or affected by these perturbations, either adversely or beneficially (Adger, 2006; Pachauri and Reisinger, 2007). Adaptive capacity refers to the capacity of a livelihood system to accommodate environmental and policy change by effectively combining a range of assets to plan for the future and implement adaptation decisions in order to also create and shape change (Adger, 2006; Ensor and Berger, 2009).

Adaptive capacity refers to the capacity of a livelihood system to accommodate environmental and policy change

However, quantitative results and analysis of the PVA and its components are not presented here. Rather, emphasis is placed on the vulnerability of socio-ecological systems that require qualitative analysis in order to reveal the context-specific nature of building socio-ecological resilience. Thus, a 'starting point' definition of vulnerability was adopted, in which 'vulnerability is determined by the environmental and human characteristics of the community, revealing the *process* through which climate change hazards generate livelihood impacts (Ensor and Berger, 2009: 14-15, emphasis added). This approach moves beyond an 'end point' analysis that focuses on the impacts of climate change after adaptation has taken place.

The approach taken in this paper, therefore, emphasizes vulnerability as a component of socio-ecological systems, and stresses the ways in which the elements of vulnerability operate at the given spatial scale of the community (Adger, 2006). This moves our attention beyond the outcomes of a single stress or hazard – an approach commonly adopted in the disaster risk reduction field – to help build an understanding of vulnerability, adaptation and livelihood resilience in the context of local knowledge, skills and opportunities. As Adger and Barnett (2009: 2803) put it, 'communities value things differently and these [values] must be taken into account if adaptation is to be effective, efficient, legitimate, and equitable'. These values can both enable and constrain effective adaptation, as they construct the ethics, knowledge, culture and institutional structures that place (mutable) social limits on adaptation (Adger et al., 2009). Therefore, the results presented here explore perceptions and experiences of perturbations in watershed dynamics from within the particular spatial context of the community. Community-based processes of adaptation are understood within a nexus of institutions and policy-making scenarios. These dynamics are particularly important when grappling with the complex nature of property and use rights surrounding

Community-based processes of adaptation are understood within a nexus of institutions and policy-making scenarios

water, the management of which is a fundamental process of effective adaptive action.

Community-based governance of adapting to water variability enables communities to integrate socio-ecological risks into a dynamic system. Community-based mechanisms start from the local context and engage with the capacities, knowledge and practices of adapting through collective action. This approach grounds adaptation in local rule-making procedures that can facilitate the organization of complex adaptive systems (Ostrom, 2010a). Such an approach helps to unveil the already existing local governance systems that can facilitate adaptation, rather than wading in with expensive, externally designed engineering plans for large-scale water management that ignore local initiatives, as has previously occurred in the Chitwan district of Nepal (Ostrom, 1999). Thus, the following analysis explores *existing* adaptive strategies, and then places these strategies into the local water governance context.

The analysis explores existing adaptive strategies, and places them in the local water governance context

Site selection and research methods

The research was carried out during April–June 2010 in the districts of Chitwan and Nawalparasi. The neighbouring districts lie in south-central Nepal, and are divided by the natural topography of the Narayani River. Chitwan is dominated by *terai* and Nawalparasi by *siwalik*. According to a study conducted by Practical Action Nepal, Chitwan exhibits a high increasing trend in minimum annual temperatures and post-monsoonal temperatures (Marahatta et al., 2009). These trends equate to warmer winters and less predictable rainfall, the impact of which has been felt in decreasing soil moisture, off-seasonal damage to crops, and the decreasing water level of the Narayani and Rapti rivers since 1963 (Gurung et al., 2010). Nawalparasi, meanwhile, is one of the few districts in Nepal to exhibit a decreasing trend in annual mean maximum temperature as well as a decreasing trend in average winter and post-monsoon temperatures (Marahatta et al., 2009). Nonetheless, these changes affect ecosystems and watersheds, as rainfall is becoming increasingly erratic and punctuated by an increasing frequency of extreme precipitation events, such as hail storms.

The research was conducted in two different villages in each of the districts of Chitwan and Nawalparasi. In Chitwan, the villages of Laukhari and Swargadwari are both located in the village development committee (VDC) of Meghauli; in Nawalparasi the villages of Kadampur and Kirtipur are located in the neighbouring VDCs of Divyapuri and Devchuli, respectively. The research locations were selected because of the social, political and/or bio-physical links between the villages in

each district. In Chitwan, the two villages fall under the management of Meghauli VDC and they both face challenges from the same two rivers (Rapti and Narayani). Water management activities in the Chitwan communities are structured around a disaster management committee (DMC), which was established as a collaborative venture between local and international NGOs, local government, and local residents, in order to reduce vulnerability to the increasingly erratic flows of the two rivers. In Nawalparasi, the two villages are linked by a watershed that is defined by the valley that drains into the Baulaha River; Kirtipur is in the *siwalik* upstream area of the watershed in the VDC of Devchuli, and is linked by a tributary of the Baulaha River to the downstream community of Kadampur located in the *terai* of Divyapuri VDC. Water users' committees were previously established by residents in the area and are supported by a district irrigation office and a users' federation. Although a space for community-based water governance is theoretically supported by national and district policy, local residents must form and register users' committees. Where disagreement exists over water use, a lack of VDC support for committees has resulted in their abandonment in favour of committees that focus on fixed resources, such as forests.

In all four research locations, agriculture is the primary livelihood

In all four research locations, agriculture is the primary livelihood and currently revolves around the production of rice, maize (corn) and wheat. Crop production is supplemented by livestock rearing, often just for subsistence, and in Meghauli by fishing. Incomes are supplemented by wage labour in nearby towns, seasonal migration, remittances from family members who have migrated to India and, more recently, by the production of alternative fruit and vegetable crops such as watermelon, bananas, lemon and mangos.

In each village, qualitative and participatory research methods were carried out. To develop an overview of the bio-physical and socio-economic context, as well as gain insight into local policies and political discourse, an in-depth, semi-structured interview was conducted with a key informant from each village. Key informants included representatives of VDCs and non-government initiatives (e.g. the community forest scheme). To develop an understanding of community perceptions of climate change and the adaptive practices in each village, focus group discussions were also conducted and included the application of participatory tools such as community resource and hazard mapping, seasonal calendars, historical timelines, hazard ranking, impact ranking (on both resources and livelihoods), capacity assessments and Venn diagramming. The interviews and dialogue from focus groups were recorded and transcribed verbatim into the qualitative analysis software QSR NVivo 8, which was used to code and analyse the content according to relevant themes.

Sensitivity to changes in watershed dynamics

These changes present a serious challenge to agriculture as a primary livelihood strategy

Members of all four communities identified the presence of longer and hotter summers, associated with a general unavailability and unpredictability of water supply. When combined with warmer winters and shorter monsoon seasons, these changes present a serious challenge to agriculture as a primary livelihood strategy. Crop failures are increasingly common owing to insufficient rainfall and/or delayed and shortened rainy seasons, which reflects the high sensitivity of crop production to water. In Kadampur, reliance on wheat has resulted in large areas of land left fallow for the past three years because of a lack of water, and the persistent lack of overnight dew, which operated as a form of irrigation, has forced the abandonment of lentil crops entirely. By contrast, farmers in Laukhari and Kirtipur have diversified their production and are experimenting with various fruits and vegetables that are less dependent on timely rainfall. In Swargadwari, meanwhile, socio-economic constraints (such as possessing only de facto land-use rights, which jeopardizes security of tenure) can prevent diversification, thereby increasing sensitivity. Since there is no history of agricultural maintenance on these lands, the soil is of poor quality, deficient in groundwater and nutrients. Reliable and diverse irrigation is a fundamental component of reducing sensitivity to water stresses, yet the *de facto* system reduces incentives to invest in improvements and places legal constraints on the ability of farmers to absorb socio-ecological shocks. By contrast, farmers in the other research locations have benefited from the implementation of shallow tube wells, catchment reservoirs and irrigation canals. However, the results of these initiatives are not equal across space and social groups (see Table 1).

Insufficient rains have also affected fishing livelihoods in Swargadwari, as fish stocks in the Rapti River have been decreasing in correlation with the decreasing river level. This community-based observation is supported by data on river levels that show the continuous decrease in volume of the Rapti River since 1963, and by a consultation held upstream in Pokhara where the river level has dropped to such an extent that bridges have become redundant (Gurung et al., 2010). Despite the dropping river level, flash floods are also becoming more common (as revealed by community observations and local government records), which means that alternative practices, such as fish farming, are not possible, leaving the fishing livelihood system extremely sensitive.

Flash floods damage crops, infrastructure and food stores

Flash floods are, therefore, a major cause for concern, as they damage crops, infrastructure and food stores, increase the threat of waterborne diseases and present a direct risk to lives. During monsoon, both the Narayani and Rapti rivers break their banks to inundate Laukhari and Swargadwari. According to local residents, the increase in frequency

of flash floods has also exacerbated the impact of river erosion, which is decreasing the area of land available for agriculture and community forestry, as well as damaging natural flood defences.

In Nawalparasi, although the Baulaha River previously ran year-round to Kadampur, it is now dry and prone to flooding during monsoon. This has led to the paradox of a decreased water level in the catchment reservoir (built to provide a reliable irrigation source), yet an increased scale of crop, land and infrastructure damage due to flooding. However, this situation is not just a result of changing climatic conditions, as human interference in the ecosystem, such as de-vegetation and the alteration of river beds, is compounding the dryer conditions. As Few (2003) has pointed out, the magnitude, speed of onset and duration of floods are often enhanced by factors such as de-vegetation, river alteration, land use and urbanization – factors that are in abundance in Kadampur and recognized by local residents as major challenges. Meanwhile, erratic rainfall upstream has been associated with an increase in frequency of landslides. Landslides are perceived to present the greatest threat to the village source of drinking water, but also damage crops, livestock and infrastructure such as the irrigation canal and village buildings. Extreme hailstorms, which damage infrastructure and threaten livestock, are also perceived to be increasing in frequency in Kirtipur.

Existing strategies for adapting to water variability

Strategies have emerged from a combination of local ingenuity and support from local government and NGOs

Table 1 presents the livelihood adjustments that research participants in the four villages identified as existing forms of coping and adaptation directly in relation to water. The strategies have emerged largely from a combination of local ingenuity and support from local government and NGOs. This section explores four themes that emerge in relation to these strategies, before attention turns to community-based governance as a means to enhance their effectiveness, sustainability and equality.

First, Table 1 reveals the prominence of technological and infrastructural developments in attempts to manage water supplies. The first four were implemented to establish a reliable water supply for irrigation and safe water for sanitation, while the second half of the list in this section relates to technological interventions that attempt to build long-term resilience to floods. Common to all of the developments, however, is the particular nature of the implementation environment, characterized by technical support from Practical Action and the respective village development committee (VDC). In Kirtipur, for example, the irrigation system consists of a river dam, from which a 6 inch tube leads to a concrete canal. This

Table 1. Specific strategies for coping with and adapting to water-related stresses and shocks

Strategy	*Effectiveness (constraints; sustainability)*	*Implementation environment*
Technology and infrastructure		
Shallow tube wells: water for irrigation	Access determined by socio-economic status (poor remain vulnerable); limited spatial coverage (e.g. 7 Ha); communities lack financial capital to invest in STWs.	Reliance on financial and technical support from the VDC and DDC; restricted government budget for these activities.
Reservoir: water storage	Unequal access; drying of water sources; damage to irrigation canals during floods.	Technical support from VDC and Practical Action.
Deep bore well (> 80m): water for irrigation	Experimental, unsure if it will reach water; different geological conditions to other experiences.	Experimentation; visiting successful deep bores; technical support from NGOs and government.
Aqueduct: reliable water supply for irrigation and sanitation	Increased number of harvests per year; clean water source; unequal access; doubts over longevity/sustainability (source will dry up).	Technical and financial support from Practical Action, VDC, DDC, and District Agriculture Development Office; voluntary labour from the community.
Raised plinths: Protects possessions, food, and infrastructure	Houses and possessions remained undamaged by floods; does not protect livelihoods (i.e. crops and livestock).	Technical support from Practical Action; awareness raising and skills training.
Bridge construction: evacuation route	Effective if flood doesn't exceed previous levels; not tested in more extreme conditions	Technical support from Practical Action.
Dam construction: flood prevention	Successfully reduced the impacts of floods, but has not eliminated them altogether.	VDC implementation.
Early warning system: degree of warning to allow for evacuation	Short term coping strategy; lack of resources to pay tower personnel; untested – no floods since implementation	Technical support and implementation by Practical Action and Disaster Management Committee
Stronger building materials: protects against hail storms	Planned.	Need access to stronger materials, either locally or through improved transportation infrastructure; need technical knowledge and skills for building.
Agriculture		
Use over flow river as irrigation source: seasonal use of overflow channel to irrigate crops	No longer possible: river runs dry except during monsoon, when the entire community floods; water storage not explored.	Biophysical conditions; experimentation
Vegetable/fruit farming: requires less irrigated land area	High yields; enhanced income; vegetable thieving; lack of transport infrastructure to access downstream markets with heavy vegetables (e.g. yams).	Technical support from Practical Action; experimentation; local/traditional practices (ancestors successfully cultivated yam in dry conditions).
Use of hybrid seeds: increase yield of existing crops	Require large volumes of water; loss of traditional varieties; dependent on the market (no seed saving); dependent on chemical fertilisers.	Access to agricultural extension services (*'agrivets'*)
Cultivate jatropha: Sell for biodiesel; reduced irrigation demand.	Too early to assess; need technical support for jatropha cultivation.	Community forest technical support and awareness-raising; ability to plan.

Strategy	*Effectiveness (constraints; sustainability)*	*Implementation environment*
Ecosystem management		
Plantations and forest conservation: Reduced flood impacts; provide source of NTFPs.	Downstream: bamboo plantations have been either destroyed by floods or died due to drought. Upstream: reduced frequency of landslides; prevents drinking water contamination; slows run-off.	Education and awareness-raising by community forest; planning ahead; formal education; awareness-raising and planning in community meetings/forums.
Traditional climate projections	Unproven method: likelihood of a rainy or dry year is predicted using three pieces of soil and a bucket of water (moist soil/empty bucket = sufficient rain).	Reflects need for climate information.
Coping with hazards		
Climb trees: saves lives during floods	Extremely short-term; saves lives, not livelihoods; unsustainable, even in short term.	Biophysical conditions (climbable trees); last resort.
Shelter and food distribution: disaster response	No plans by VDC to provide more long-term support to seasonal variations; farmers still have to react as events occur.	VDC implementation
Banana plantation: Use trees as boats during floods.	Short-term coping strategy for floods; bananas provide added subsistence and income benefits.	Experimentation; ability to think of alternatives and plan ahead.
Temporary relocation: Shelter and compensation	Short-term; insecure; requires valuation of land prior to flood.	VDC provides shelter; National Park compensates for land lost in buffer zone.

infrastructure was developed by Practical Action and with financial support from the VDC. However, the community as a whole was also sufficiently mobilized to actively seek technical support, and local residents voluntarily provided their labour for construction purposes. Elsewhere, irrigation developments have been less uniform, such as in Kadampur where the reservoir and two privately owned dig wells provide water to a small and privileged proportion of the community. Similarly, the community learned of deep boring following the development of an 80 m deep bore by a private corporation. While the results of this experiment are yet to be seen, if the deep bore is successful, questions remain as to how access will be determined. In other areas, meanwhile, irrigation is simply not effective enough, such as in Swargadwari, where the shallow tube wells do not cover a large enough area and the community lacks the technical and technological capacity to source water from the nearby Rapti River.

Flood evasion, protection and early warning mechanisms have been developed

Beyond irrigation, the infrastructural capacity in the four villages is generally low, and relies on sporadic technical and financial investment from the respective VDC and NGOs such as Practical Action. Flood evasion, protection and early warning mechanisms have all been developed as a result of partnerships between Practical Action, VDCs and district development committees (DDC), the

result of which has been the successful establishment of disaster management committees in Chitwan. In Kirtipur, the community building that houses important information-sharing meetings about adaptation options was built with the technical and financial support of Practical Action. There is differentiation, therefore, in the ways in which technical support manifests at the community scale.

A second theme relates to agricultural adjustments to account for water variability, adjustments that appear to rely on the input of information, knowledge and expertise from key service providers. For example, links to agricultural service providers, locally known as agrivets (agricultural and veterinary services), have helped to build technical knowledge in terms of the combinations of hybrid seeds, fertilizers and pesticides that are available to and beneficial for farmers working with unreliable water supplies. Similarly, in experimenting with alternative crops such as medicinal plants and jatropha, farmers in Kadampur require the capacity to effectively cultivate these crops and sustain the agricultural system. Community members identified the community forest scheme as a key service provider in this context, indicating inadequate support from agriculture-specific support institutions. Whether the capacity to support jatropha cultivation currently exists in Kadampur remains to be seen.

Agrivets have built knowledge of the seeds, fertilizers and pesticides for farmers with unreliable water supplies

The third category in Table 1 relates to ecosystem management, which also has strong ties to the community forest scheme. In Kirtipur, plans are in place to manage water flows using plantations around water sources and to prevent overland flow on the steep slopes. These plans emerged from community-based knowledge and information-sharing, which revolved around one well-educated community member who brought ideas to the table. The community now faces the challenge of implementing the plans without access to stable institutional support in relation to ecosystem management. They are currently seeking support through traditional village development committee channels, which they describe as slow, cumbersome and often ineffective. By contrast, ecosystem management activities have been implemented downstream in Kadampur with the support of the community forest scheme, the VDC, and local and international NGOs. A bamboo plantation was developed on the banks of the Baulaha River to help bind the soil, reduce the speed of overland flow, and provide an extra source of income through the use of non-timber forest products. However, the bamboo plantation has largely failed; over 50 per cent of the plants perished because of a lack of water, which raises questions about the appropriateness of external advice on local ecosystem processes.

Short-term strategies of coping with hazards enable livelihoods to bounce back to their previous states

Finally, Table 1 includes short-term strategies of coping with hazards, which enable livelihoods to bounce back to their previous states. These measures do not specifically reduce sensitivity to water-related hazards in the long term. Nonetheless, in relation

to disaster and hazard management, it is important to note the emergence of disaster management committees in both Chitwan and Nawalparasi. These committees grew from consultations held between communities, VDCs, DDCs and NGOs such as Practical Action. The result is a community-based mechanism for managing the impacts of water-related hazards. The effectiveness of the committees raises the question of why water users' committees, which are a component of the National Water Plan (2002–2027), have seen less success.

Improved community-based water governance for effective adaptation

The previous section illustrated the importance of institutions and organizations in a variety of capacities: to provide necessary technical support; to provide a means of transforming ideas into action; and to contribute necessary information and knowledge to enable informed decision-making. Indeed, the governance context appears to be strong in relation to technical, agricultural, ecosystem management and disaster risk reduction activities. However, with water as the main driver of vulnerability in the area, it is curious that water governance remains largely absent from conversations with community members and key informants.

Water governance remains absent from conversations with community members

The National Water Plan (NWP) of Nepal, which identified the human right to clean and adequate water for sanitation, placed emphasis on water user and sanitation committees and water user associations (WUAs), stipulating for example that all irrigation facilities should be co-managed by WUAs (WECS, 2002). In response, district irrigation offices (DIOs) and an Irrigation User Committee Federation (IUCF) have been established to help support local water and irrigation committees. Local residents are responsible for registering users' committees with the appropriate DIO. However, over time committees have become inactive and a correlation has emerged between inactive committees and water projects that have failed to manage resources effectively (Water Aid Nepal, 2010). In the case of Nawalparasi, the WUA has been disempowered as it is subsumed within a group that has been registered with the district agriculture development office (DADO). This group is managing the irrigation schemes, effectively overriding the power of the WUA as a decision-making or conflict resolution forum. While there was no perceived lack of support from the DIO and the IUCF, the group registered with the district agriculture development office has been requesting more support on water-related issues. Channelling concerns through the DADO adds a layer of bureaucracy that limits the responsiveness and effectiveness of local institutions in dealing with water concerns.

The National Water Plan (NWP) of Nepal identified the human right to clean and adequate water for sanitation

In some cases, the lack of effective watershed management institutions compounded a reluctance to experiment or implement adaptation decisions due to a fear of failure. These fears could be alleviated by the effective support mechanisms that are associated with an institutional context that possesses a balance between rigidity and flexibility. This follows Gupta et al.'s (2010) analytical framework, which outlines six dimensions of institutions that enable effective adaptation: 1) encouraging the involvement of a variety of perspectives, actors and solutions; 2) enabling social actors to continuously learn and improve their institutions; 3) allowing and motivating social actors to adjust their behaviour; 4) mobilizing leadership qualities; 5) mobilizing resources for implementing adaptation measures; and 6) supporting principles of fair governance. Enhancing these attributes can help build an effective system of polycentric governance, which is characterized by multiple governing authorities that exercise independence to make norms and rules within a specific domain by drawing on local knowledge and learning from others (Ostrom, 2010b). In the research locations, the institutions that underpin water resource management were too weak to meet Gupta et al.'s (2010) criteria. Rather than explore water management options through water institutions, such as user committees, local residents prioritized the role of existing strong institutions (community forestry) and externally supported new institutions (disaster management committees). At the same time, there was a perceived lack of representation within decision-making scenarios pertaining to water-related problems.

The institutions underpinning water resource management were weak

Communities were turning to the community forestry scheme for information on watershed management

The fact that communities were turning to the community forestry scheme for information on watershed management indicates the ineffectual nature of water-oriented committees and associations. The community forest scheme has been supported by successive policy implementation since the 1976 National Forestry Plan, policies that have helped to devolve forest management to community forest user groups (CFUGs). Local people in the CFUG make decisions regarding forest management, including its use and the distribution of benefits, and to communicate the diverse interests within a CFUG, members elect an executive committee on a periodic basis to take part in decision-making forums with government (Larson et al., 2010). The formalization of these processes has helped to build a strong institutional base to community forestry initiatives across the country. By contrast, water user committees and associations have simply been encouraged by the NWP rather than supported through specific policies that devolve decision-making and user rights.

The lack of attention to general water governance institutions at the local level also reflects the framing effect, which results from pre-existing knowledge and expertise (Inderberg and Eikeland, 2009). It was significant, for example, that the research was carried out in

existing Practical Action disaster risk reduction (DRR) sites, which caused an over-emphasis on DRR at the expense of more long-term water governance strategies. The VDCs, meanwhile, have also focused their attention on DRR and the isolated development of shallow tube wells (perhaps because shallow tube wells were identified in the National Water Plan as a cost-recovery mechanism for rural areas). In some cases this meant that while villages are relatively well protected against floods, their fish stocks are depleting and they remain unable to effectively use river water for irrigation. The only strong community-based institutions evident in the research locations, therefore, were the community forest user committees and the disaster management committees. While agrivets and agricultural cooperatives have proved important for agricultural diversification, they have not been directly involved in water-related issues.

There is a gap in local participation in decision-making

Thus, the lack of active and engaged community-based water governance mechanisms reflects a gap in opportunities for local participation in decision-making frameworks. Part of the problem here is the nature of water as a mobile resource. In contrast to the ways in which forest resources can be tangibly shared, dividing water use rights is a diffuse issue, which creates a barrier to collective action (Ostrom, 2010a). As a result, piecemeal interventions are taking place, often with unproven effects (such as the experimental deep bore well and the early warning systems). These piecemeal interventions are occurring despite calls for collective water management in some communities, where residents have voiced their frustrations at a lack of representation within local government and a lack of effective say in decision-making processes. Although the VDC holds consultations with local communities (in VDC offices, which are in many cases many hours' walk from relevant villages), the perception amongst affected communities is that little concerted action has emerged as a result, as the VDC chooses to reinforce the status quo.

There are continuous disputes between downstream and upstream communities

In some cases, a status quo of isolated interventions and perceived lack of participation in decision-making is producing conflict between different stakeholders in the watershed. For example, community members in downstream areas have blamed upstream communities for disruption to the watershed, supposedly caused by the physical alteration of tributary rivers. Upstream, the only intervention in the natural watercourse is a small diversion channel which feeds the irrigation canal. Downstream, meanwhile, the activities of local mining corporations have diverted the natural river course and exposed the river bed to more rapid water absorption. Identifying the particular cause of watershed alterations has become a continuous dispute between the downstream and upstream communities, a dispute that traditional VDC channels are struggling to resolve and which is creating a barrier to mutually beneficial adaptive action. The

dispute has also been exacerbated by the involvement of a key player in the downstream area, who holds sway over local government and the community forestry scheme, despite having personal economic interests in the mining activities. With no effective institution for community-based watershed management (which creates a reliance on the VDC and the community forestry scheme), this key player is able to wield his power to the benefit of local economic interests. Thus, principles such as trust, transparency, collaboration, equity and accountability – all of which are identified by Gupta et al. (2010) as essential for effective institutional support – are not being met.

Conclusion

In response to the increasingly erratic behaviour of water, rural communities in Chitwan and Nawalparasi are struggling to alter their livelihood practices and protect their villages against dangerous extreme events. In doing so, strategies focus on technical solutions, disaster-risk reduction approaches, and ecosystem management practices, for which there is significant institutional support. The research shows that while, in principle, water may be a social and moral issue, in practice, it is not being dealt with as such. It is being conceived as a technical issue, capable of management through enhanced technical capacity and technological options. Effective water governance requires a variety of hydrological, legal, political, institutional and engineering dimensions to be addressed. Currently, sporadic work is being done in these areas, but local communities are not able to participate in decision-making scenarios that ensure fair and equal results.

Local communities are not able to participate in decision-making scenarios that ensure fair and equal results

The above analysis, therefore, reinforces arguments for process-oriented approaches to adaptation, or what Ensor and Berger (2009) have called 'starting point analysis'. Simply focusing on outcomes does not address the underlying factors that determine adaptive capacity, and effective adaptation will not be achieved if focus is simply placed on technical solutions or disaster risk reduction. For these strategies to enhance adaptive capacity in the long term, more coherent mechanisms for the governance of water resources must be developed. Such mechanisms can help to overcome the unequal results of coping and adaptation strategies, as well as the uneven nature of local decision-making. Exploring these governance mechanisms means moving beyond rapid participatory vulnerability assessments, which attempt to facilitate comparisons of vulnerability across space by measuring and quantifying exposure, sensitivity and adaptive capacity. Such an approach shrouds the complexity and contextual nature of governing adaptation. Thus, there is a need for more research into how institutional differentiation at the local scale might feed into broader processes of adaptation.

The success of community forestry schemes and disaster management committees illustrates the benefits of community-based governance

Indeed, the success of the community forestry scheme and the disaster management committees illustrates the benefits of community-based governance. Water users' committees are a component of the National Water Plan, yet they have become redundant and ineffective. The district irrigation offices, Irrigation User Committee Federation, VDCs and non-governmental actors must turn their attention to reviving *effective* and *autonomous* watershed management committees, which can provide a tangible locus for resolving conflicts around water-related issues. By directly addressing the desires of local residents to more actively participate in decision-making scenarios, effective water governance could be built from the bottom up and helped to feed into broader governance frameworks. This process could support a polycentric system of governance that draws on local knowledge and learning at multiple scales (Ostrom, 2010b). This call for enhanced water governance is not simply an external parameter, as local residents have called for increased representation in decision-making scenarios. Currently, with VDC and DDC channels largely ineffective, bureaucratic and cumbersome, conflict resolution revolves around informal mechanisms that rely on social and kinship ties. The revival of effective community-based water committees through a polycentric system would not only bring legitimacy to social networks that help to resolve conflicts, but also produce a more even distribution of power, thereby reducing the uneven nature of local decision-making.

Attention must be paid to local power relations and to ensuring the equal representation of community members

These observations point to the need identified by Young (2010) to think systematically about institutional reform, in order to take advantage of opportunities to make planned changes in environmental governance regimes. Establishing and maintaining such institutional mechanisms, however, will be a contested process open to potential control by local elites. Attention must be paid to local power relations and to establishing bases to these institutions that ensure the equal representation of community members and their concerns. Given that water users' committees have stalled in the past, focus should also be on creating stability and sustainability within these institutional structures.

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