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REVIEW ARTICLE

Adaptation policy and practice in densely populated glacier-fed river basins of South Asia: a systematic review

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Abstract Rivers are the cultural, social and economic backbone of South Asia, and therefore, the focus of public, political and scientific debate. Himalayan glaciers are the source of numerous large Asian river systems, which support rich ecosystems and irrigate millions of hectares of fields, thereby supporting about a billion people who live in their catchments. Impacts of climate change in river systems are likely to have considerable social, economic, ecological and political implications. This paper reviews literature for three major glacier-fed river systems of South Asia—Brahmaputra, Ganga and Indus—to understand governance mechanisms for climate adaptation in the region. A systematic review methodology is applied to examine adaptation responses in the riparian countries of these Himalayan river basins in three different levels—policy objectives, institutions and practice. Using the "fit for purpose" governance framework, we try to examine how far or near is the region for operationalizing principles of adaptive governance.

Keywords River basins · Glacier fed · Systematic review methodology · Climate policy · Adaptive governance

Introduction

Glacier and snow-pack-dependent river basins situated in the Himalayan region come under the climate change "hotspot" category according to the Intergovernmental Panel on Climate Change (Cruz et al. 2007). Reduced water flows in the major Himalayan river systems are expected to result in adverse impacts on agricultural production, hydro-energy generation and physical infrastructure (Vass et al. 2009; Xu et al. 2009; Mirza 2011; Immerzeel et al. 2012; Rupper et al. 2012), which will have significant welfare implications for the entire South Asia region. Climate change is also associated with the risk of flooding, and in the South Asian countries of Bangladesh, India, Nepal and Pakistan, the frequency and magnitude of disastrous floods is observed to have already increased (Atta-ur and Khan 2011; Gaurav et al. 2011; Mirza 2011; Moors et al. 2011; Tariq and van de Giesen 2012). Similarly, the frequency of glacial lake outburst floods (GLOFs) in the Himalayas is reported to have risen in recent decades (Dahal and Hagelman 2011). Thus, although the distinction between strictly climate-induced events and anthropogenic influences that aggravate the severity of natural hazards is still unclear, there is enough evidence to suggest the increased vulnerability of the region.

The three major Himalayan river basins—Brahmaputra, Ganges and Indus—that are the focus of this paper are spread over six countries of South Asia (Afghanistan, Bangladesh, Bhutan, India, Nepal and Pakistan). The basins of the Indus and Ganges rivers together cover 2.20 million km^2 and are inhabited by over a billion people (Sharma et al. 2010); the lower Brahmaputra basin is home to nearly 300 million people (Kamal-Heikman et al. 2007). India's National Ganga River Basin Authority (NGRBA) reports that more than half of the poor in the country live on the main stem of the Ganges and that by 2,050, this population is expected to rise to approximately 720 million from an estimated 500 million in 2001 (Hosterman et al. 2012).

Given the large geographical spread of the three river basins along with the huge number of poor people living in

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the region, adaptation to the anticipated adverse impacts of climate change is soon expected to feature dominantly in the mainstream policy discourse of the concerned countries. There is already recognition of the threat by the national governments, as evident from several initiatives and policy measures adopted in the region. As part of their reporting obligations to the United Nations Framework Convention on Climate Change (UNFCCC), in the form of their National Communications (NCs) and National Adaptation Programmes of Action (NAPAs), for example, South Asian countries have reviewed developmental objectives and focused on optimizing outcomes of developmental activities that would also deliver climate change co-benefits. The emphasis is on the most advantageous utilization of available human, technical and infrastructural resources to reduce vulnerabilities and build adaptive capacity of people and ecosystems.

This paper is an attempt to inform the above discourse by presenting a comprehensive assessment of the state-of-knowledge as well as state-of-affairs with respect to climate change adaptation policy and practice in the South Asia region. A systematic review methodology is adopted for the purpose, and the findings of the study are expected to assist in the design of adaptation interventions that aim to build resilience of vulnerable populations and their livelihoods, which is the focus of this special edition (De Souza et al. 2015) and also identify priorities for collaborative adaptation research in the region.

Materials and methods

Systematic review methodology

Systematic review methodology is emerging as a promising tool for synthesis and rigorous characterization of vast and emerging body of knowledge for identification of research gaps in an "unobtrusive" way (Ford and Pearce 2010; Berrang-Ford et al. 2014). Although a relatively new methodology in the field of climate science, several advantages over the standard review methods are cited, the most significant being the scope for conducting both quantitative and qualitative analysis of trends in the literature while providing essential details on the review procedures applied, which can help in validating interpretation and replicating the study to test interpretation (Berrang-Ford et al. 2011; Ford et al. 2011; Biesbroek et al. 2013). Greater transparency in syntheses of knowledge is expected to help the public discourse move from the scientific process to public policy actions by clarifying the evidential basis for climate change science (Ford and Pearce 2010; Lesnikowski et al. 2011, 2013; Petticrew and McCartney 2011).

This study is based on information generated from the systematic mapping of peer-reviewed published journal papers available via ISI Web of Knowledge and a limited selection of grey literature documents, primarily government reports. The review focuses on literature published post 2006 and is limited to publications in English. The year 2006 is identified as the base year for the review to build upon the information generated post IPCC Fourth Assessment Report (IPCC 2007) which covers information till 2006.

Searches for peer-reviewed literature

The ISI Web of Knowledge database was searched to extract relevant articles. The keywords (Table 1) were identified by making reference to flagship reports on climate change (e.g. IPCC 2007) and consultations with experts who helped refine the choice of keywords used for the searches. Using these keywords, 192 research articles were identified and the title and abstract of the articles reviewed applying the inclusion and exclusion criteria mentioned in Table 2. In case of doubt, the full text of the articles was screened to ensure relevance. Finally, 33 peer-

Table 1 Search terms used in Web of knowledge

S. no	Choice of keywords
1	Topic = ("climat*" OR "global warming" OR "climate hazard" OR "extreme weather" OR "flood" OR "drought" OR "glacier" OR "temperature" OR "precipitation" OR "disaster") AND Topic = ("adapt" OR "vulnerab*" OR "cop*" OR "capacity" OR "resilience" OR "policy" OR "practice" OR "case stud*" OR "disaster reduc*" OR "risk management" OR "response") AND Topic = ("government" OR "nation*" OR "transboundary" OR "policy" OR "program" OR "scheme" OR "socioeconomic" OR "population" OR "communit*" OR "farmer" OR "livelihood" OR "freshwater" OR "watershed" Or "water management" OR "food" OR "employment" OR "data" OR "irrigation" OR "yield" OR "institution" OR "development" OR "cooperation" OR "conflict" OR "security") AND Topic = ("South Asia" OR "India" OR "Afghanistan" OR "bhutan" OR "Nepal" OR "Pakistan" OR "Bangladesh" OR "Himalayas") AND Topic = ("river" OR "river basin" OR "Ganga" OR "Ganges" OR "Indus" OR "Brahmaputra")
2	Topic = ("climat*" OR "global warming" OR "climate hazard" OR "flood" OR "drought" OR "glacier" OR "precipitation" OR "disaster") AND Topic = ("gang*" OR "indus" OR "Brahmaputra") AND Topic = ("integrat*" OR "mainstream" OR "policy" OR "practice" OR "development" OR "governance")

Table 2 Inclusion and exclusion criteria

Included	Excluded
Literature published between 2006 and 4 May 2013	Literature published before 2006 and after 4 May 2013
Indexed in the ISI web of knowledge	Not available in ISI web of knowledge
Findings relevant to the geographical area being examined	Regions beyond the scope of this study
Policy and practice relevant findings	Scientific assessments, model validation
Content relevant to the research	Irrelevant content
Reviews and articles	Proceedings paper and editorial material

reviewed articles were extracted for detailed review and analysis as meeting the inclusion criteria.

Searches for grey literature

Acknowledging that all knowledge related to policy and practice may not be in the peer-reviewed domain (Lesnikowski et al. 2011, 2013) and recognizing the methodological constraints in use of grey literature in systematic review (Ford et al. 2011), a limited selection of "grey" literature documents (documents that do not pass through the scientific peer-reviewed system) relevant to the study were identified. These are primarily government reports on climate change and country submissions to the UNFCCC, as these follow extensive multi-level consultative processes (proxy for a peer-reviewed process) (Lesnikowski et al. 2011, 2013).

Adaptive governance and the analytical framework

The analytical framework of the present study is drawn from the "adaptive governance" paradigm which is well suited for resource governance given the challenge of climate change (Rijke et al. 2012). The adaptive governance paradigm seeks to learn from diverse knowledge systems and experience, networking among various actors to facilitate social learning of novel solutions and leadership to navigate change in social processes (Folke et al. 2005). It recognizes systems thinking as a methodology for management and seeks stakeholder participation in every level of policy making for robust understanding of natural and social risks and feedbacks (Pahl-Wostl 2009).

Adaptive governance has the potential of guiding planning processes which can produce strategies which are not only robust in design but also socially acceptable. Most of the literature on this approach offers either the need for adaptive governance or identify factors influencing its emergence. However, Rijke et al. (2012) offer an operational framework, which has identification of purpose, mapping of the context and evaluation of the governance outcomes as three key steps for achieving adaptive governance. The participation of stakeholders takes a central role in each step, and hence, their outcome depends on the mix of stakeholders' value system and interests.

In this study, we link the three steps of Rijke et al. (2012) to three levels of governance, essentially, policy objectives, institutions and practice. Policy objectives define the desired goals for a society. Expert judgement has guided us to assess national climate policy objectives using the following five normative criteria:

- *Distinction of climate change as additional stressor*—Variability in climate system becomes additional to the existing risks posed by nature and society. It is a long-term phenomenon and can influence every aspect of provisioning society; hence, it is crucial to identify its role as an additional stressor to existing developmental challenges.
- *Mainstreaming climate change into development*—Development has been a key priority in global south. But the climate change risk challenges the sustainability of development initiatives hence incorporating climate risks in the planning phase of such initiatives becomes a key factor.
- *Influence of climate science in scale and scope in climate action*—It is the guidance of climate science that differentiates climate change planning from any development planning. But there is always a limitation of precision of climate models and coupling of social–ecological factors that influences decision and action; hence, the degree to which climate science can guide is important.
- *Identification of institutional framework for climate action*—Climate action will require cross-sectoral activity for e.g. issues of linkages of energy, water and agriculture. But the governance mechanisms in global south is yet to come out of a legacy of reductionist structures that have been framing rules for resource utilization and access; hence, identification of institutional frameworks for novel activities becomes important.
- *Integration of capacity building in policy goal*—There is a need to enhance capacity in research and development for climate science to reduce uncertainty, but

equally important is the capacity to support integrated approaches and learning within decision making.

The second level of governance has institutions, which are a means to achieve policy objectives. The mapping of the institutional landscape is done in terms of function and scale of operation of the institutions that are specifically mandated to address the climate policy objectives. Finally, in the practice landscape, we examine the diversity of adaptation responses and seek to identify the key influencing factors on policy outcomes in the study region.

Results

Majority of the published studies on adaptation in the major Himalayan river basins are focused on the Ganges river basin and identify flooding as the principal hazard

The number of scientific publications on adaptation in the three major Himalayan river basins is observed to have increased significantly in recent years (2011 and 2012) although there is no clear trend over the entire review period (Fig. 1).

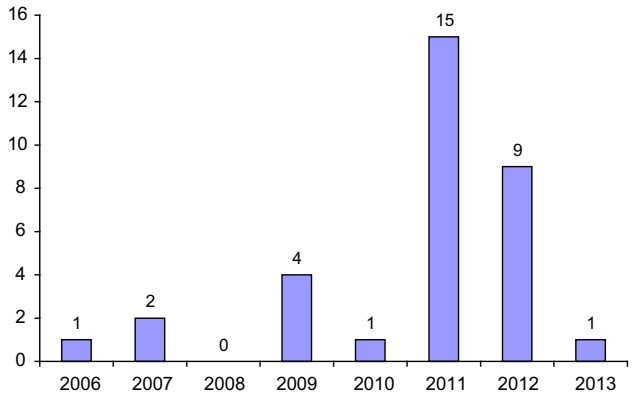

Fig. 1 Year-wise distribution of research papers (data till 4th May 2013)

Table 3 presents a basin-wise listing of the studies reviewed, and clearly the majority of the papers (approx. 27 %) have concentrated on the Ganges river basin. An analysis of the papers shortlisted for this study identify flooding as the principal hazard in these river basins (52 %), which is likely to get exacerbated in the light of climate change. This includes studies with a direct reference to floods (Chowdhury and Ward 2007; Osti and Egashira 2009; Atta-ur and Khan 2011; Barua and van Ast 2011; Dahal and Hagelman 2011; Gaurav et al. 2011; Karki et al. 2011; Mirza 2011; Chaliha et al. 2012; Jain et al. 2012; Shah et al. 2012; Tariq and van de Giesen 2012; Alfieri et al. 2013) as well as those with an indirect reference (Xu et al. 2009; Bocchiola et al. 2011; Kreutzmann 2011; Rupper et al. 2012).Other key vulnerability factors include high population density in the river basins, agriculture-based economy, unplanned development and human encroachments over floodplains, deforestation and the bio-physical parameters. The safety of hydroelectric power plants and infrastructure is a major concern in the light of GLOF events particularly as hydroelectric power is a major economic export for Bhutan (Rupper et al. 2012) and since India is planning a number of hydroelectric projects in the Himalayas (Jain et al. 2012).

Adaptation interventions reported in the published literature are categorized under planning and decision making, research, awareness and capacity building, and provisioning of infrastructure and technical resources

As evident from Fig. 2, majority (73 %) of the papers examined emphasize the need for and provide specific guidance on ways for proper *planning and decision making* in the context of climate change (Chowdhury and Ward 2007; Mustafa 2007; Osti and Egashira 2009; Pittock 2009; Vass et al. 2009; Xu et al. 2009; Lebel et al. 2010; Atta-ur

Table 3 Basin-wise list of studies from peer-reviewed literature

Basin focus	References
Ganges (9)	Osti and Egashira 2009, Vass et al. 2009, Dahal and Hagelman 2011, Hosterman et al. 2012, Moors et al. 2011, Pandey et al. 2011, Immerzeel et al. 2012, Manandhar et al. 2012, Jain et al. 2012
Brahmaputra (4)	Chaliha et al. 2012, Gain et al. 2012, Rupper et al. 2012, Shah et al. 2012
Indus (8)	Fowler and Archer 2006, Mustafa 2007, Atta-ur and Khan 2011, Bocchiola et al. 2011, Gaurav et al. 2011, Karki et al. 2011, Kreutzmann 2011, Tariq and van de Giesen 2012
Ganges–Brahmaputra (3)	Chowdhury and Ward 2007, Barua and van Ast 2011, Mirza 2011
Ganges–Brahmaputra–Indus (3)	Xu et al. 2009, Lebel et al. 2010, Nandargi and Dhar 2011
General (6)	Pittock 2009, Perveen and James 2011, Pittock 2011, Saleth 2011, Viviroli et al. 2011, Alfieri et al. 2013

Studies specific to Nepal are placed under Ganges river basin; studies specific to Bhutan are placed under Brahmaputra river basin; articles placed in the "General" category are not specific to any particular river basin but have relevance for the study

and Khan 2011; Gaurav et al. 2011; Karki et al. 2011; Kreutzmann 2011; Mirza 2011; Moors et al. 2011; Pandey et al. 2011; Perveen and James 2011; Pittock 2011; Saleth 2011; Hosterman et al. 2012; Manandhar et al. 2012; Gain et al. 2012; Tariq and van de Giesen 2012; Barua and van Ast 2011; Chaliha et al. 2012; Alfieri et al. 2013). These include developing flood forecasting and early warning capabilities, improved dialogue and collaboration between actors and sectors, better institutional coordination and transparent systems for monitoring and evaluation. The need for good governance, at all scales, with a greater role for local actors, strengthening regional cooperation and strengthening water management institutions have been repeatedly emphasized in the literature.

Strengthening *research* efforts is identified as a priority by 55 % of the papers reviewed (Fowler and Archer 2006; Chowdhury and Ward 2007; Mustafa 2007; Xu et al. 2009; Bocchiola et al. 2011; Gaurav et al. 2011; Karki et al. 2011; Nandargi and Dhar 2011; Perveen and James 2011; Viviroli et al. 2011; Chaliha et al. 2012; Gain et al. 2012; Hosterman et al. 2012; Immerzeel et al. 2012; Jain et al. 2012; Rupper et al. 2012; Shah et al. 2012; Alfieri et al. 2013). These are primarily for improving capabilities for probabilistic forecasting and projections for future hydrological behaviour. Model simulation and parameterizations studies have been recommended for reducing uncertainties. Developing long-term research programmes, undertaking detailed studies at the regional as well as local level and generating a consolidated knowledge base areas are among the priority areas that have been identified.

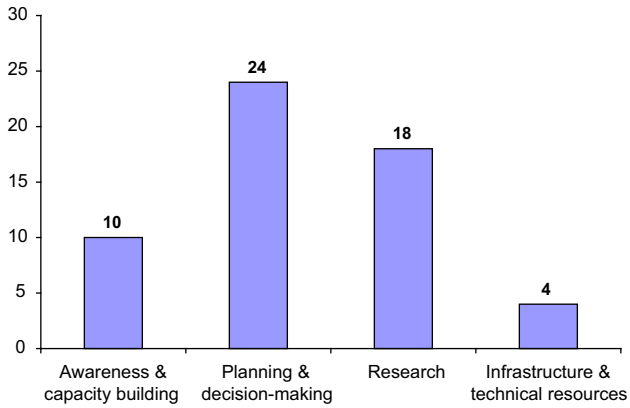

Fig. 2 Priorities identified for adaptation policy (from peer-reviewed literature)

Approximately 30 % of the papers identify gaps in the levels of *awareness and capacities* of stakeholders, particularly local communities, to perceive climate risks and respond to the challenge (Chowdhury and Ward 2007; Lebel et al. 2010; Atta-ur and Khan 2011; Barua and van Ast 2011; Dahal and Hagelman 2011; Karki et al. 2011; Moors et al. 2011; Gain et al. 2012; Manandhar et al. 2012; Shah et al. 2012). Only 12 % highlight specific *infrastructural and technical resources* required to aid in decision making (Atta-ur and Khan 2011; Gaurav et al. 2011; Viviroli et al. 2011; Jain et al. 2012). These include adopting structural measures for flood control, land use zoning, GIS-based interactive maps for spatial planning, river basin-scale flood risks maps and improved observation networks.

Ambiguity in climate policy objectives exists in varying degree among South Asian countries

Table 4 (based on information presented in supplementary material) brings out the diversity in climate policy objectives among the South Asian countries. For instance, while both Bangladesh and India have national climate policies that are complete in terms of goal setting (as per our five criteria), the others have built-in ambiguities/deficits in their policy purpose which may lead to challenges for their operationalization.

There is a common emphasis in the national-level climate policy objectives on livelihood security

The national-level climate policy documents reviewed for this study have a commonality in their aim to build the adaptive capacity of people by means of providing *livelihood security* in the face of climate change risks. For instance, the Climate Change Policy, 2011 of Government of Nepal aims to build resilience of local communities by enhancing capacities for efficient management of natural resource base and use of climate-friendly technologies. Due emphasis is also given to ensuring peoples'

Table 4 Cross-country comparison of climate policy objectives in South Asia

Country	Distinction between CC and development	Mainstreaming	Scientific basis	Institutional framework	Capacity assessment
Afghanistan	A	A	A	A	A
Bangladesh	P	P	P	P	P
Bhutan	A	P	P	A	P
India	P	P	P	P	P
Nepal	A	U	P	P	P
Pakistan	A	P	U	P	U

P present, *A* absent, *U* unclear

participation, especially of poor marginalized indigenous communities, women, children and youth, in the implementation of climate adaptation and climate change-related programmes. Similarly, the 2012 National Climate Change Policy of Government of Pakistan gives particular attention to the needs of economically and socially vulnerable sectors of the economy for the success of climate-resilient development in the country. It recognizes climate change as a serious threat to poverty reduction efforts and emphasizes the need to integrate poverty–climate change nexus into economic policies and plans (MoCC 2012).

India's Second National Communication to UNFCCC (MoEF 2012) states that the country "has pursued aggressive strategies on forestry and coastal management, recognizing their ecological as well as livelihood significance" (p164). More relevant to the river basins context is the Draft Water Policy 2012 (MoWR 2012a), which recognizes the potential threat to livelihoods by climate change-induced variability of water resources. Further, for safeguarding livelihoods, the policy suggests adopting integrated farming systems and encourages non-agricultural developments.

Institutions reported in the reviewed literature are primarily focused on strategic knowledge generation and management

Table 5 presents a list of the institutions that find mention in the reviewed literature (both peer reviewed and grey) and have a specific relevance to our study of adaptation response in the three South Asia river basins. It is clear that there is not much functional diversity among the listed institutions, and the dominant focus across countries is strategic knowledge generation.

The institution-level focus on strategic knowledge generation and management can be illustrated through a few examples. In India, the National Ganga River Basin Authority (NGRBA) and Brahmaputra River Valley Authority (BRVA) have been restructured to overcome earlier deficiencies in their management systems; generation of strategic knowledge base is a priority in the restructured management plans (MoEF undated; MoWR 2012b). Along with a Ganga Knowledge Centre, the NGRBA suggests formulating City-level Citizen Monitoring Committees and Forums for carrying out social audits of the River Ganga. Similarly, in Pakistan, the Indus River System Authority (IRSA) identifies the need to develop a GIS/MIS Centre and Decision Support System to develop its analytical functioning capacity.

One of the eight priority areas in India's National Action Plan on Climate Change (NAPCC) is a National Mission on Strategic Knowledge on Climate Change. India also provides an example of coordinated approach to strategic knowledge generation in the context of climate change. The Indian Network for Climate Change Assessment (INCCA), a network-based programme that brings together over 120 knowledge institutions and over 220 scientists from across the country, was established by Government of India in 2009 to carry out integrated assessments of climate change impacts on a collaborative mode (MoEF 2010).

The need for policy reforms to deal with climate change is commonly reported by the South Asian countries in their submissions to the UNFCCC

The need for institutional reforms for tackling the climate change challenge is well acknowledged by the South Asian countries in their submissions to UNFCCC. Afghanistan highlights the need for improving legal, policy and implementing frameworks by developing new legislation related to natural resource management (NEPA 2009, 2013). The Water Act of Bhutan 2011 recognizes climate change as an additional stressor which cannot be addressed within the purview of the existing policy framework. Bhutan also iterates the need for establishing an independent Water Authority as per the Water Act (Government of Bhutan 2011). Pakistan's National Climate Change Policy 2012 suggests formulation and enforcement of river flood plain regulations and laws for addressing projected increase in the frequency and intensity of extreme climate events (MoCC 2012). Bangladesh seeks to build cross-country collaborations and develop regional action plans with a focus on key issues including water security (MoEF 2009).

NAPAs provide a roadmap to adaptation practice while identifying the key barriers at the national level

Most countries recognize the scale of analysis for water resource management to be at the river basin or watershed level, and the major projects proposed in the NAPAs of Afghanistan, Bhutan and Nepal are designed at this scale (NEC undated, 2009; NEPA 2009; MoE 2010; NEC 2011). Besides, a range of activities have been prioritized including GLOF Hazard Zoning, Early Warning Systems, flood prevention and management, and strengthening of the hydrological and meteorological networks (Table 6).

Adaptation projects in the river basins under study are mostly at the local scale, with an emphasis on disaster risk management, and having government as the executing agency

Figure 3 is illustrative of the diversity of adaptation projects in the region. Majority (52 %) of the projects are initiatives at the local scale, and the experiential learning is inadequately documented. One-third of the adaptation

Table 5 Institutions (regulations, organizations, networks) for achieving climate policy outcomes in South Asian countries

Country	Institution	Function	Scale
Afghanistan	National Climate Change Committee	Steering and coordination	Political jurisdiction (national)
	Supreme Council for Water Resources Management	Advising and coordination for promoting integrated water resource management	Political jurisdiction (national)
Bangladesh	National Steering Committee on Climate Change	Steering and coordination	Political jurisdiction (national)
	Flood Forecasting and Warning Centre (FFWC)	Generation of strategic knowledge	Political jurisdiction (national)
	National Disaster Management Council (NDMC) headed by the Prime Minister	For formulating and reviewing disaster management policies	Political jurisdiction (national)
Bhutan	National Climate Change Committee	Technical-level task force, convenes for project implementation only	Political jurisdiction (national)
	Bhutan water partnership (BhWP)	An interministerial body to coordinate all programmes related to water resource protection, development and management	Ecosystem
	The water regulation, 2011	Practical and effective implementation of the provisions of the Water Act of Bhutan, 2011 particularly in light of climate change	Political jurisdiction (national)
India	National Ganga River Basin Authority (NGRBA); Brahmaputra River Valley Authority (BRVA); Ganga Knowledge Centre (proposed)	Restructured to focus on integrated water resource development with the river basin used as the unit for planning Generation of strategic knowledge base and creating knowledge repository	Political jurisdiction (national)
	City-level Citizen Monitoring Committees and Forums (suggested by NGRBA)	For carrying out social audits of the River Ganga	Political jurisdiction (city)
	India Network for Climate Change Assessment (INCCA)	Generate strategic knowledge	Political jurisdiction (national)
	Prime Ministers Council on Climate Change	Steering and coordination	Political jurisdiction (national)
	Draft national water policy 2012	Proposes a national level legal framework on water governance particularly in view of climate change impacts	
Nepal	Climate change council under the chairmanship of Prime minister	Steering and coordination	Political jurisdiction (national)
	Multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC)	Coordination and dialogue among and between government agencies and donors	Political jurisdiction (national)
Pakistan	Indus River System Authority (IRSA)	Knowledge generation and management	Ecosystem
	Prime Minister's Committee on Climate Change	Steering and coordination	Political jurisdiction (national)
	National Climate Change Policy Implementation Committee (Proposed)	Regular monitoring and upgrading of the National Climate Change Policy at an interval of 5 years	Political jurisdiction (national)
All countries	World Bank, UNDP, ADB, GIZ, UNEP, RCN, IDRC, DFID, CIDA, SIDA, DANIDA, FAO, IUCN, USAID, AUSAID, among others	facilitation and capacity building, knowledge generation and management	Political jurisdiction (national and regional)
	ICIMOD	Capacity building, knowledge generation	Ecosystem

Table 6 National adaptation programmes of action (NAPAs)

Country	Likely climate change impacts and key adaptation needs	Prioritized activities	Challenges and barriers to implementing adaptation measures
Afghanistan	Floods due to untimely and heavy rainfall; flooding due to thawing of snow and ice; increasing temperatures	Improved water management and use efficiency; Climate-related research and early warning system; Land and water management at the watershed level	Lack of capacity in terms of human resources; Low levels of awareness of the current and potential impacts of climate change; addressing both immediate development needs and climate change, limited analytical capability, especially for analysing climatic data to assess threats and potential impacts, and develop viable solutions, limited resources
Bhutan	Increased GLOF events and flooding, increased rainfall in areas without proper drainage systems can cause soil instabilities leading to landslides and flash floods	GLOF hazard zoning, early warning systems, flood protection of downstream industrial and agricultural area, landslide management and flood prevention	Lack of national capacity in terms of human resources, integrating new concepts like adaptation to climate change effects into immediate infrastructural and development needs, limited analytical capability, especially for climate data to analyse threats, potential impacts and develop viable solutions, limited information and awareness about climate change
Nepal	Water resources and energy impacted by changes in hydrological cycle and climate-induced disasters increase in current frequency of hydro-meteorological extreme events such as avalanches, floods and inundation	Integrated watershed management, promoting water management at river basin level at municipal areas, flood management, non-conventional irrigation systems in water stressed areas, monitoring GLOFs, early warning systems, hazard mapping, assessing disaster impacts, institutional and research capacity, managing existing hydrological and meteorological network	Weak governance (mainly due to extended political transition), limited delivery of development-related services, poor coverage of infrastructural facilities, high poverty rates, accumulated and additional costs to adaptation, lack of public awareness on climate change disasters and limited reach of early warning systems

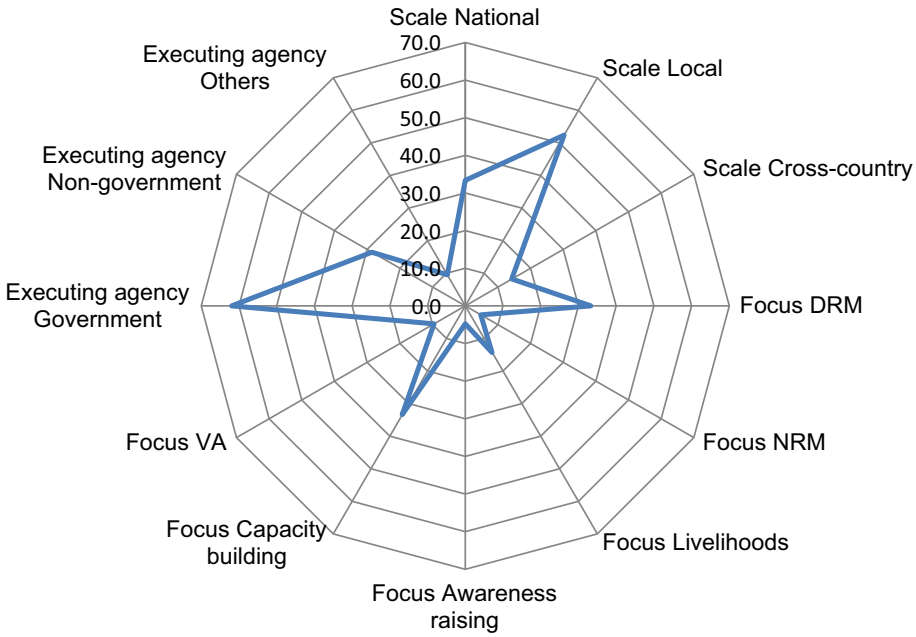

Fig. 3 Percentage distribution of adaptation projects in terms of scale, focus and executing agency (see supplementary material)

projects are at the national scale and only three out of the total twenty-one projects reviewed have a cross-country character. In terms of their focus, while a third of the projects are on disaster and risk management, another one-third of projects have capacity building as their core objective. This emphasis on disaster and risk management in adaptation projects in large river basins is also brought out in Ford et al's review in this special edition (Ford et al. 2014). Similarly, their finding for all "hotspots" about the overwhelming involvement of national governments in adaptation initiatives and absence of private sector is strongly corroborated in our review of adaptation projects in countries sharing the Himalayan river basins. We find 62 % of the adaptation projects having national governments as the executing agency and not a single project with private sector involvement.

There are very few reports of cross-country adaptation projects/programmes

Among the South Asian riparian countries, enhanced regional collaboration for undertaking integrated scientific research, policy making and implementation of cross-country adaptation measures has been cited as a necessity (Xu et al. 2009; Mirza 2011; Viviroli et al. 2011). Dealing with major disasters (e.g. through international organizations) requires anticipation at the transnational level calling for substantial planning and information at different levels (Alfieri et al. 2013). Enhanced cooperation among the co-riparians will strengthen the knowledge and database required for better flood forecasting and issuance of early warnings which can considerably bring down the losses to life and economy.

As highlighted by Karki et al. (2011), intergovernmental organizations like the International Centre for Integrated Mountain Development (ICIMOD) play a pivotal role in building scientific knowledge and capacity by engaging various national, regional, and international actors. A noteworthy cross-country initiative, involving all concerned regional governments, is the establishment of regional flood information system in the Hindu Kush Himalayan Region, for timely exchange of flood data and information for reduction of flood vulnerability in the Ganges–Brahmaputra–Meghna and Indus river basins (ICIMOD 2012). The intergovernmental regional institutions are uniquely placed at the interface of science and policy, and gauging the policy impact of the various programmes can provide vital insights on barriers to policy uptake of research findings.

Discussion

The need to strengthen adaptation planning and decision making (i.e. governance mechanisms) in Himalayan river basins gets priority in the reviewed literature. The adaptive governance paradigm recommends unambiguous policy purpose, clarity in institutional arrangements and policy-practice fit along with stakeholder involvement for successful outcomes (Rijke et al. 2012). From this perspective, the finding of policy ambiguity at national level in Afghanistan, Bhutan, Nepal and Pakistan raises questions about the capacity of the region to operationalize principles of adaptive governance. It is also pertinent to note that the majority of the riparian countries seem to have formulated policy objectives that do not clearly distinguish climate change as an additional stressor to development challenges. On the other hand, capacity building has been integrated into the climate policy objectives of most of the countries.

Our mapping of the institutional landscape points to the need for functional overarching institutional mechanisms at national and regional levels for effectively addressing climate change in a coordinated manner and building technical and institutional capabilities. For example, the absence of a dedicated Ministry of Water Resources in Bhutan seem to have restricted relevant adaptation response in the water sector to project-scale activities without any long-term institutional planning. On the other hand, to overcome the challenge of coordination among multiple agencies, Nepal has formed a Multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC). India's National Action Plan on Climate Change is steered by the Prime Minister's Council on Climate Change and has prompted similar initiatives at the sub-national level. High-level political commitment helps promote cross-sector policy development (Pittock 2011) and is possibly one of the principal reasons behind its successful diffusion to lower levels of governance.

In the mapping of institutions across countries, a key finding is that there is a common emphasis to strategic knowledge generation to meet climate policy outcomes. Our review suggests that there is a need for integrated assessments factoring social and ecological considerations for adapting to changes in water availability (Pandey et al. 2011; Perveen and James 2011; Viviroli et al. 2011) and studies on the economics of climate change adaptation (Chowdhury and Ward 2007; Osti and Egashira 2009; Attaur and Khan 2011; Tariq and van de Giesen 2012).

Compared to structural measures, non-structural measures such as an effective seasonal climate knowledge base have better feasibility and possibly greater potential to be effective in mitigating the damaging effects of floods. More importantly, such strategic knowledge has applications across sectors and beyond national borders. Chowdhury and Ward (2007), for instance, identify the need for seasonal climate information and forecasts that can feed into current flood preparedness and management measures in Bangladesh. Another example of knowledge based non-

structural approach to flood management is basin-scale flood risk maps—such GIS-based, interactive maps may utilize historical data analysis as well as modelling approaches and can be linked to an online database and flood warning system (Gaurav et al. 2011).

However, the emphasis over knowledge generation seems to be focussed on political jurisdictions at national level. This ignores the local-level knowledge systems that are recognized as repositories of traditional knowledge and management practices (Kreutzmann 2011; Gain et al. 2012; Manandhar et al. 2012). Similarly, most of the transboundary water sharing agreements in the region are yet to factor in climate change uncertainties (Lebel et al. 2010). Karki et al. (2011) cite that the effectiveness of the Indus Basin Treaty between India and Pakistan, the only transboundary institutional arrangement for Indus Basin water management, has been greatly reduced in a changing climatic scenario. In an extreme scenario, climate change-induced severe reductions in water flow may result in conflict situation and threaten to undo the existing arrangement based on mutual cooperation. Lebel et al. (2010) opine that, for any new agreement among riparian countries, a preferred alternative would be to promote trust and cooperation by focusing on benefit sharing (considering, for example, power generation benefits, flood control, international trade and food security among others) rather than just physical allocations of water.

Thus, in a river basin context, a scale mismatch between problem and management institutions has major implication for policy. Tucker et al. (2014) cite studies which identify this "disjuncture between policy-making or administrative units compared to the geographically determined unit" in South Asia's river basins. This requires that the traditional fragmented approach to water management has to be replaced by more holistic system view approaches (Gain et al. 2012).

There is an indication of the policy-practice mismatch when one looks at the livelihood-focused adaptation initiatives in the practice domain and contrasts this with the policy emphasis. Out of the total twenty-one adaptation projects reviewed, only three local scale initiatives in two countries—India and Bangladesh—have an explicit focus on livelihood. But, as Ford et al. (2014) cautions, many adaptation actions are undocumented and in many other instances likely to be built into existing mainstreamed programmes to address development priorities. An example of the latter possibility is India's national-level Integrated Watershed Management Programme (IWMP), which has been highlighted as a major adaptation initiative of the Government of India, under which the activities provide sustainable livelihoods to the people residing in watershed areas (MoEF 2012). Similarly, the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), which aims to provide minimum job for 100 days in a year to the adult family members of rural households below poverty line, has been linked to development of land and water resources in villages that would contribute to sustainable and climate-resilient agriculture. It is well acknowledged that effective adaptation interventions require harnessing synergies among various government schemes (Vass et al. 2009; Mirza 2011; Hosterman et al. 2012) along with stakeholder involvement in monitoring and evaluation of policy implementation (e.g. Lebel et al. 2010; MoWR 2012a).

Conclusion

The study uses the adaptive governance framework to identify three levels—policy, institutions and practice—which together serve to define the adaptation response in the Himalayan river basins. Apart from India and Bangladesh, there is still ambiguity in goal setting which may constrain policy implementation. At the institutional level, the observation that most of countries are in the process or have already designed structures for knowledge generation and management reflects the capacity for operationalizing the policy mandate of strengthening the scientific base for informed decisions. Thus, a focus on uncertainty reduction for robustness of policy and planning in the South Asia region can be inferred. However, most of the structures maintain the levels of political jurisdiction as their functional scale, which raises a question of fit with the complex issues of climate change that play out in ecological scale. Further, in the practice level, there is a dearth of documentation of initiatives which can specify as adaptation responses. This makes it difficult for evaluation the policy-practice fit, and hence, again questions the capacity to operationalize adaptive governance in the region.

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