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ADAPTING WATER MANAGEMENT IN INDIA TO CLIMATE CHANGE: INSTITUTIONS, NETWORKS AND BARRIERS

SCHOOL OF WATER, ENERGY AND ENVIRONMENT

PhD in Environmental Technology
Academic Year: 2012 - 2016

Supervisors: Prof Ian Holman and Dr Simon Jude
May 2017

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ABSTRACT

Climate change is experienced most through the medium of water. The ability of water institutions and the factors that enable or hinder them to purposefully adapt to the new and additional challenges brought by climate change require better understanding. Factors that influence their perception of climate change impacts and initiatives being taken for adaptation are shaped by various enabling factors and barriers through the interaction with both governmental and non-governmental institutions across administrative scales. Better understanding of these adaptation enablers and barriers is essential for devising adaptation strategies.

This research aims to identify and expound the characteristics that enable or hinder institutions to adapt for water management, and hence, it evaluates the involvement of key governmental and non-governmental institutions in India and the inter-institutional networks between them. It surveyed webpages and online documents of sixty Union Government institutions and interviewed representatives from twenty-six governmental, non-governmental, research and academic institutions operating at the national level and another twenty-six institutions operating within the State of Himachal Pradesh in India to assess the characteristics that enable or hinder adaptation. While the online projection of institutional involvement and interaction among key Union Government institutions on climate change and water indicate a more centralized network pointing to Planning Commission and Ministry of Environment and Forest, the interview responses indicated a more distributed network with both Ministries of Water Resources and Environment and Forest recognized as key institutions thereby indicating a potential variation in perception of who is in-charge. Moreover, online documents show institutions that are involved in water have less mention of climate change compared to Union Government ministries involved in less climate-sensitive sectors indicating that impacts of climate change on water are potentially ignored.

While it is evident that research and consulting institutions engaging with both national and state level institutions play a key role in enabling adaptation, various barriers pertaining to data and information accessibility, inadequacy of resources and implementation gaps exist particularly due to inter-institutional network fragmentations. Although barriers identified in this study bear resemblance to barriers identified by other researchers in other contexts, this research shows similar barriers can emerge from different underlying causes and are highly interconnected; thereby indicating the need for addressing adaptation barriers collectively as a wider governance issue. Since

many of the adaptation barriers emerge from wider governance challenges and are related to larger developmental issues, the findings have important policy implications. Among the various issues that the government needs to address is improving the inter-institutional networks between water institutions so that information dissemination, sharing of learning experiences and data accessibility is improved and prescriptive legislations are seen to be inadequate in this regard. Restructuring the way officials in government water institutions are recruited and deployed is suggested as a potential solution for improving the inter-institutional networks.

The research elucidates that inter-institutional networks and transboundary institutions are two pillars that supports adaptation and also bridges the gap between adaptive capacity and adaptation manifestation that enable water institutions to cross the chasm of adaptation barriers. Thus the thesis presents an important analysis of key characteristics that enable or hinder water management institutions to adapt to climate change which have been so far under acknowledged by other studies through the analysis of the state of climate change adaptation in India. Therefore, this study provides valuable insights for developing countries, particularly, facing similar challenges of adapting water management for climate change.

Keywords: adaptive capacity, interconnected, multilevel, transboundary institutions

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DISSEMINATION OF RESEARCH FINDINGS

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- **Azhoni, A**., Holman, I. and Jude, S: *Contextual and interdependent causes of climate change adaptation barriers for water management: evidences from Himachal Pradesh, India*. Science of the Total Environment. Volume 576, 15 January 2017, Pages 817–828 http://doi.org/10.1016/j.scitotenv.2016.10.151
- **Azhoni, A**., Holman, I. and Jude, S.: *Adapting to climate change by water institutions: enablers and barriers* (Under review. Journal of Hydrology)
- **Azhoni, A**., Holman, I. and Jude, S: *Inter-institutional networks across scales for adapting water management to climate change: insights from national and state level water management institutions in India*. (Upcoming)

Conference Presentations

- Azhoni, A., Holman, I. and Jude, S: *Climate change adaptation attributes across scales and inter-institutional networks: insights from national and state level water management institutions in India*. 10th World Aqua Congress International Conference. New Delhi, India. 24-25 November 2016.
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- Azhoni, A., Holman, I. and Jude, S: *Climate change adaptation barriers for water management: insights from water institutions in Himachal Pradesh, India*. European Geophysical Union, Vienna, Austria, 17-22 April 2016. Vol.18 EGU2016-10022, 2016
- Azhoni, A., Holman, I. and Jude, S: *Climate change adaptation through institutional involvement for water management in India*. India Water Week, Mandi, Himachal Pradesh, India. 17 January 2015
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- Azhoni, A., Holman, I. and Jude, S: *Which institutions matter for climate change for water management in India?* Changing Water Cycle – Natural Environmental Research Council NERC, Oxford, UK. 25-26 June, 2014

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CGWB	Central Ground Water Board
CWC	Central Water Commission
DEST	Department of Environment, Science and Technology, Government of Himachal Pradesh
GIZ	Gesellschaft für Internationale Zusammenarbeit
GoI	Government of India
IIT	Indian Institute of Technology
INCCA	Indian Network for Climate Change Action
IPCC	Inter-governmental Panel on Climate Change
IPH	Irrigation and Public Health Department, Government of Himachal Pradesh
MWR	Ministry of Water Resources
MEF	Ministry of Environment and Forest
NAPCC	National Action Plan on Climate Change
NGO	Non-Governmental Organisation
NIH	National Institute of Hydrology
NIT	National Institute of Technology
NMSKCC	National Mission on Strategic Knowledge for Climate Change
NWM	National Water Mission
PMCCC	Prime Minister's Council on Climate Change
SSAPCC	State Strategy and Action Plan on Climate Change, Himachal Pradesh
TERI	The Energy and Resources Institute

1 INTRODUCTION

Climate change is arguably the biggest challenge the world faces today (IPCC, 2012). It has the potential to impact almost all areas of life but the immediate effects are more visible through the medium of water (Seneviratne et al., 2012). It is likely to exacerbate the distorted distribution of water both temporally and spatially (Seneviratne et al., 2012). Climate change has the potential to distort the precipitation patterns both spatially and temporally (Seneviratne et al., 2012) and increase the water demand in many sectors such as irrigation due to increased evapotranspiration (Wang et al., 2014). This will affect the groundwater recharge (Holman, 2006) with reduced infiltration thereby increasing floods on one hand and drought like situation at other seasons. Such a scenario will also affect the water quality due to higher sediments during floods and higher contaminant concentration during the dry season (Whitehead et al., 2009). The retreating glaciers (Seneviratne et al., 2012) and the changing monsoon cycle (Hassan et al., 2015; Singh, 2013) will adversely affect the fresh water availability and quality in various parts of the world exacerbating saline intrusion in coastal aquifers. Concerted efforts on mitigation are unlikely to stop the climate change due to greenhouse gas emissions already committed. Therefore, adaptation is unavoidable while mitigation is not neglected (IPCC, 2014a).

The ability of a system to adjust to the impacts and consequences of the changing climate, reduce its vulnerability and increase the resilience by taking advantage of new opportunities is crucial (IPCC, 2014b). Individuals and communities can adapt to climate change and are already adapting in certain circumstances (IPCC, 2014a). However, individuals and communities can adapt only to a certain extent without the involvement of governmental as well as non-governmental institutions (Butler and Adamowski, 2015). Increasingly, it is being realised that institutions, large or small, governmental or non-governmental, also need to adapt to the changing climate (Berkhout, 2012; Inderberg, 2011). It is now being widely recognised that public utility services institutions such as Municipal Corporations that delivers public water supplies, electricity grid companies, and infrastructure development agencies, need to urgently adapt to climate change (Fünfgeld, 2015; Porter et al., 2015; Shi et al., 2015). Adaptation can be in various forms; anticipatory (Kuruppu and Willie, 2014), autonomous or planned adaptation (Pittock, 2009). Adaptation in water management will include going beyond structural supply measures (Stakhiv, 2011) and consider forecasting/warning systems, demand management and related behavioural changes

(Gifford et al., 2011), economic and fiscal instruments (Tompkins et al., 2010), legislation and structural changes in the institutions (Crabbé and Robin, 2006; The Royal Commission on Environmental Pollution, 2010).

The capacity of a system to adapt depends on factors including how effectively decision makers can gather the required information and knowledge so as to recognise the threats and identify options for adjusting to the new and changing scenario (Smit and Pilifosova, 2003). Social networks between individuals are known to enhance adaptive capacity through an enhanced sharing of resources (Dow et al., 2013). However, inter-institutional networks function at a more complex level as institutions are made up of individuals (Pahl-Wostl, 2009) with different personalities and motivations. Social networks between key officials allow institutions to cross or blur formal institutional and sectoral boundaries, building 'relational capital' (Wallis and Ison 2011) and it provides "a constellation of relationships that can be activated when needed" (Lejano and Ingram 2008 p.251). However, knowledge concerning networks among public institutions and how adaptation is actually being delivered is limited (Arnell, 2010). Moreover, the existence of social networks does not in itself enhance the adaptive capacity of institutions if the institutional network is exclusive (precluding inter-sectorial cooperation), rigid, leaves conventional wisdom unchallenged and does not enable learning (Newman and Dale, 2007). There is a need to understand the factors and circumstances that strengthens ties and cooperation between various institutions and sectors for information diffusion and knowledge exchange (Popp et al., 2013). As the literature on adaptation grows, research on identifying characteristics and attributes that enables (Wilby and Vaughan, 2011) or hinders (Moser and Ekstrom, 2010; Sciulli, 2013) institutions to adapt to climate change is emerging (Biesbroek et al., 2013). However, knowledge regarding the circumstances under which such enabling factors can be enhanced, created or shared among institutions or how adaptation barriers emerge and persists and affects institutions operating at different scales is limited (Eisenack et al., 2014). This research addresses this key knowledge gap by critically analysing how institutions [defined in Box 1.2] operating at different administrative scales in India are involved in climate change adaptation for water management. India, with a complex multilevel water governance system [elaborated in Section 1.5] facing multiple challenges [described briefly in Section 1.2 below and succinctly captured by the then Prime Minister's address in Box 1.1] makes an ideal case to explore the complexities of adapting water management for climate change which is potentially relevant to other developing countries facing similar challenges.

1.1 The Paris Agreement and adaptation challenge

As the impacts of climate change becomes more evident, adaptation is rapidly being recognised as a key priority in the climate discourse. It is being emphasised that mitigation need to be complimented by adaptation as mitigation alone is insufficient to reduce the risks due to the emissions already committed and the efforts to contain greenhouse gases emissions become more uncertain (Bosello et al., 2013; Jones et al., 2007; Mata and Budhooram, 2007; Vignola et al., 2012). The recent Paris Agreement (UNFCCC, 2015) by 197 countries under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) reinforces the urgency of adaptation while mitigation is also given additional thrust (Simonet and Fatorić, 2015; UNFCCC, 2015). It calls for strengthening mechanisms for enhanced transparency on assessing adaptation and emphasises the need for bolstering adaptation commitments from state actors and recognises the multi-level nature of adaptation governance (Lesnikowski et al., 2016).

The Paris Agreement not only makes a notable emphasis on the need for adaptation but also on the multilevel and non-hierarchical nature of climate change adaptation. This framing is observed as more in line with the climate change scholarship, which advocates a polycentric nature of climate change adaptation (Huitema et al., 2011) and shaped by diverse actor networks (Pahl-wostl and Knieper, 2014) rather than state-centric and top-down (Lesnikowski et al., 2016). The recognition of the polycentric nature of climate change regime provides an opportunity for participating countries to develop contextually sensitive and politically realistic adaptation strategies. Article 7 of the Agreement calls for all parties to engage in assessments of impacts and vulnerability, the adoption of national adaptation plans, the determination of nationally prioritized actions, and the implementation of monitoring and evaluation of these actions. For meaningful implementation of these, the Agreement calls for strengthening of information sharing, exchange of learning experiences and good practices and strengthening scientific knowledge on climate change by improving the effectiveness of cooperation and facilitation between institutions and decision makers. The linking of the global long term goal for adaptation in the Paris Agreement (Article 7, para 1) with the Intended Nationally Determined Contributions (INDCs) provides a key opportunity for developing economies to translate capacity-building and financial assistance into tangible policies (Lesnikowski et al., 2016) while continuous and enhanced

international support is also to be provided to developing country Parties for the implementation (UNFCCC, 2015).

While the Paris Agreement enhances opportunities for enhancing adaptation, its effectiveness ultimately depends on the ability of the implementing institutions to enforce its agreements efficiently. Although the Paris Agreement is being hailed as a "new beginning" towards overcoming the many divisions between developed and developing countries (Streck et al., 2016), significant works remain to be done to clarify how the long term goal for adaptation set out in the Agreement, particularly Article 7, will be meaningfully realised (Lesnikowski et al., 2016) or how the progress in adaptation is to be tracked (Ford et al., 2015). Lesnikowski et al., (2016) enlists three key challenges that may impede the meaningful realisation of the Paris Agreement goals:

a) The identification of appropriate reference points within countries for assessing the successfulness of 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change' (Article 7, para 2) is challenging because adaptation actions within and across sectors and institutions is deeply context specific.
b) The diverse perspectives on what constitutes a 'progression beyond previous efforts' (Article 9, para 3) and how adaptation intersects with broader development and risk reduction efforts poses challenge to transparent and consistent decision-making on climate financing.
c) In order to work out and implement the Agreement, how the funding is to be generated and where the spending should be focused remains an issue.

In this respect, Ford et al., (2015) highlighted the need for tracking adaptation and evaluate the progress made towards developing and implementing adaptation policies. The challenge for tracking and monitoring adaptation remains due to much debate about what constitutes adaptation, which proxies can be adopted to measure its success and which information are to be tracked (Ford et al., 2015). Therefore, developing standards, methodologies of evaluating each stakeholder's involvement and contribution to the adaptation process, indicators and baselines for assessing the progress made and exploring ways and means of disseminating and sharing of information and learning experiences between key institutions is of paramount importance for turning the Agreement into tangible implementation.

1.2 Climate change challenges to India's water management

The Indian subcontinent of more than a billion people is likely to be impacted severely by a changing climate (Mall et al. 2006; May 2004; Naswa and Garg 2012; Sanghi and Mendelsohn 2008;). Among the greatest direct impacts of climate change is on the water availability which will have further impacts on food security and other policy areas (Bates et al., 2008). Providing adequate water supply, protecting livelihoods from floods and droughts, and tapping the rich water resources into beneficial irrigation for food security in India continues to be a challenge and climate change is likely to exacerbate these challenges. Emphasising the seriousness of the climate change threats, the then Indian Minister for Environment and Forest stressed that "no country in the world is as vulnerable, on so many dimensions, to climate change as India" (MEF 2010; p.9). Different regions in the country experience either water stress and scarcity or floods at different seasons or locations (MWR, 2008). Climate change impacts will directly and seriously affect more than 70% of India's population who are solely dependent on agriculture and allied activities (Central Water Commission, 2010).

Box 1.1: Prime Minister's address to National Water Resources Council on 28th December, 2012 in New Delhi

"… *water, or the lack of it, could well become the limiting factor to our social and economic growth in the future. With around 18% of the world's population but only 4% of its usable fresh water, India already faces a scarcity of water, which is a vital and stressed natural resource. Climate change could further aggravate the distortions in water availability in our country. Receding glaciers would negatively impact flows in our major rivers and pose a major new threat to the welfare of millions of our people*."

Dr Manmohan Singh, the then Prime Minister of India in his opening statement to the National Water Resources Council while adopting the National Water Policy 2012. Available at http://pmindia.nic.in/speech-details.php?nodeid=1266. Accessed on 29/12/2012.

The diverse geography of tropical forest in the East to arid desert in the West, snow covered mountains of the North to the coastal plains of the South, dry rocky plateau of the Southern Central to flat plains in the North of Central give rise to a wealth of diverse biological and cultural hotspots in India. The huge variation in the precipitation patterns with extreme annual rainfalls of more than 12000 mm in the North-eastern region to less than 13mm in the Western Thar Desert (Jain et al., 2013) makes water

management in India a huge challenge. To add to all these complexities is the huge variation in the seasonal rainfalls with about 75% of annual rainfall occurring within June-September (Central Water Commission, 2005) and changing monsoon patterns (Singh, 2013) that makes it all the more difficult to address water problems. Climate change is likely to exacerbate all these challenges (Mall et al., 2006). India being a developing economy, faces greater challenges not only because of greater climate change impacts but because it is perceived to have lower adaptive capacity (Mertz et al., 2009).

1.3 The need for water institutions to adapt

Box 1.2: Water institutions

The term 'institution' is commonly used in two different meanings. Douglas North (1991; p.3) in his seminal work on institutions defined institutions as laws, traditions, rules that are devised by constitutional governments as well as informal constraints like social sanctions, taboos and code of conducts, etc. and theorised that they are "humanly devised constraints that structure political economic and social interaction" and consists of both informal constraints and formal rules. On the other hand, Sir Paul Collier (2015) dismissed this definition of institutions and proposed that institutions should be understood as "teams of people with a mandate and capacity". He argued that any legislation can produce rules but rules without supporting institutions that actually have a proper mandate, dedicated team that internalise it and has the capacity to implement those rules are a dead letter and hence institutions have to be built. Similarly, in the context of climate change adaptation, the Ministry of Water Resources, Government of India in its National Water Mission under National Action Plan on Climate Change (MWR, 2008) construed that while "…laws and policies provide a framework for the actions of the executive, institutional structures provide the enabling circumstances for the action." For the purposes of this thesis, institution refers to all types of organisations; governmental as well as non-governmental institutions and agencies. Therefore, it includes State Government departments, Union Government Ministries and agencies, research and academic institutions, consulting firms, regulatory authorities and non-governmental organisations.

Government institutions play the major role in developing countries both for climate change adaptation in general and water management in particular and they are key in enabling society to adapt (Jogesh and Dubash, 2015). Therefore, government institutions, particularly in water sector, need to actively participate in climate change

adaptation. Knowledge regarding the actions being undertaken by institutional bodies; governmental and non-governmental, for adapting water management to climate change is scattered and mostly focused in industrialised countries (Preston et al., 2010). Climate change adaptation studies in low income countries are mostly focussed on natural systems and vulnerable communities (Ford et al., 2014). Very little knowledge exists regarding adaptation by institutional bodies, particularly by government institutions.

Informal institutions, such as the ways in which societies interact, also play an important role in climate change adaptation (Berman et al., 2012) although in a much less visible way (Helmke et al., 2012). However, formal institutional bodies, particularly the government institutions, having their mandate enforced by government legislations play the major role in allocation of resources and hence play the dominant role in enabling societies to adapt. They play the key role in demarcating responsibilities between actors, mediate trade-offs and serve as authorities and facilitators of actions (Cook et al. 2010; p.4). Water institutions are thus at the very heart of how society interacts with water. They regulate the provision of a variety of ecosystem services and goods and maintain environmental integrity while also targeting to meet human needs. Hard infrastructures such as dams, canals and other water bodies are at their disposal and hence how they regulate the distribution and control of water resources shape many other activities in a society. Water institutions are thus critical to how we address the challenges of climate change impacts, which makes it important to ensure that those institutions are themselves resilient to climate change (Cook et al., 2010).

1.4 Recent initiatives to address climate change in India

Realizing the impending challenges of climate change, the Prime Minister's Council on Climate Change (PMCCC) after its first meeting held on 13th July 2007 came up with the National Action Plan on Climate Change (NAPCC) (PMCCC, 2008). Recognizing that "India needs a national strategy to adapt to climate change" (PMCCC, 2008) this document identified Eight National Missions among which the National Water Mission in one. A primary objective of the National Water Mission includes "Comprehensive water database in public domain and assessment of impact of climate change on water resources" (MWR 2011). The expected results of the mission are to assist the country to adapt to climate change while pursuing economic growth (PMCCC, 2008). While the National Water Mission provides a broad aim, working out its details and implementing them are at an initial stage (Byravan and Rajan, 2013). Summary of the National Action

Plan on Climate Change and National Water Mission is provided in the Appendix A and Appendix B.

In order to enhance the capacity of Indian institutions to address the challenges of a changing climate, bringing together key research institutions in the country through an improved network was identified by the NAPCC as a key strategy (PMCCC, 2008). For this reason, the Government of India under the aegis of the Ministry of Environment and Forests initiated the Indian Network for Climate Change Action (INCCA) in 2007. The underlying assumption was, coordination among various institutions (18 in INCCA) will improve the adaptive capacity through sharing of knowledge, improve decision making and planning, monitoring and collection of data and minimize conflicts of interest (INCCA, 2010). Hence, one of the eight missions in NAPCC is *National Mission on Strategic Knowledge for Climate Change* (NMSKCC). Among the chief assumptions for having a 'Strategic Knowledge Mission' is "the current modes of data generation and information and knowledge sharing in India do not enable required integrated approaches" (MST 2010; p.3).

1.5 Indian water institutions

Water governance in India involves multiple institutions at multiple levels of operation. Several Union Government institutions are directly involved in the development of water infrastructure and/or monitoring and collection of information related to water besides other governmental departments and research institutions. While the Ministry of Water Resources along with its allied institutions functions as the apex body at the Central/Union Government level and lays down policy guidelines and programmes for the development and regulation of the country's water resources, environmental clearances for all major hydro projects, such as dams and canals for power generation (under the Ministry of Power) and irrigation, are to be obtained from the Ministry of Environment and Forests. On the other hand, the Planning Commission plans and allocates funds for infrastructure development in the country including development of water storage systems, flood defence and major irrigation and inland water ways. Ministry of Earth Sciences and the Ministry of Science and Technology focus on development of technology including forecasting of weather and other related areas while Ministry of Environment and Forests monitor aspects related to water quality and pollution. However, water being a state subject, according to the Constitution of India, the State Government is responsible for water supply and irrigation (Iyer, 1994). On the other hand, most of the rivers in India are inter-state and hence conflicts over sharing

of river water sources emerge (Richards and Singh, 2002; Swain, 1998) causing conflictual interests between the Union and State government(s) or between state governments (Richards and Singh, 2002). Overlapping of jurisdiction for water governance between the Union Government and the State Government institutions make the coordination between the two levels crucial. This multi-layered governance of water in India whose complexity is being intensified by a changing climate makes it an ideal case to explore the challenges of what makes institutions adaptive.

The role and effectiveness of water institutions in India is not without debate. Various researchers have highlighted the strengths and weaknesses of water institutions in India (Ananda et al., 2006; Aubriot and Prabhakar, 2011; Bottrall, 1992; Marothia, 2003; Reddy and Reddy, 2002). National Water Policy (MWR, 2002) itself emphasized the need to reorient the existing water management institutions which has been reiterated in the revised National Water Policy 2012 (MWR, 2012). Lack of coordination within government ministries and departments has been a major weakness (Narain, 2000). Ananda et al., (2006), in a preliminary assessment of water institutions in India, suggests the need to not only take into account the "proven criteria of institutional design but also the changing socioeconomic, political and cultural factors" (Ananda et al., 2006; p.927). It pointed the gap in knowledge to understand the nature of relationship between formal and informal institutions for understanding the overall institutional performance. More recently, Byravan and Rajan (2013) have identified that the fragmented authority between the Centre and States and weak institutional structures is a potential barrier to effectively implement the NAPCC. The need for "interdepartmental coordination" with "greater synergy and interaction among different organizations" has been emphasized (Byravan and Rajan 2013; p.31).

1.6 Research aim and objectives

Based on the literature review (briefly discussed above and elaborated in Chapter 2) which identified the need for research this thesis aims to:

> *Evaluate the involvement of Indian institutions operating at Union and State levels for adapting water management to climate change in order to identify factors and circumstances that enhance or hinder adaptation for water management.*

The aim of the thesis is to be achieved through the following five objectives:

- To identify, from the existing literature, key characteristics that facilitate water

management institutions to adapt to climate change and identify knowledge gaps.

- To evaluate the involvement and inter-institutional networks among the key institutions operating at the Union Government level in India for evaluating the factors that enhance, share or create characteristics of adaptation.
- To identify the underlying causes of adaptation barriers for Indian water institutions operating at the State level and the inter-relationships between the barriers so as to advance knowledge regarding the emergence and sustenance of adaptation barriers.
- To assess and compare the availability of adapting characteristics at the Union and State level in order to evaluate if the absence of certain adapting characteristics at the State level can be circumvented by the presence at the Union level and vice-versa or its absence causes a bottleneck for adaptation at the other scale.
- To consolidate knowledge regarding relationship between adaptation enabling characteristics, barriers and adaptation manifestation so as to assist in framing adaptation strategies for water management.

1.7 Methodological approach

The research strategy must be appropriate for the intended research objective. Experiments, surveys and case studies are the three main approaches to which research strategies are often classified (Robson, 2011). Depending on the purpose of the research, Robson (2011) classified research enquiries into exploratory, descriptive or explanatory although a particular study may be concerned with more than one purpose. Exploratory research, sometimes referred synonymously as qualitative research (Ritchie, 2003), focus on finding out 'what is happening to draw new insights' regarding a particular phenomenon or process or to assess the phenomena to shed new lights (Robson, 2011). Descriptive enquiry, on the other hand, aims 'to portray an accurate profile of persons, events or situations' and hence requires extensive previous knowledge of the situation and may be qualitative and/or quantitative while explanatory researches primarily focuses to 'seek explanation of a situation or problem', usually in the form of causal relationships, and may be qualitative and/or quantitative (Robson, 2011; p.42). Robson (2011) suggests that case studies are more appropriate for

exploratory enquiries while surveys are appropriate for descriptive studies and experiments for explanatory studies. While quantitative and qualitative approaches can be complimentary (Ritchie, 2003), qualitative researches are more appropriate when the social context is highly complex and the understanding of the social processes is vague or at an initial stage (Robson, 2011). Although quantitative methods are useful for testing hypotheses (Robson, 2011), qualitative methods provide an opportunity to elucidate social phenomena (Ritchie, 2003) which cannot simply be reduced to numbers and graphs. Qualitative methods facilitate a contextual research in identifying what exists in the social world and its manifestations as experienced by the study population and offers an opportunity to explore what lies inside and how they are understood by those within (Ritchie, 2003).

Since this research aims to identify factors and circumstances that enhance or hinder institutions to adapt to climate change, a case study approach using qualitative method that unravels the contextual situations based on the perspectives of insiders was considered most appropriate. Moreover, previous knowledge regarding the (collective) involvement and challenges of adaptation for Indian water management institutions being scattered, it was concluded that an exploratory approach will best suit the enquiry. Because of its facility to examine subjects in their own context, a qualitative method provides the opportunity to explore the factors that influences the attitude, decision, belief or perception (Ritchie, 2003) of actors. The perceptions of climate change risks and impacts and how institutions can address or face the new or anticipated situation and why they believe what can or cannot be done to avert or adapt to the new situation is best evaluated through a flexible method which captures the associations between people's thinking and acting. Although some researchers argue that causes and effects in social enquiry can only be speculative (Spencer et al., 2003), evaluative research, which is central to much of policy related investigations, enables the assessment of how well does a policy work. For example, how international and national policies of climate change adaptation, such as the Paris Agreement (UNFCCC, 2015) or National Action Plan on Climate Change (PMCCC, 2008), can best be exploited to enhance the capacity of institutions operating at various levels can meaningfully be turned into tangible adaptation needs to be explored through such evaluative methods. The flexible methods of investigation in qualitative research provides an opportunity to investigate the dynamics of inter-institutional relations and identify the factors that influences a particular attitude, belief or perception and the motivations that lead to such decision, action or non-action (Ritchie, 2003).

1.7.1 Identification of key stakeholder institutions

In relatively large-scale studies the question of whose perspective is important and who should be involved becomes pertinent. It is widely recognised that involvement of stakeholders (Reed et al., 2009) and the interactions between them (Prell et al., 2009) is critical for management of large-scale issues such as environmental managements and climate change adaptation (André et al., 2012; Conde et al., 2005). The term 'stakeholder' is often understood differently by different people in different contexts. Researchers and practitioners may have contrasting or interrelated views on who is responsible for climate change adaptation (André et al., 2012) or which (government or non-governmental) institutions should be involved in framing adaptation strategies and where the resources and information can be gathered from or disseminated to for enabling adaptation. Broadly, stakeholders include individuals, groups or institutions who are affected or can affect a given phenomenon (Reed et al., 2009) or those who can affect a decision or are affected by the decision and hence have an interest or stake in the issue (André et al., 2012). Since identification of key stakeholder institutions and their involvement is critical for successful adaptation (Dilling et al., 2015) a careful identification of relevant actors at different levels become necessary. Several aspects are required to be considered when a vast and inter-sectoral issue, such as climate change adaptation and water management, is to be carried out in environments where multiple institutions interact and overlapping or complimentary actions are carried out. These complex contexts demand rigorous methods of identifying the key institutions (Reed et al., 2009) and the relationships between them. For identifying the key stakeholder institutions and analysis of the inter-institutional networks between them, their attributes of mandates, types, and roles need to be taken into account. Since the involvement of key institutions in climate change research, planning and implementation of adaptation strategies is vital, identifying who is currently involved, who influences the decision making processes and who else should be involved becomes crucial. Therefore, this research adopted a double-pronged approach in identifying the key institutions at the Union Government level in India and at a state level. First, the key stakeholder institutions are identified by analysing the online documents of sixty Union Government institutions (ministries or similar institutions) headed by a minister or of similar level (further discussed in Section 3.2.1 and 3.3.1 of Chapter 3). This is supplemented by asking the representatives from these key institutions about their perceptions of who is involved and who needs to be involved (discussed at greater length in Section 3.2.2 and 3.3.3 of Chapter 3).

1.7.2 Inter-Institutional Network Analysis

The capacity of an institution to adapt is shaped not only by the availability of internal resources and the efficiency of how they utilise the resources and execute the plans but also on the inter-institutional networks through which information, knowledge and expertise is shared and acquired (Dilling et al., 2015). The sudden explosion of Social Network Analysis tools, such as Gephi, Prajek, Netminer, NodeXL, and UCINet, among others, since the past decade indicates the growing recognition of the need to understand individuals (and institutions) relationally. Social Network Analysis involves the analysis of patterns formed by the nodes (points representing individuals or institutions as actors) and ties (lines indicating relationship) between individuals or institutions, mathematically or visually, in order to assess their effects on other members of the network formed by the intersecting lines that connect them (Scott, 2012). Social Network Analysis tools for assessing the structure of networks amongst individuals have been widely applied in various fields including natural resources governance (Bodin and Crona, 2009), construction management (Pryke, 2012), and coastal environment management (Pourebrahim et al., 2010).

Network analysts consider that the other institutions with whom an institution must transact plays a significant role (Dowd et al., 2014) in enhancing its adaptive capacity (Brockhaus et al., 2012). They emphasise that the actions, attitudes and behaviours of actors (individuals or institutions) are best explained by their position within the networks in which they are embedded and their relationships with other members because it constrains or enhances their actions and are shaped by them (Pryke, 2012). The information gained from the networks of previous alliances enable institutions to determine with whom to cooperate in order to gain access to critical resources (Gulati and Gargiulo, 1999) and hence networks evolve. Therefore, Pryke (2012) suggests that a network has to be viewed as a dynamic system rather than a static representation of power relations. Social Network Analysis is therefore not applied here to exclude other methods but rather to complement and supplement qualitative research. It is rather applied here as a preliminary tool to identify key stakeholders and their relations with other key stakeholder institutions in order to explore where and with whom to focus. Since qualitative contextual data are also particularly important, besides the network structure, to understand the internal inter-institutional relational dynamics, which are not apparent in the written documents, it was concluded that inter-institutional networks analysis need to be complemented with qualitative in-depth interview.

1.7.3 Collection and analysis of qualitative data

Since the aim of this research is to draw out the challenges of climate change adaptation for water management institutions, the (subjective) meanings of their experiences and the varied and multiple approaches to their understanding of the challenges of climate change became crucial. The research, therefore, has to rely on the participant's views of the situation as much as possible and take into account the complexity of views of the respondents rather than narrow the meanings into a few categories or ideas (Creswell, 2007). In order to facilitate such an enquiry, the interview questions are, therefore, deliberately framed to be broad and general so that the participants can construct the meaning of the situation (Creswell, 2007). Three pilot interviews were conducted within Cranfield University who have knowledge regarding climate change adaptation in the Indian context before going to the 'real field'. These pilot interviews enabled the framing of semi-structured questions to flow more seamlessly although the follow-up questions in a semi-structured interview is guided by the responses.

Among the various approaches and paradigms of analysing data, social constructivism is one which seek to understand the world in which an individual lives and work (Creswell, 2007) through their perspective and hence fits the research approach appropriately. Since perceptions and understandings of climate change adaptation barriers are formed through interaction with others and through historical and cultural norms that operate in individual's lives, it becomes imperative that instead of starting with a theory, through the inquiry a theory or pattern of meaning is inductively developed (Merriam, 2009). This means grounded theory study suited the approach best as "a key idea of grounded theory is that rather than taking the theory "off the shelf", it is generated or "grounded" in data from participants who have experienced the process" (Creswell, 2007; p.63). Hence this particular approach best suited the method for Chapter 3 and 4 which aim to explore the key barriers of climate change adaptation particularly from an insider's point of view. Whereas in Chapter 5, since the researcher has become familiar with the data and also since the aim was more specific, which is to assess the availability of specific adaptation attributes, a thematic approach, which is a robust method for policy analysis (Braun and Clarke, 2006; Fereday and Muir-Cochrane, 2006), was adopted. The thematic approach of evaluating the availability of adaptation attributes is elaborated further in Section 5.2.4.

1.8 Structure of the thesis

This thesis examines the adaptation to climate change by water institutions in India through four chapters which are structured in the format of journal articles and hence can be read as standalone papers, except chapters 1 and 6. Having set the context of the research and its aim and objectives in chapter 1, the following chapter situates the research within the broader literature by reviewing the existing literature and thereby identifying gaps in knowledge. It briefly summarises the key potential impacts of climate change for water management and then reviewed the existing frameworks of evaluating adaptation by institutions. It identifies the key characteristics of adapting institutions and the types of climate change adaptation barriers in literature. Thus this chapter addresses the first research objective of identifying key knowledge gaps and explores the questions regarding what constitutes good adaptation practice and how institutions adapt to climate change and which factors or attributes of institutions are essential for water management institutions to adapt to climate change.

In chapter 3, a novel method to evaluate the involvement of each of the sixty Union Government institutions, headed by a Union Minister or similar level, in climate change adaptation and water governance discourse is introduced. Websites of each of these institutions were systematically evaluated to identify the institutions potentially more involved in the discourse based on their number of online documents and webpages that mention climate change and water. In addition, the 'inter-actions' between the key Union Government institutions are also quantified by analysing how often they mentioned the names of other institutions in their online documents that contained climate change and water as keyword. This provided the foundation for in depth qualitative analysis including selecting key stakeholder institutions and other research and academic and non-governmental institutions partnering with them. Following the identification of key institutions thus, in-depth qualitative interviews were carried out that identifies adaptation initiatives and barriers and the inter-institutional networks as perceived by the representatives from these institutions. This chapter is therefore, explorative; aiming to understand the overall big picture of climate change adaptation in India and the relations between the key institutions. Hence, it addresses the aim of the thesis with the second objective which is to evaluate the role and involvement of different institutions and inter-institutional networks in enabling adaptation and thereby generating knowledge regarding characteristics that enhances adaptation.

Chapter 4 is more analytical and critically investigates the contextual causes of barriers

in order to gain knowledge regarding the emergence and persistence of climate change adaptation barriers by focusing more on the water supply institutions delivering water to users. It goes beyond identifying the existing barriers and challenges of adaptation or classifying them into different categories of barriers but specifically analyses the underlying causes of such barriers and hence is more focused on why and how barriers emerge and sustains, although it starts with identifying the barriers. The semi-structured interview data collected from respondents in 26 institutions operating within the State of Himachal Pradesh are used to draw conclusions as to how the different barriers emerge, sustain and are connected to other barriers. These barriers are then compared with barriers reported in literature in other contexts so as to appraise its contextual socio-economic and political causes. Hence, this chapter is geared towards achieving the third objective which is to identify the causes of adaptation barriers.

Chapter 5 then brings together the institutions operating at the two levels and hence is more comparative and confirmatory; comparing the existence of adapting attributes at the two scales of institutional operations in India – Union Government level and State Government. This chapter first identifies the availability of key adapting characteristics at the two levels and examined the implications of the prevalence or absence of such characteristics on the institutions at the other level. The relationship between the institutions operating at the two scales is evaluated by analysing the perspectives of respondents about the role of the institutions at the other level. This means, the data is analysed to understand if certain traits of adaptation are available with the institutions at the scale being examined, the consequences thereof and if its absence can be circumvented by the presence at the other scale of operation or the lack of it is creating a bottle for adaptation at another scale as well. Then it analyses how the inter-institutional networks between water institutions can be enhanced so that adaptive capacity can be enhanced across scales. Thus this chapter addresses objective 4.

Finally, the thesis concludes with Chapter 6 by consolidating and reflecting on the key knowledge this thesis has generated and furthered the discourse on climate change adaptation barriers and enabling factors of water institutions. It draws out key insights regarding the attributes and characteristics of adaptation and the emergence and sustenance of adaptation barriers. Key insights gained from this study for policy implementation and further gaps in knowledge are also identified for future research. A schematic diagram showing how each of the chapters contributed towards the aim of the thesis through addressing each objective is depicted in Figure 1.1 in the next page.

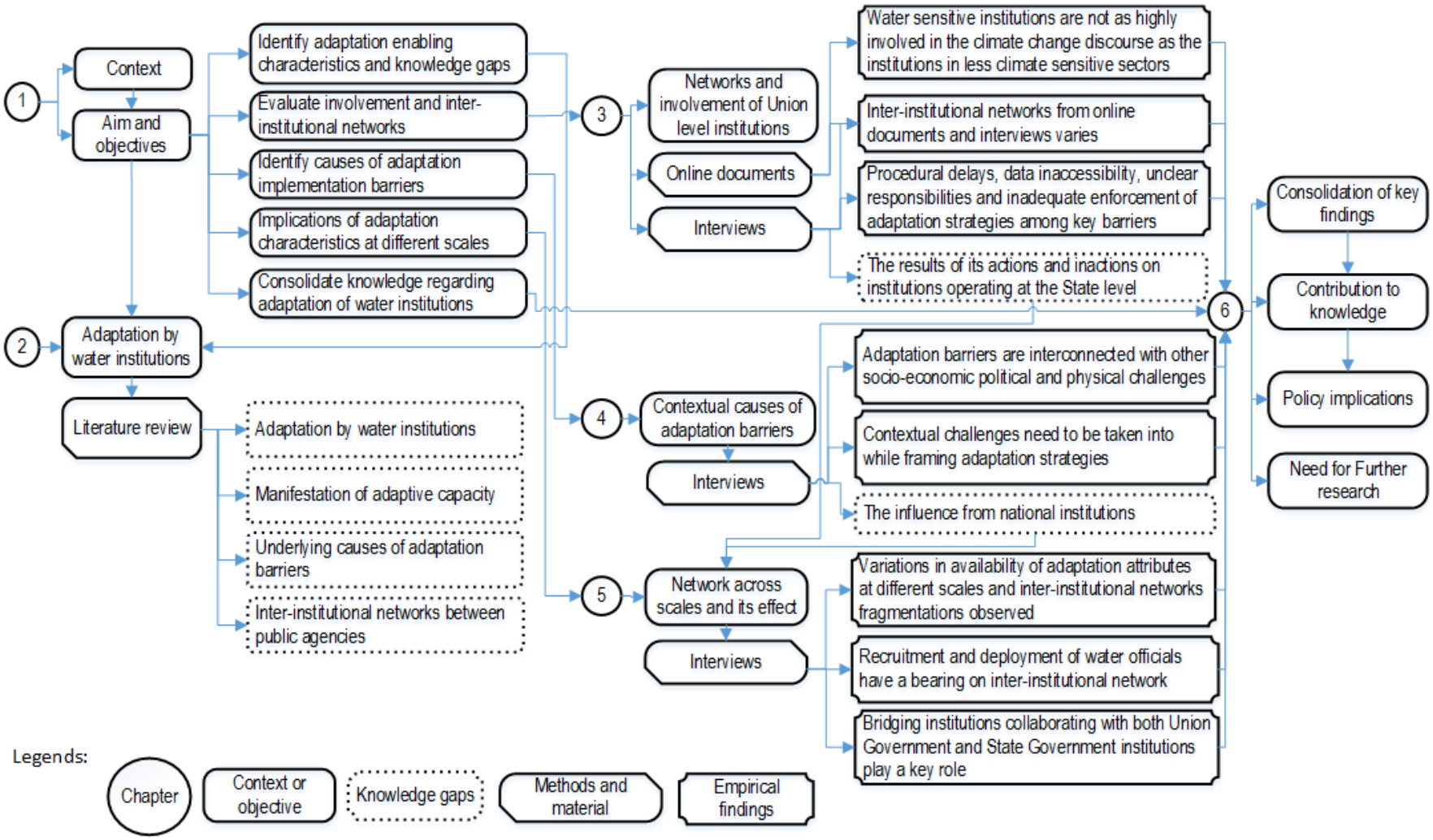

Figure 1.1: Diagram highlighting how the different chapters contribute to the aim of the thesis

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2 ADAPTING TO CLIMATE CHANGE BY WATER INSTITUTIONS: ENABLERS AND BARRIERS

Abstract:

Climate change will be experienced particularly though the medium of water. Water institutions, that are managing societal and ecological needs of water, are therefore likely to experience the impact the most. This study reviews the current literature regarding adaptation to climate change by water institutions and barriers.

Literature on adaptive capacity is growing and there is general consensus on the determinants of adaptive capacity although variations exist regarding how it is to be evaluated, enhanced and applied to policy making due to its dynamic, contextual and latent nature. Since adaptive capacity is hard to measure and successful adaptation difficult to define, some studies focus on the existence of adaptation attributes of institutions. However, manifestation of adaptation is limitedly known; the sporadic studies are focused on industrialised countries which have little relevance to water management institutions in developing economies, such as India, where management of water is the responsibility of government institutions. As the need for adaptation grows, studies on the existence, emergence and sustenance of adaptation barriers are emerging. But the root causes of these barriers are often overlooked and the interconnectedness of the barriers is limitedly addressed.

Increasingly, combining top-down and bottom-up approaches of adaptation are being recommended due to the limitations in each of them. However, knowledge regarding how institutions operating at different scales enhance adaptive capacity of institutions operating at another scale is lacking due to the limited studies of inter-institutional networks across scales. Social networks among actors is recognised as a key factor to enable adaptation, particularly when there is a limit in the internal capacity; acquiring resources through an effective network is recommended. However, network studies are generally focused on individual actors and rarely between public institutions. Moreover, current literature is inadequate to understand the relationship between adaptation enabling characteristics, barriers and adaptation manifestation.

Keywords: adaptation, adaptive capacity, barriers, climate change, institutions, water

2.1 Introduction

Changes in climate in the recent decades that have caused impacts on natural and human systems have been reported widely (IPCC, 2014a). These include changing precipitation and melting of snow altering hydrological systems. Glacier fed river systems, such as those arising from the Himalayas, are reported to be undergoing changes in the seasonal river discharges leading to floods and droughts at different seasons (Singh et al., 2016; Upgupta et al., 2015; Xu et al., 2009). The rise in global temperatures also triggers increased water demand, particularly in irrigation (Wang et al., 2014), due to increased evapotranspiration. Precipitation patterns in many regions are reporting to be undergoing changes with the wet areas becoming even more wet and the dry areas getting drier leading to floods and droughts simultaneously at different locations and different seasons (Barnett et al., 2005; Jaswal et al., 2015; Rajeevan et al., 2008). In addition, this changing climate is likely to affect the availability of groundwater due to decreased recharge and increased demand (Holman, 2006) in various locations. Climate change is also likely to impact water quality (Whitehead et al., 2009) and not just the availability and quantity (Arnell, 2004; Kundzewicz et al., 2008). It will increase the sediments during floods (Wulf et al., 2012) and increased concentration of contaminants during the dry season (Whitehead et al., 2009). Therefore, it is reasonable to conclude that the immediate and direct impacts of climate change are going to be experienced through the medium of water although climate change impacts almost all areas of life.

The compelling and growing body of evidence of a changing climate points to the need for urgent actions (IPCC, 2014a). While not neglecting the ongoing efforts of mitigation, adaptation actions are urgently required (Simonet and Fatorić, 2015) to complement mitigation (Füssel, 2007) due to the emissions already committed (IPCC, 2007) and the inadequacy of international agreements for reducing greenhouse emissions (Spash, 2016). The Intergovernmental Panel on Climate Change (IPCC, 2014b) defined adaptation as “the process of adjustment to actual or expected climate and its effects”. Within human systems, adaptation is aimed at moderating or alleviating harmful effects or to take advantage of the beneficial opportunities (Noble et al., 2014) and hence generally distinguished between anticipatory, autonomous and planned adaptation depending on how and when adaptation is initiated. Planned adaptation involves deliberate policy decisions by the use of available information regarding the present and future projections to review the suitability of current and planned practices, policies

and infrastructure (Mimura et al., 2014). Planned adaptation for water management generally take the form of alterations to methods and procedures, such as design standards and the calculation of climate change allowances in infrastructure design (Arnell, 2011; Charlton and Arnell, 2011). However, actions solely focused on adapting water management to climate change are rare (Charlton and Arnell, 2011) or at least they are often not named so (Moser and Boykoff, 2013) because strategies and investment plans are driven by many other factors besides climate change. Climate change is often not the primary concern for the short term (Klein et al., 2014), particularly so in developing economies with competing developmental pressures. However, it is often aimed to be integrated into the developmental plans (for e.g., Sietz et al., 2011). Planned adaptation is also used synonymously with anticipatory adaptation (Preston et al., 2013). Autonomous adaptation, on the other hand, is often triggered spontaneously by changes in the natural and human systems (Bhave et al., 2014) and consists "those that do not constitute a conscious response to climate stimuli, but result from changes to meet altered demands, objectives and expectations which, whilst not deliberately designed to cope with climate change, may lessen the consequences of that change" (Bates et al., 2008 p.48). Autonomous adaptations can also be understood as those that are undertaken without the intervention of external agencies.

Most studies to date have focused on impact and vulnerability assessments (Moser and Boykoff, 2013) which are ground work actions but not adaptation action in itself (Berrang-Ford et al., 2011). Significant deficiencies in climate preparedness exist even in highly industrialised countries such as Australia, UK and USA (Preston et al., 2010) which are often presumed to have higher capacity to deal with climate variabilities. Yet, adaptation is especially relevant for developing countries which are struggling to address the challenges being posed by climate variability (Ford et al., 2014; Krysanova et al., 2010; Nyamwanza and Kujinga, 2016) compounded by other competing developmental priorities. Limited researches on adaptation in developing economies (Mertz et al., 2009; Spires et al., 2014) mostly focus on communities (Archer et al., 2014; Hammouri et al., 2015; Younus, 2010), sectors (Dany et al., 2015; Marothia, 2003; Upgupta et al., 2015) or physical systems such as river basins (Pandey et al., 2011; Sud et al., 2015) but rarely the agencies that administer water. This study addresses this important knowledge gap by reviewing the current literature to draw knowledge for water institutions to adapt to climate change, particularly in the context of developing economies where water administration is primarily the responsibility of

public institutions, with the aim to identify key characteristics that enables or hinders adapting water management to climate change. It is divided into five sections. Section 2 brings together the current knowledge on adaptation by water institutions by drawing knowledge from adaptation studies in general, the assessment of adaptive capacity and barriers and how adaptation is manifested in likely implementation of adaptation strategies. Section 3 establishes the case for enabling adaptation and reducing barriers through inter-institutional networks. Finally, section 4 draws the current gaps in knowledge before conclusions are drawn with key messages in section 5.

2.2 Adaptation by water institutions

Institutions rarely remain static and virtually all undergo changes in what they do and how they do. For water management institutions, these changes may be triggered by external factors such as water scarcity, natural calamities, legislation, political reforms, and technological change, and/or by internal factors such as change in leadership and management, policy and innovation (Saleth et al., 2000). Since climate change is projected to increase the water demand and reduce availability (Jiménez Cisneros et al., 2014), adaptation options in water sector is generally categorised into supply side management and demand side management (Arnell et al., 2001). Water institutions generally resort to increasing reservoir capacity, additional and alternative sources such as ground water extraction, transfer water from another basin, and enhance treatment and recycle to meet the demands (Arnell and Delaney, 2006; Tompkins et al., 2010). However, these options generally require huge investments. On the other hand, to reduce the demand side of water management, governments may impose higher tariffs or promote alternative and efficient methods of water usage but are ultimately mostly dependent on the water users rather than on institutional bodies. Reducing water demand in developing economies through tariff structures is particularly challenging when compounded by population growth and land-use change (Mertz et al., 2009). Therefore, water management institutions themselves require undergoing changes to avert and reduce undesirable impacts and take advantage of new opportunities.

Approaching from organisational change theories, Berkhout (2012) distinguishes adaptation by institutions into three perspectives: a) utility-maximising, b) behavioural and c) institutional, such as legislations and formal and informal rules. In utility-maximising approach, institutions pursue adaptation if “the cost of making the effort is less than the resulting benefits” (Mendelsohn 2000; p.585). In this approach, the costs

of alternatives and benefits and the costs of inaction need to be known. For this reason, in this approach adaptation is mostly reactive (Berkhout, 2012). Utility-maximising approach is criticised for its inability to take into account the uncertain nature of climate impacts and issues of perception, interpretation, and the learning processes of organisational adaptation (Berkhout et al., 2006). On the other hand, arguing from the traditions of behavioural economics and organisational studies, Berkhout (2012) concurred that 'actors do not conform to the expected tenets of utility theory' and instead use 'thumb rules' in responding to new situations and hence stressed the importance of perception and interpretation of potential risks. Moreover, institutions are shaped by the constraints of external factors such as laws, regulations and socio-cultural-politico-economic context in which they are embedded (Pahl-Wostl, 2009; Roggero, 2015). Adaptation in the water sector needs to go beyond structural measures (Stakhiv, 2011) and incorporate other measures including forecasting/warning systems, insurance instruments and other ways to improve efficiency of water use and related behavioural change through economic and fiscal instruments, legislation, and institutional change (Crabbé and Robin, 2006). As the recognition of the need for adaptation transitions into construction of adaptation strategies and plans (Mimura et al., 2014), questions regarding whether or not the agencies managing the system have the capacity to adapt to the new and uncertain situations become even more urgent.

2.2.1 Assessment of adaptive capacity

In climate adaptation discourse, adaptive capacity, defined by IPCC as 'the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2014b; p.1758) of climate change is increasingly gaining research interest (Preston et al., 2015) as it is considered to be the link between vulnerability and resilience (Engle, 2011). In the context of water management institutions, it may be understood as the capacity of the institution to continue to provide the level of services being provided, avert the sudden and unexpected situations such as floods, deteriorating quality, or take advantage of the changed circumstances. Adaptive capacity is also known to be largely shaped by the institutional capacity to grasp the potential challenge and the seriousness of the risks, plan suitable strategies and implement them (Brown et al., 2013).

Various examples of adaptive capacity assessments exist in the literature. For

instance, Gupta et al. (2010) proposed an indicator based approach to evaluate the adaptive capacity of a society to adapt to climate change based on “the inherent characteristics of institutions – systems of both formal and informal rules – to empower social actors to respond to short and long term impacts either through planned measures or through allowing and encouraging creative responses” (Gupta et al., 2010; p.461). It listed six dimensions which are supposed to be distinct and non-overlapping such as a) variety – involvement of different actors, levels and sectors that provide room for multiple frames of references and options, b) learning capacity, c) room for autonomous change, d) leadership, e) resources, and f) fair governance. It proposed the possibility of deriving quantitative indicators but has at least two challenges: a) subjectivity in assigning the scores and data collection, and b) aggregation of the score is not possible as the criteria are not additive due to the difference in weightage as each determinant bears varying impact. Engle and Lemos (2010) and Juhola and Kruse (2015) also used similar determinants, derived from Brooks et al. (2005) and Smit et al. (2001), for evaluating adaptive capacity at the basin and regional level respectively with the assumption that good governance enhances adaptation. However, the types of governance and management approaches that affects adaptive capacity are not addressed by Engle and Lemos (2010) and Juhola and Kruse (2015) concluded that the results of adaptive capacity assessment can be influenced by the methods adopted. Similarly, Pandey et al. (2011) applied four parameters; a) natural capacity, b) physical capacity, c) human, and d) economic capacity, to assess the adaptive capacity of water resources system in a basin. It used Analytical Hierarchy Process (to overcome the challenge of aggregating the score) to decide the weightage of the indicators which is transparent and participatory to some extent. However its applicability in other contexts and policy making is limited due to the dynamic nature of water usage which changes depending on economic and land use change. Other studies, such as Clarvis and Allan (2013), used qualitative approaches of evaluating adaptive capacity at the national scale using similar determinants mentioned above. Examples of various approaches of assessing adaptive capacity can be categorised depending on the method of assessment, scale, and sector, among others:

a) **Method of assessment**: indicators (Gupta et al., 2010; Hinkel, 2011; Pandey et al., 2011), participatory (Henly-shepard et al., 2014; Munaretto et al., 2014; Smajgl, 2010), scenario based (Dessai et al., 2005; Flörke et al., 2011; Pilli-Sihvola et al., 2014)

b) **Scale of assessment**: individual households (Aulong et al., 2012), community (Murtinho, 2016; Pearce et al., 2012; Whitehead, 2009; Younus, 2010), local municipalities (Hogarth and Wójcik, 2016; Shi et al., 2015), regional (Juhola and Kruse, 2015), basin (Engle and Lemos, 2010), national (Clarvis and Allan, 2013; Haddad, 2005), multilevel (Pahl-Wostl, 2009; Westerhoff et al., 2011).
c) **Sector of assessment**: water (Engle, 2007; Pandey et al., 2011), forest (Brown et al., 2010), building construction (Hertin et al., 2003)

The generic determinants of adaptive capacity in the above examples bear resemblance to (or developed from) the list characterised by Smit et al., (2001) although the selection of the indicators or determinants largely depends on the purpose, scale, or sector of the study. It indicates that there is near consensus regarding the generic determinants of adaptive capacity. From Smit et al. (2001) and others listed above, the determinants of adaptive capacity applicable to water institutions can also be broadly categorised under five key parameters, which Juhola and Kruse (2015) differentiated into three dimensions, a) awareness, b) ability, and c) action, as listed in Table 2-1.

Table 2-1 Determinants of adaptive capacity

Dimensions	Determinants	Indicators
Awareness	Knowledge and awareness	Availability of knowledge
		Awareness of adaptation options
		Awareness of resources availability
Ability	Technology	Technology for monitoring and treatment
		Capacity to undertake research
	Infrastructure	Availability of dams, canals, wells,
	Human capital	Leadership
		Technical expertise
Action	Institutional and governance	Effectiveness of governance
		Clear adaptation strategies
		Equity
	Economic resources	Availability and accessibility to fund
	Autonomy	Ability to decide and act independently

Although consensus is emerging regarding the generic determinants of adaptive capacity, contentions exist when it comes to methods of evaluation and its applicability to policy making (Engle, 2011; Hinkel, 2011). One of the main challenges of adaptive capacity evaluation pertains to its latent nature (Bohensky et al., 2010; Engle, 2013). Moreover, due to uncertainty in climate change projections and its impacts, vulnerability and adaptive capacity evaluation and application of its results in policy making remain challenging (Hinkel, 2011). Additionally, as it is contingent upon other economic and technological factors (Fitzsimons et al., 2009; Moench, 2010), it is dynamic and changes over time.

2.2.2 Attributes of adapting institutions

Since evaluation of adaptive capacity is challenging, identifying the availability of 'adaptation attributes' (Lonsdale et al., 2010; Wilby and Vaughan, 2011) and 'adaptation readiness' (Ford and King, 2015) is the approach adopted by some studies for evaluating adaptation by institutions. Wilby and Vaughan (2011) and Lonsdale et al., (2010) identified adaptation attributes based on the existing characteristics of the institutions as institutions which are adapting to current climate variabilities are more likely to have greater adaptive capacity (Dessai and Hulme, 2004). These attributes include a) visionary leaders who can articulate adaptation goals and acquire resources, b) clearly stated adaptation objectives which are regularly reviewed, c) prioritised actions based on comprehensive risk and vulnerability assessments, d) implementable guidance and training to the operating staffs, e) flexible institutional structure that enable learning and decision making within the existing code of practice, f) adaptation pathways being guided by low-regret adaptive measures, g) partnering with other institutions for resources pooling, h) monitoring and reporting progress against clearly defined targets, and i) effective communication internally and externally.

The framework proposed by Ford and King (2015) uses similar criteria such as the existence of a) political leadership for adaptation, b) institutional structure for adaptation, c) decision making and stakeholder engagement d) availability of usable science e) funding and f) public support for adaptation and applied to pilot studies to assess the 'adaptation readiness'. Its aim was to capture the actions being done to plan and prepare for adaptation. However, due to procedural and conceptual challenges, the approach has limitations as extracting diverse data sources and developing indices for evaluating 'readiness' remain difficult for application to policy making similar to the challenges of evaluating adaptive capacity. Knowledge regarding

how readiness factors actually drive adaptation action on the ground remains limited due to the nascent state of studies on actual manifestation of adaptation (Moser and Boykoff, 2013). Just as the availability of adaptive capacity in itself does not ensure adaptation, adaptation readiness alone is inadequate to assume that adaptation will automatically occur (Tilleard and Ford, 2016). Therefore, although the concept of adaptation readiness goes beyond adaptive capacity (Tilleard and Ford, 2016) it is insufficient to understand how actually adaptation will unfold, particularly in the presence of adaptation barriers and limits.

2.2.3 Barriers to adaptation

As climate change adaptation studies progress from awareness to policy and planning (Mimura et al., 2014) to implementation, various challenges for successful adaptation are being discovered (Eisenack et al., 2014). Although institutions seldom remain static in some aspects, it also exhibits inertia in other aspects (Berkhout, 2012) due to barriers which are also both external and internal. Achieving the desired adaptation goals is contingent not on adaptive capacity alone but also upon many factors such as socio-economic and cultural factors that shape decision makers' perceptions of risks (Liu et al., 2016; Smith et al., 2014) and willingness to act (Adger et al., 2009; Gifford et al., 2011; Grothmann et al., 2013) or prioritise actions.

With the increased recognition for the need to understand the factors and circumstances that stop, delay or reduce adaptation effectiveness (Biesbroek et al., 2014), barriers to adaptation have been defined from different perspectives with terms such as limits (Dow et al., 2013a), challenges (Fünfgeld, 2010), obstacles (Bedsworth and Hanak, 2010), and constraints (Klein et al., 2014), often being used synonymously. Klein et al. (2014) differentiated adaptation constraints from limit by defining the former as "factors that make it harder to plan and implement adaptation actions" (Klein et al., 2014; p.923) and the later, following Adger et al. (2009), Dow et al. (2013), Islam et al. (2014), and Moser and Ekstrom (2010), as "The point at which an actor's objectives or system's needs cannot be secured from intolerable risks through adaptive actions" (Klein et al., 2014; p.923) and categorised into hard adaptation limits; beyond which adaptive actions are not possible, and soft adaptation limits as adaptation options currently unavailable. A consensus is emerging among researchers to use 'limit' to refer to the threshold beyond which existing adaptations cannot overcome it and it is used to refer more towards natural and physical challenges whereas 'barrier' is more commonly referred to the challenges due to the sociological and institutional factors

(Barnett et al. 2015; Moser and Ekstrom 2010). Therefore, Moser and Ekstrom (2010) defined barriers as “obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc.” (Moser and Ekstrom, 2010; p.22027)

Moser and Ekstrom (2010) structured barriers according to three stages of adaptations – understanding phase, planning phase and management phase. Barriers at the understanding phase could include the unavailability or inaccessibility to information and knowledge, legitimacy, credibility, trust and receptivity to the information and willingness and ability to use it (Moser and Ekstrom, 2010). At the planning phase, leadership roles regarding authority and ability to identify risks and opportunities, assess and devise adaptation alternative strategies and building consensus, credibility and trust are essential. How actors perceive what options and alternatives are under their control is particularly pertinent at the planning phase because their deliberations will be limited by this perception (Moser and Ekstrom, 2010). Therefore traits of the governance system regarding who have control over the processes of policy making and resources allocation play an important in determining the adaptation outcome (Berrang-Ford et al., 2014). Adaptation processes that have reached the management phase from which empirical studies regarding how barriers emerge are limited (Moser and Boykoff, 2013) both because of the barriers at the understanding and planning phase in addition to the recentness of the climate change adaptation (Moser and Ekstrom, 2010).

Empirical studies that specifically focus on adaptation barriers are relatively very recent (Biesbroek et al., 2014). Most of the studies on adaptation barriers to date are focused at the local level, such as municipalities or local communities, and rarely at the national level or across scales with Clarvis and Allan (2013) an exception. The barriers reported from case studies mostly related to the cognitive barriers such as the inability to understand the risks contextually (Jones and Boyd, 2011; Shemdoe et al., 2015) and make sense of adaptation alternatives or lack of information and data relevant to the scale of their influence (Amundsen et al., 2010; Baker et al., 2012; Pasquini et al., 2013). Assumptions of inability to change make some actors surrender to the situation (Jones and Boyd, 2011) while lack of local autonomy (Crabbé and Robin, 2006) and inaction by other institutions at a scale above the local bodies (Carlson and McCormick, 2015) were also reported as critically hindering adaptation for local bodies. Lack of trust (Clarvis and Allan, 2013), interest (Pasquini et al., 2013), leadership

(Measham et al., 2011), and climate scepticism (Baker et al., 2012; Engle, 2012) were also some of the barriers reported. Inadequate financial resources, infrastructure, focus on short-term issues and competing developmental priorities (Engle, 2012) and legislation issues such as unclear roles of actors (Amundsen et al., 2010) and lack of consistent and clear policy guidelines from state and federal governments (Baker et al., 2012) and cultural normative behaviours such as apathy and trust (Engle, 2012) are other barriers identified from empirical studies.

2.2.4 Adaptation manifestation

Adaptation manifestation can be understood as how actually successful adaptation will appear when barriers are overcome and the desired goals of adaptation are met (Smit and Wandel, 2006). Although adaptation research is transitioning from raising awareness of impacts to strategizing adaptation (Mimura et al., 2014), very limited studies exist in literature from which insights can be drawn to conclude that adaptation was successful (Moser and Boykoff, 2013). Eliciting opinions from a range of experts, Doria et al. (2009) defined successful adaptation as "any adjustment that reduces the risks associated with climate change, or vulnerability to climate change impacts, to a predetermined level, without compromising economic, social, and environmental sustainability'' (Doria et al., 2009; p.815). However, very few actual cases of adaptation actions being manifested as successful exist from which one could empirically explore the question of adaptation success because adaptation planning rarely specify 'clear goals, endpoints, metrics or criteria for success' (Moser and Boykoff, 2013). The limited reports of adaptation occurring are confined to industrialised countries (Berrang-Ford et al., 2011; Westerhoff et al., 2011). "Small adjustments of building adaptive capacity to implementing actions and creating deeper systemic change in public and private institutions in a range of sectors", particularly in water supply and flood defence are reported from the examples of the UK (Tompkins et al., 2010; p.627). It found that activities that have the potential of immediate effect from current climate variabilities, such as the water supply and flood control systems and construction section, are most visible. Most of the adaptation outputs are related to research and planning while creating networks, legislations However, even here adaptation being trickled down to the local institutions is less evident and is mostly government driven (Tompkins et al., 2010).

Manifestation of adaptation in other contexts, such as developing countries, where water is administered by government institutional bodies with different legal authorities

as compared to water companies in UK, are poorly studied (Sud et al., 2015). In many of the developing economies, such as India, water supplies, flood control, hydropower generation and inland navigation is controlled and operated by government institutions with limited local autonomy as compared to water companies in industrialised countries such as UK. Hence, it is difficult to apply learning experiences from developed economies to the developing countries, where competition for limited available resources continues to be a major challenge.

2.3 Enabling adaptation

Adaptation consists of levels of actions to be undertaken by individuals for their own benefit or by the government institutions to protect its citizens (Adger et al., 2005). These actions take place within a hierarchical structure of different institutional bodies operating at different levels that interact, influence, enable or hinder the adaptation actions at another level (Adger et al., 2005; Lyle, 2015). Therefore, adaptation opportunities are expected to be shaped by the dynamics of the layers of institutions operating at different scales. Decision makers operating at different scales respond to the decisions made by actors at another scale (Smajgl and Prananingtyas, 2009). The capacity of institutions to adapt to the changing climate is therefore expected to be largely enhanced or undermined by the actions or inactions taken by actors beyond which an institution is operating. Therefore, understanding the possibility and likelihood of an institution to adapt to the changing climate will involve understanding the influences from institutions operating at different scales or tiers of governance (Smajgl and Prananingtyas, 2009). This is particularly so in the case of highly bureaucratic form of governance where multiple institutions at multiple levels perform complementary or overlapping functions.

Recent studies on adaptation have shown that both public and non-governmental institutions – including research and academic institutions – play a crucial role in enabling adaptation (Adekola, 2012; Agrawal, 2010; Frantzeskaki et al., 2014; Wang et al., 2013) at multiple scales (Kirchhoff et al., 2015; Pahl-Wostl, 2009). Water management institutions operating at various levels, therefore, need to inter-act with various institutions and sectors for adapting its management to climate change (Berkhout, 2012; Wilby and Vaughan, 2011). Moreover, when the internal resources are limited, institutions need to acquire resources from beyond their operating scale to enhance their capacity (Vedeld et al., 2015). Recognising the need for multi-stakeholder and multi-sectoral engagement, both in water management and climate

change adaptation in general, literature on inter-institutional networks, which was previously concentrated more in the business and services sector such as manufacturing and tourism, is now emerging (Adekola, 2012; Inderberg, 2012; Steinberg, 2009).

Managing water in changing climatic conditions, often compounded by growing demands due to other developmental pressures, require effective collaboration across scales and sectors to reduce competing policy agendas (Vedeld et al., 2015) and enhance the sharing of limited resources and multiplying learning experiences. Although studies regarding the interaction between scales are emerging, knowledge regarding the feedback loops between institutions operating at different scales that shape the temporal dynamics of climate adaptation are limitedly known (Lyle, 2015). Current knowledge regarding the flows of knowledge and resources from higher levels of government through cross-scale networks are inadequately studied to understand how socially equitable and sustainable adaptation to climate change can be enhanced. Climate change affects different sectors, actors and regions differently and hence the need for adaptation varies and so does the adaptive capacity across scales, sectors and actors (Grothmann et al., 2013; Prutsch et al., 2014). Locality based studies are required to draw out particular sociological perspectives on adaptation (Amaru and Chhetri, 2013) in order to complement national adaptation policies.

2.3.1 Devolution of capacity to institutions operating at different levels

Institutions operating at different levels; from national to regional and local have both distinct and complementary roles in developing and implementing adaptation strategies (Adger et al., 2005; Fidelman et al., 2013; Nalau et al., 2015). This is particularly so for adapting water management to climate change from basin level management institutions to regional and national governments and local municipal bodies (Bisaro et al., 2010; Finger et al., 2006; Lebel and Garden, 2008; Mollinga et al., 2006; Pittock, 2011; Wilby and Wood, 2012). The extent to which the various stakeholders are involved in the design and application of adaptation measures shapes its outcome (Juhola and Westerhoff, 2011). However, despite this emerging consensus on the multi-level nature of adaptation, knowledge regarding how institutions operating at different levels; national, regional, and local, operate and inter-act with one another, or how such inter-actions, or the lack of, create enabling mechanisms or hinders adaptation is limited (Amundsen et al. 2010; Dannevig and Aall 2015; Vedeld et al. 2015).

Significant gaps generally exist between institutions operating at different scales both in terms of risk perceptions and adaptive capacity (Butler et al., 2015). Knowledge regarding the impact of this variance is limited due to the scant critical attention from adaptation researchers on the key issue of the relationship between institutions operating at different levels (Wyborn, 2015). Empirical knowledge regarding the lack of adaptive capacity for institutions operating at one scale being circumvented by the presence at another level or the absence of adapting attributes at one level causing bottleneck for creating adaptive capacity at another is limited (Pahl-Wostl, 2009; Wyborn, 2015). Moreover, this multi-level institutional interaction is shaped by the governance and institutional structure within that context. Research on multi-level governance of adaptation is emerging in the recent past (Bizikova et al., 2015; Dannevig and Aall, 2015; Lyle, 2015; McGloughlin and Sweeney, 2011; Schreurs, 2010; Vedeld et al., 2015). However, knowledge regarding how institutions at different scales influence the adaptive capacity at different scales is not consolidated due to a lack of frameworks to understand these complex structures. Therefore, empirical studies are required to address this key knowledge gap to understand how the prevalence or absence of adapting attributes of institutions operating at one scale affects the adaptive capacity at another scale.

2.3.2 Inter-institutional networks for adaptation

In theory, networks are 'self-organising, collaborative, non-hierarchical, flexible, and topological' and 'the conditions of possibility and actions of network participants' are generally considered as 'a property emerging from the relationship with other participants rather than by their own inherent characteristic' (Leitner and Sheppard, 2002, p.148-149). Network theory analysis goes beyond socio-political studies that look at individual organizations (Steinberg, 2009) and includes the importance of non-technical approaches to planning procedures (Lienert et al., 2013). Since climate change is a multi-dimensional issue, the need for a multi-dimensional adaptation strategy achieved by involving multiple stakeholders across scales can hardly be ignored.

Studies regarding the importance of network between municipal bodies (Fünfgeld, 2015), experts (Rousselin, 2015), and individuals for both climate change adaptation (Dow et al., 2013b) and sustainable management of resources (Baird et al., 2015; Bodin and Crona, 2009) are emerging in literature. For example, at the individual level, Aulong et al. (2012) assessed the adaptive capacity of South Indian farmers using a

weighted analytic hierarchy process and found that geographic position of farmers (proximity to district/administrative centres) and the ability to acquire information, which contributes significantly to their adaptive capacity, is enhanced by social networks. The authors considered social networks as a key element in enhancing the adaptive capacity of the farmers because it increases the farmers' awareness to climate and economic changes. Networks amongst non-profit organizations have been shown to be effectively improving the adaptation to climate change (Steinberg, 2009). Earlier, Brooks and Adger (2005) also indicated that existence of networks enhances adaptive capacity. Studies in Finland and Italy found that adaptation mainly takes place through both formal institutions and networks across actors at various scales but the adaptation at the national scale remain somewhat limited due to the limited coordination (Juhola and Westerhoff, 2011). Whereas, in the UK, the networks created through the UK Climate Impacts Programme (UKCIP) enabled anticipatory actions at various scales in different sectors (Tompkins et al., 2010). The ability of a wider set of actors to plan adaptation is largely enhanced by the presence of an effective network. Ziervogel and Downing, (2004) have pointed out that understanding the networks between stakeholders enables to determine the key opportunities and barriers to the flow of specific information. Because networks allow the institutions to cross institutional boundaries and blurs formal categories it provides "a constellation of relationships that can be activated when needed, can be perturbed for new information or ways of doing, or simply turned to for an extensive store of knowledge" (Lejano and Ingram, 2008; p.251).

2.3.3 Transboundary institutions

In complex multi-stakeholder and multi-sectoral systems, such as water management or climate change adaptation, where multiple actors from various sectors are expected to be involved, institutions that mediate between science and policy (boundary institutions), coordinate the actions between the various (types or groups of) institutions (bridging institutions) and between resources provider, user and regulatory groups (intermediaries) are increasingly recognised to be playing a key role in enhancing the adaptive capacity (Kalafatis et al., 2015; Kirchhoff et al., 2015; van Enst et al., 2016). Sternlieb et al., (2013) collectively clubbed them together as transboundary institutions – "institutions that transcend multiple boundaries". Boundary institutions are recognised to play the distinct role of mediating between science and policy and act as the linkage that "make collaboration possible by engaging actors on the basis of their convergent

interests" (Sternlieb et al., 2013; p.120). Bridging institutions on the other hand are recognised as "conduits between social networks with the potential to link diverse nodes of expertise for collective action" (Sternlieb et al., 2013) and provides "an arena for knowledge co-production, trust-building, sense making, learning and horizontal collaboration and conflict resolution" (Berkes, 2009 p.1695). The bridging institutions are distinct third party formal entities that act as brokers between peer level groups or vertically across state and federal institutions (Sternlieb et al., 2013). Intermediaries are distinguished more by "the character of work they do rather than the characteristics of the institution itself" (Moss, 2009; p.21). As the need for disseminating information gained importance, such as in climate change and environmental conservation awareness, intermediaries are gaining increased attention and their crucial role in disseminating knowledge and enabling adaptation increases. As the same institution can act as mediating between science and policy as well as between institutions operating at different scales vertically or between different types of institutions or groups of institutions, the terms are sometimes used interchangeably. Sternlieb et al. (2013) suggests that transboundary institutions facilitate vertical integration and hence it should focus on deep learning that transforms norms and values. Therefore, it suggests the need for considering the role institutions such as universities as they have become active participants

In the UK, institutions such as UK Climate Impacts Programme (UKCIP) Office have been known to have played a key role in bridging the gap between science and policy (McKenzie Hedger et al., 2006). Its role in enhancing the capacity of decision makers to evaluate risks and plan adaptation is well recognised (Gawith et al., 2009). By bridging the gap between research and policy, UKCIP enabled decision makers to produce research in the ways that are useful to policy makers (McKenzie Hedger et al., 2006) and through communicating the impacts of climate change to the stakeholders, UKCIP raised awareness of the need to adapt and also provided the tools to decision makers for planning adaptation strategies (Gawith et al., 2009). Engagement by private sector was found to be patchy and hence fundraising did not occur easily as expected, and stakeholder fatigue was observed over the period as stakeholders' views began to be coloured by unscientific press reports (Porter et al., 2015). However, the work of UKCIP enabled to blur the gap between the 'expert' and 'lay' and stands out as an example of bridging the gap between sectors, scales, research and policy communities (Tompkins et al., 2010). The efforts of UKCIP in equipping local authorities with more accessible information has resulted in enabling them to enhance their adaptive

capacity with the staff now engaging with 'relevant information' although knowledge being translated into satisfactory tangible adaptation action remain unsettled due to other barriers such as budgetary cuts and inadequate 'political appetite' (Porter et al., 2015).

2.4 Discussion

The literature surveyed thus far drew out knowledge concerning a) climate change impacts and adaptation needs, b) adaptation enablers, c) barriers, and d) adaptation manifestation which has been synthesized into a conceptual diagram as shown in Figure 2.1 below. Since the impacts of climate change will be immediately experienced through the medium of water, water institutions need to incorporate adaptation measures within their management which is why building adaptive capacity becomes a priority. As the diagram suggests, adaptive capacity and adaptation barriers are closely related, often inverse of each other. For example, the lack of adaptive capacity components such as knowledge, economic and infrastructural resources and inadequate institutional mechanisms become a barrier. However, the availability of adaptive capacity in itself does not ensure the absence of adaptation barriers. Instead, the effective utilisation of adaptive capacity is reduced by barriers (Oberlack, 2016). The available adaptive capacity is to be utilised by institutions whose risk perceptions and adaptation choices are shaped by its cultural and normative behaviours as well as cognitive capacity of individuals within those institutions. The adaptive capacity is utilised in an institutional context which is shaped by existing laws and implemented via a 'normative' procedure (although what is normative is questionable). In addition, the inherent uncertainty of climate change has an impact on the utilisation of the adaptive capacity, such as the question of when and where to utilise the financial and human resources, although the existence of adaptive capacity, such as the existence of a flexible institutional mechanism, is expected to overcome the challenges of uncertainty (Dessai and Hulme, 2009). Although the diagram does not aim to represent the process of adaptation – the figure being a mere conception of the various essential components concerning adaptation – it can be seen that existence of adaptive capacity in itself does not ensure that adaptation will follow automatically without the barriers being overcome.

Inter-institutional networks enable decision makers and actors to acquire additional adaptive capacity from beyond the institution (Baird et al., 2015; Bodin and Crona, 2009) and overcome barriers and thus enable the translation of adaptive capacity into

adaptation manifestation. On the other hand, the role of transboundary institutions (Sternlieb et al., 2013) is particularly important both for enhancing the adaptive capacity (Berkes, 2009) and also for reducing the adaptation barriers (Oberlack, 2016) as shown in the figure. Although the components in the conceptual diagram [Figure 2.1] are not exhaustive in itself, and is only an indication of the various aspects involved in adaptation, it also indicates the inadequacy of current literature to understand how exactly a) different actors perceive climate risks, b) the adaptive capacity is utilised, c) barriers can be overcome, and d) successful adaptation is manifested in various contexts. While it is clear that barriers need to be overcome in order to translate the available latent adaptive capacity into successful adaptation or create additional capacity, the figure also indicates the gaps in knowledge regarding how adaptation is played out in different contexts. Therefore, it also depicts the disconnectedness in knowledge regarding the relationships between risk perceptions, enablers, barriers and manifestation of adaptation.

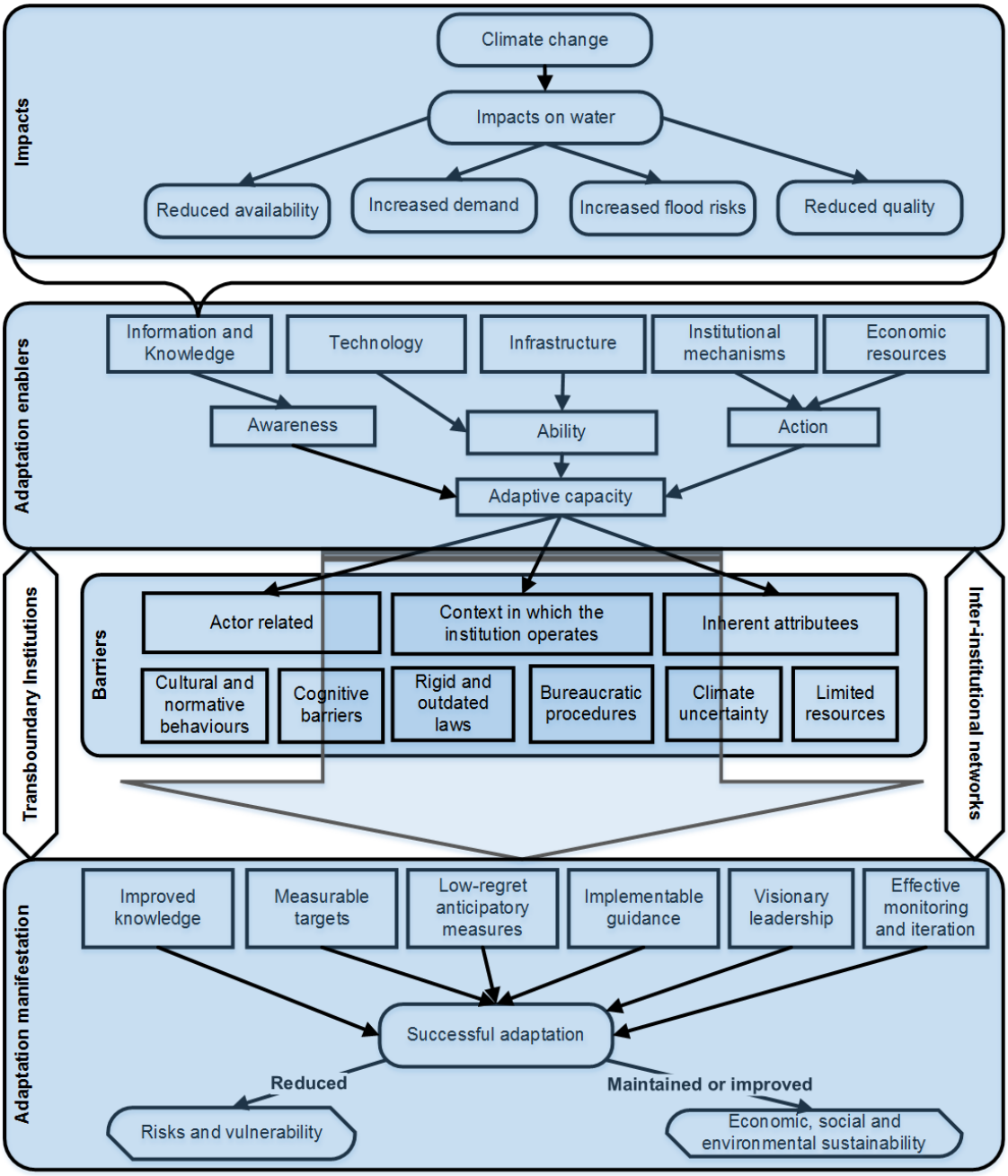

Figure 2.1: Conceptual relationship between the key components of climate change adaptation

The remaining part of this section draws out the key knowledge gaps based on the literature surveyed and discusses its implications.

2.4.1 Adaptation by institutions

Adaptive capacity evaluations, particularly in developing economies, focus on communities but rarely on the institutions that administer water.

The most important element in adapting water management to climate change – the water management institutions – is conspicuously ignored, particularly in studies of developing economies. Perhaps it is implicitly assumed that institutions which administer water for public good will adapt if the society or the sector as a whole adapts to the changing climate. But this is putting the cart before the horse. Institutions that are administering the ecological and societal needs of water have to lead in adapting to the changes. As the need for adaptation increasingly become prominent (Mimura et al., 2014), research on vulnerability of physical systems (Upgupta et al., 2015) and the adaptive capacity (Pandey et al., 2011) is emerging even in the context of developing economies (Mertz et al., 2009). However, most of these studies tend to focus on communities or the vulnerability of physical systems and rarely on the capacity of institutions which are expected to enable society (and ecology) to adapt to the climate. Nevertheless, some key lessons on the characteristics of adaptation can be drawn from some of these studies.

Literature on adaptation (Arnell and Delaney, 2006; Berkhout, 2012; Grothmann and Patt, 2005) show that the adaptation process involves a) perception, b) evaluation, c) enactment, and d) feedback, which are not necessarily sequential but interactive and often reinforcing or constraining one another (Klein et al., 2014). Extreme weather related events make institutions increase their preparedness (Engle, 2013) because it shapes the risk perceptions. Decision makers need not necessarily respond based on 'true' level of risk inherent in the changing climate but on risk perceptions (Burch and Robinson, 2007). Therefore, understanding how key actors within water management institutions perceive risks is essential (Brown et al., 2013; Smith et al., 2014) for evaluating the ability and likelihood of the institution to adapt to the changing climate. Risk perceptions are largely shaped by awareness of the potential threats (Halady and Rao, 2010; Marshall et al., 2013) but socio-cultural contexts also play a key role (Mauelshagen, 2012). Evaluation of the adaptation options depends largely on the available economic, technological, legal, or cultural reasons and may be evaluated differently by different actors (Arnell, 2011). It also is shaped by the cognitive capacity of decision makers (Grothmann et al., 2013) to articulate the resources requirement (Porter et al., 2015). Since adaptation is an iterative process, implementing the adaptation strategies and experiences gained through such implementations are important for iterating the adaptation strategies (Berkhout, 2012). Understanding whether or not the water management institutions can reduce the likely impacts and/or take advantage of the new opportunities clearly becomes an important concern.

2.4.2 Adaptive capacity limitations

Evaluation of adaptive capacity and application for policy making remain contested due to its latent, dynamic and contextual nature.

Although consensus on the determinants of adaptive capacity is growing, its evaluation and application for policy making is contested. The generic determinants of adaptive capacity listed by Smit et al., (2001) continues to be the framework in different context, sectors and scales of assessments with slight modifications in the details as the literature on assessments of adaptive capacity keeps growing over the past decade. However, contestations remain regarding the methods of data collection, assessments, and criteria to be used for the measurement of adaptive capacity (Engle, 2011; Hinkel, 2011). Existing frameworks of adaptive capacity assessments are helpful in enabling to understand the system's ability to adapt. However, due to the diverse and context-dependent nature of climate change vulnerability and risks, adaptation planning and assessment approaches vary. For example, Marshall et al., (2013) focused on the human potential required to convert existing resources into successful adaptation strategies while Pandey et al., (2011) considered the availability of resources as a key component of adaptive capacity. The latter, therefore, stressed on the need to explore the factors that influences the adaptive capacity besides climate change awareness.

Evaluation of adaptive capacity is challenging because of its latent and context specific nature and likely shaped by dynamic variables (Juhola and Kruse, 2015). Determinants of adaptive capacity are difficult to generalise and do not carry equal weight between contexts (Engle, 2011; Pandey et al., 2011). Methods of adaptive capacity evaluation using aggregated indices (Gupta et al., 2010; Pandey et al., 2011), have been found to be of limited use due to the difference in context and subjectivity. Since adaptation to climate change is variable-rich, multidimensional and perhaps chaotic, a single approach is unlikely to understand different challenges (Biesbroek et al., 2013). Rigorous conceptual frameworks for evaluating the adaptive capacity of institutions are lacking as there remains contentions regarding the usefulness, transparency and objectivity of adaptive capacity indicators being applied (Hinkel, 2011). This shows that not only are the methods of evaluating adaptive capacity contested, its applicability to policy making remain controversial, particularly the use of quantitative indicators (Hinkel, 2011), but also confining to determinants of adaptive capacity alone leaves out other key factors such as adaptation barriers and is inadequate to understand why the availability of adaptive capacity is not an assurance that adaptation will occur (Burch

and Robinson, 2007).

Since availability of adaptive capacity in itself does not guarantee that adaptation will occur automatically, research need to go beyond assessing the availability of adaptive capacity to how the existing capacity can be utilised successfully and enhanced. Other factors such as attitudes of actors, inherent uncertainty of climate change and other institutional challenges such as rigid and outdated processes of decision making can hinder the utilization of adaptive capacity (Moser and Boykoff, 2013). Overcoming adaptation barriers will therefore be required for transforming adaptive capacity into adaptation manifestation. Gaps in knowledge regarding the adaptation policy and practice are particularly pertinent in developing countries (Ford et al., 2014). Adaptation tracking is particularly challenging due to the inconsistencies regarding what actually counts as adaptation actions and what counts as adaptation preparation (Ford et al., 2015). Since there is more or less consensus regarding the determinants of adaptive capacity, future studies need to focus on developing the capacity, particularly when the physical resources are limited, and how the existing or developed capacity can be put to better use so that the desired goals of adaptation is achieved.

2.4.3 Adaptation manifestations limitedly visible

Sporadic studies that report manifestation of adaptation are confined to industrialised countries and unlikely to have huge relevance for water management institutions in developing economies where public institutions administer water.

In spite of the growing efforts on adaptation, manifestation of adaptation is limitedly observed (Mimura et al., 2014), and much less from developing countries (Sud et al., 2015). Although the number of studies on adaptation techniques for reducing the impacts and assessment methods applied are growing, examples or empirical studies that demonstrates how adaptation is actually being delivered is very limited (Arnell, 2010). Observed visible adaptation such as those reported in the UK (Tompkins et al., 2010) are isolated and unlikely to be directly applicable to developing economies where the socio-economic cultural and governance system is different. Nevertheless, some key examples of how UKCIP promoted adaptation by bridging between policy, research and implementing institutions (Gawith et al., 2009) are key lessons which institutions in other countries can learn. However, this requires taking into consideration the socio-cultural and economic contexts in addition to institutional regulations and legislations of how water is governed and administered.

In many developing economies, such as India, water is administered by government institutions as opposed to private companies such as in the UK. Since the rules and laws that bind government institutions and private institutions are different its operation is expected to be different. Moreover, government institutions are expected to be driven by services whereas private companies can be expected to be driven by profit (which is not to say government institutions are not concerned about profit). On the other hand, performance of water companies, such as in UK, are assessed and regulated by regulatory authorities and Environment Agency (Arnell and Delaney, 2006) and compete with other potential service providers whereas government water supply institutions are not regulated in that manner. Therefore, although important lessons, such as incorporating risk factors in to the design and planning of infrastructure, can be adopted and borrowed, taking into consideration the physical parameters, the governance and management are unlikely to be hugely relevant to one another. Moreover, as adaptation depends on risk perceptions and available resources and technology, socio-economic and cultural factors are likely to play a key role in how water institutions respond to similar or different impacts. The main challenges for climate change adaptation continue to be the question regarding understanding the drivers of past adaptation efforts and how it can be mainstreamed into other general developmental praxis (Mertz et al., 2009).

2.4.4 Need for identification of barriers contextually

Studies that take into account the socio-cultural and economic contexts of adaptation barriers are limited and its root causes and relations limitedly addressed.

Adaptation will entail the identification of the underlying causes of barriers to overcome them. Best top-down national or regional plans do not necessarily translate into successful adaptation (Preston et al., 2010) as adaptation is context specific and contingent upon such factors including aptitude and attitude of implementing institutions towards risks (Wilby and Vaughan, 2011), political and circumstantial priorities (Haddad, 2005) besides the availability of resources and technology. Moser and Ekstrom (2010) propose that working through barriers, rather than skipping entire phases of the decision process, will prove beneficial for the decision outcome. Therefore, exposing the factors that stop, divert or delay institutions to effectively adapt are crucial in the adaptation process (Berkhout, 2012). Moser and Ekstrom (2010) posited that, on one hand, not even best practices are barrier free and hence, identifying and recognising their presence can enable institutions to overcome them

and may still require adjustment in the next iteration. On the other hand, not questioning the validity of such challenges could itself become an obstacle for adaptation (Moser and Ekstrom, 2010) and ultimately become a limit (Barnett et al., 2015).

Superficially, adaptive capacity and barriers appear as mirror image of one another – the absence of adaptive capacity is a barrier. However, this is not always the case because existence of adaptive capacity alone does not ensure adaptation (Eisenack et al., 2014). Although the absence of certain determinants of adaptive capacity, such as information and resources, lead to barriers its presence does not always ensure that adaptation will occur automatically (Moser and Boykoff, 2013). Therefore, determinants of adaptive capacity and barriers have to be both taken into context, although not necessarily as separate entities, while researching for and on adaptation. As the availability of adaptive capacity in itself do not ensure adaptation, adaptation planning will require the identification of adaptation barriers, their emergence, sustenance and their relations with other determinants (Eisenack et al., 2014). Due to the contextual nature of the barriers (Eisenack et al., 2014) and their dependence on the actors (Baker et al., 2012; Engle, 2012), defining and conceptualising the causes of barriers remains challenging. This means the reasons why the expected and desired adaptation goals failed to achieve needs to be explored contextually in order to device strategies for overcoming them by studying the local specific issues.

Although there is a growing interest in adaptation barriers in general, particularly since the turn of this decade, research on barriers for institutions to adapt is relatively minimal (Biesbroek et al., 2013). Very few research addressed the causes of barriers and the interdependences between them (Eisenack et al., 2014). Moreover, knowledge on barriers to adaptation in developing economies remains scattered and barriers emerging from political, social and psychological factors are rarely mentioned (Shackleton et al., 2015). This is largely due to lack of frameworks to understand the barriers (Biesbroek et al., 2013) as it is contingent upon the societal values (O'Brien, 2009) and attitudes towards risks (Adger et al., 2009) besides the physical and natural circumstances. Adger et al. (2009) contend that issues of values and ethics, attitudes to risks, knowledge, and culture construct the context of adaptation and hence barriers are mutable. Therefore, research on why barriers emerge and their interactions and compounded impacts that shape adaptation processes are urgently required to be identified to overcome them (Shackleton et al., 2015).

2.4.5 Role of inter-institutional networks

Inter-institutional networks, particularly within public institutions and between governmental and non-governmental institutions, are poorly understood.

Increasing the adaptive capacity beyond the inherent capacity within an institution requires acquisition of capacity from other institutions. These institutions include transboundary institutions operating in other sectors or scales acting as a bridge between policy making institutions and research institutions or institutions operating at a different scale. It may be hierarchically below or above, particularly in a highly bureaucratised top-down system of governance, as inter-institutional networks can exist vertically or horizontally between institutions operating at different scales such as the national scale or more locally, as networks are expected to be 'self-organised' and not externally imposed (Leitner and Sheppard, 2002). Since effective networks enhance smooth adaptation (Lejano and Ingram, 2008) the networking barriers become barriers for adaptation as well (Burch, 2010; Vedeld et al., 2015).

Although inter-institutional networks between non-profit institutions have been shown to be enhancing the adaptive capacity by creating an 'ecosystem of institutions' through sharing of knowledge and information (Steinberg, 2009), prevailing knowledge concerning networks among public institutions remains unexplored. This is probably due to the reason that public/government institutions tend to work in silos and not much attention is given to how effectively services can be delivered through an improved coordination. Institutions being more complex (Pahl-Wostl, 2009) than individuals, social network theories of individuals cannot be applied directly to the level of institutions. Although the tools can be adapted, the explanation of the implications cannot be applied at the organisational level which is made up of individuals. Moreover, existence of social networks in itself cannot be assume to enhance the adaptive capacity (Brockhaus et al., 2012), if the network is exclusive and rigid and leave conventional wisdom unchallenged and do not enable learning (Newman and Dale, 2007). However, the presence of a strong network among the concerned institutions is expected to provide an opportunity for institutions to gather resources through the network even when the particular institution does not possess the required resource to face the challenge (Ziervogel and Downing, 2004).

2.4.6 Transboundary institutions and its role in enabling adaptation

The role of bridging institutions in enhancing the adaptive capacity of water is poorly understood and hence underappreciated.

In order to improve the adaptive capacity of water institutions operating at different scales, not only does the interaction between the various types of institutions need to be improved but the role played by bridging institutions needs to be recognised and device strategies for creating opportunities where they can be involved. The role of UKCIP in the UK in enhancing the adaptive capacity through bridging the gap between researchers and policy makers in the government by making the climate information available (Griggs and Kestin, 2011; Mastrandrea et al., 2010; McKenzie Hedger et al., 2006) is a prime example. Although reliance on one institution alone to shape the socio-political landscape may be inadequate to bring about widespread transition (Tompkins et al., 2010), it demonstrates the difference bridging institutions can make in enabling adaptation (West and Gawith, 2005). The role of such counterpart institutions in developing economies is inadequately assessed and hence is poorly appreciated.

The aim of research institutions and policy-makers is to facilitate the adaptation action (Hinkel, 2007) rather than they themselves adapting, in some sense. In this instance, research institutions are facilitating institutions as they generate knowledge regarding the need and options for adaptation. They facilitate adaptation by providing or enabling the receptors to acquire the resources necessary or create a system conducive for adaptation (Eisenack and Stecker, 2012). Therefore, actions such as development of adaptation techniques, building knowledge capacity, and developing knowledge regarding vulnerable systems, for decision makers to take adaptation measures, which are considered as adaptation facilitation, can be enhanced by transboundary institutions.

2.5 Conclusion

The importance of adaptation, particularly for water management, is widely recognised. Consensus regarding the methods of adaptive capacity evaluation and application to policy is unlikely because of its latent, dynamic and contextual nature although its determinants are more or less recognised. Therefore, few studies focus on the existence of ‘adaptation attributes’ and ‘adaptation readiness’ particularly using qualitative approaches to capture the contextual nuances. But these are primarily from industrialised countries and unlikely to have huge relevance for developing economies

where climate adaptation has to compete with other developmental priorities. The need for adaptation at all scales taking into consideration both top-down and bottom-up perspectives is widely emphasized in literature. In this regard, bridging institutions that operate across scales and sectors have the potential to enhance the adaptive capacity of water institutions by improving the inter-institutional networks. Moreover, social networks among actors are key for acquiring adaptive capacity from beyond the institution. As such, identification of factors that hinders inter-institutional cooperation by taking into account specific contextual socio-economic and political factors will go a long way in identifying adaptation barriers and overcoming them.

In spite of the growing initiatives on climate change adaptation, defining successful adaptation and discernment of the relationships between intentions, strategies, actions, and outcomes remain a challenge. Models of successful adaptation for water management are still very limited; largely due to the vast inter-sectorial nature of water management on one hand and inherent uncertainties in climate change and scale issues on the other. Moreover, adaptation being a continuous ongoing process, it is hard to evaluate if adaptation has been achieved. Since there is no end point of adaptation, as new challenges are likely to emerge due to uncertainty in climate change as well as other socio-economic factors, it is difficult to quantify or measure whether or not adaptation has been achieved. As such, questions of what actually counts as successful adaptation remains.

While the literature reviewed here provides rich insights into the understanding of the adaptation enabling characteristics and barriers, the existing studies are inadequate to draw conclusions on the relationship between the enabling characteristics of adaptation and barriers. Knowledge regarding the relationship between the adaptive capacity, adaptation barriers and manifestation of adaptation attributes are scattered and limited. The relationship between the various determinants of adaptive capacity and the various types of barriers and how do they emerge and sustain is inadequately evidenced by empirical studies. Addressing these knowledge gaps will help to improve the designing of adaptation strategies, thereby improving the ability of water institutions to address the new challenges of climate change.

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3 UNION GOVERNMENT LEVEL INSTITUTIONS, NETWORKS AND BARRIERS OF ADAPTATION

Abstract:

The capacity of a nation to address the likely hydrological impacts of climate change depends on the institutions through which water is governed and the available infrastructure, resources and technology. Networks can enable adaptation, but understanding of networks between institutions, particularly between public institutions and with other institutions, is limited.

Water governance in India is a complex top-down bureaucratic system that requires effective networks between all key institutions to successfully address climate change challenges. This research combines quantitative internet data mining and qualitative analysis of interviews with representatives from twenty-six key institutions to evaluate the involvement of key national-level institutions for adaptation and understand the bottlenecks within the inter-institutional networks that may hinder adaptation.

Institutions' online presence shows a common disconnect in the institutional discourse between climate change and water, and a centralized inter-institutional network, emanating from or pointing to limited key institutions including the Planning Commission and Ministry of Environment and Forests. In contrast, interviews suggest more complex relational dynamics between institutions and demonstrate a gap between the aspirational ideals within the National Water Mission under the National Action Plan on Climate Change and the realities of climate change adaptation. This arises from institutional barriers including lengthy bureaucratic processes and systemic failures that hinder effective inter-institutional networks to facilitate adaptation. The study has implications for understanding the involvement and barriers of complex multi-layered institutions in climate change adaptation.

Keywords: adaptation, adaptive capacity, climate change, institutions, network, water

3.1 Introduction

Climate change is likely to affect the spatio-temporal distribution, availability and demand for water (IPCC, 2014) through changing precipitation (Chou et al., 2013) and evapotranspiration patterns, glacier melt rates (Jiménez Cisneros et al., 2014), and

saline intrusion of coastal aquifers (IPCC, 2014). Water institutions – government ministries, departments and agencies, non-governmental and developmental organisations, and research and academic institutions – need the ability to anticipate and alleviate these potential threats to minimise vulnerability and damages (Bohensky et al. 2010; Matthews and Sydneysmith 2010) while also taking advantage of the opportunities (IPCC, 2007; Vincent, 2007). A range of adaptation options (Pittock 2009, Crabbé and Robin 2006; Lawton 2010, Tompkins et al. 2010, Stakhiv 2011, Gifford et al. 2011) are, therefore, needed to complement ongoing mitigation efforts (IPCC, 2014; Simonet and Fatorić, 2015).

In addition to the availability of infrastructure, resources and technology (Arnell and Delaney, 2006; Charlton and Arnell, 2011), the adaptive capacity of water-related institutions (Charlton and Arnell, 2011; Engle, 2011) will depend on how effectively decision makers can gather the required information and knowledge, recognize the need for adaptation, and decide to undertake adaptation through the appropriate deployment of resources (Yohe and Tol, 2002). Adaptation, therefore, involves the exchange of knowledge and experience (Brown et al. 2013; Adger et al. 2005; Lejano and Ingram 2008; Ziervogel and Downing 2004) through networks at various scales (Adger et al., 2005; Juhola and Westerhoff, 2011). The role of social networks to enhance the adaptive capacity of individuals (Benson et al., 2015), farmers (Aulong et al., 2012), communities (Brown et al., 2010), non-profit organizations (Steinberg, 2009) and societies (Clarvis and Allan 2014; Davies 2005; Dow et al. 2013; Lejano and Ingram 2008; McAllister et al. 2014; Pasquini et al. 2015; Provan and Milward 1999) is widely recognised, but little knowledge exists concerning networks among public institutions (Arnell, 2010) which this research seeks to address.

3.1.1 Context: Climate change adaptation in India

Facilitating adaptation is particularly important in the Indian subcontinent, where climate change is likely to impact a billion people (Immerzeel et al., 2010). It will magnify existing water management challenges of growing demand (Bhuiyan et al., 2009; Mukherjee et al., 2010), poor performance and deteriorating infrastructures (Ananda et al., 2006; Basu and Joshi, 2000). India is a welfare state (Narain, 2000) where government institutions both frame laws and policies (Saleth, 2004), meet water demands and manage water related disasters (Ananda et al., 2006). At the Union (national) Government level, multiple ministries have responsibility within the water

sphere, supported by many agencies and research institutions. This multiple institutional complexity is evident [Figure 3.1] within the current National Water Mission (NWM) (MWR, 2011) that is being implemented under the National Action Plan on Climate Change (NAPCC) (PMCCC, 2008).

A key challenge for India and many other nations is to develop institutions that are responsive to uncertain future climatic change (Bhamoriya and Ghandi, 2010). Previous institutional analyses in India have focused on the "institutional components" of water law, water policy and water administration (Ananda et al., 2006; Aubriot and Prabhakar, 2011; Bottrall, 1992; Marothia, 2003; Reddy and Reddy, 2002) or been narrowly focused on the internal capacities of institutions (Gandhi and Namboodiri, 2009; Gandhi et al., 2009). This research focusses on Union Government Ministries, government institutions and departments, non-governmental organisations, research and academic institutions and hence the term institution is used here as being synonymous with organisation (Cook et al. 2010), although it is recognised that informal institutions also influence how people interact with water. This research seeks to understand the inter-relationships between these institutions within the complex top-down bureaucratic system of water governance in India. Such complex social and inter-institutional networks (Pahl-Wostl, 2009) allow key officials to cross or blur formal institutional and sectoral boundaries, building 'relational capital' (Wallis and Ison 2011) and providing 'a constellation of relationships that can be activated when needed' (Lejano and Ingram 2008; p.251). The aim is to understand the strengths of ties and cooperation between various institutions and sectors so as to identify barriers and bottlenecks (Biesbroek et al., 2013; Eisenack et al., 2014; Moser and Ekstrom, 2010) to information diffusion and knowledge exchange (Popp et al 2013; Ziervogel and Downing 2004) and thereby identify the key opportunities (McNeeley, 2012) to develop more effective networks for adaptation that interlink between different sectors and stakeholders (Hamlet, 2011).

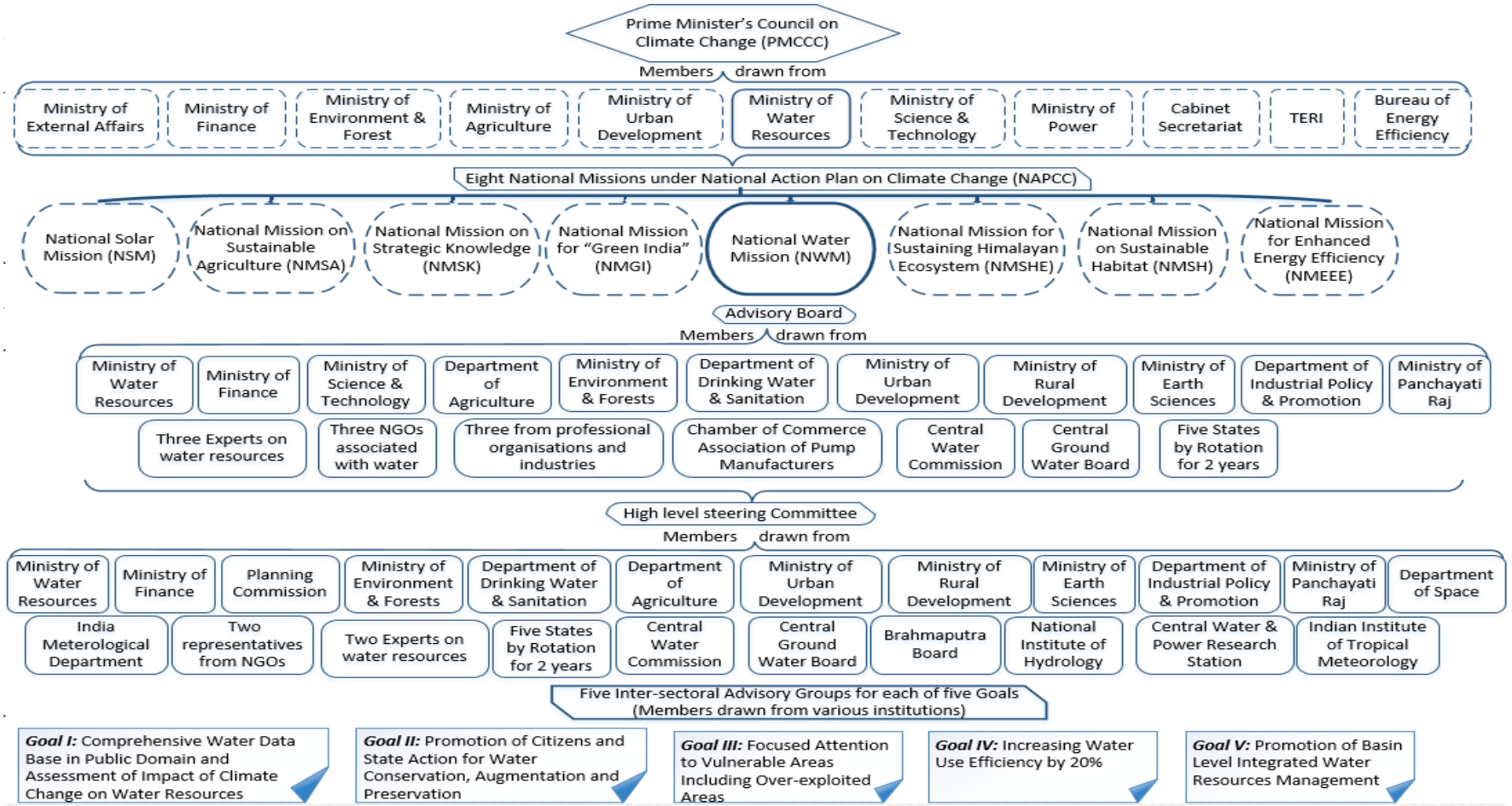


Figure 3.1: Institutions involved in the National Water Mission under the National Action Plan on Climate Change in India. (Adapted from (MWR, 2011) and PMCCC 2008)

3.2 Methods and material

This research uses qualitative and quantitative approaches [Figure 3.2] to identify and evaluate the involvement of key national-level institutions in India in climate change adaptation for water management. Their involvement, interests, inter-actions, and adaptation barriers were evaluated in two stages: a) quantitative internet data mining of the external-facing online presence of Union Government institutions, supplemented with b) qualitative analysis of interviews with key representatives.

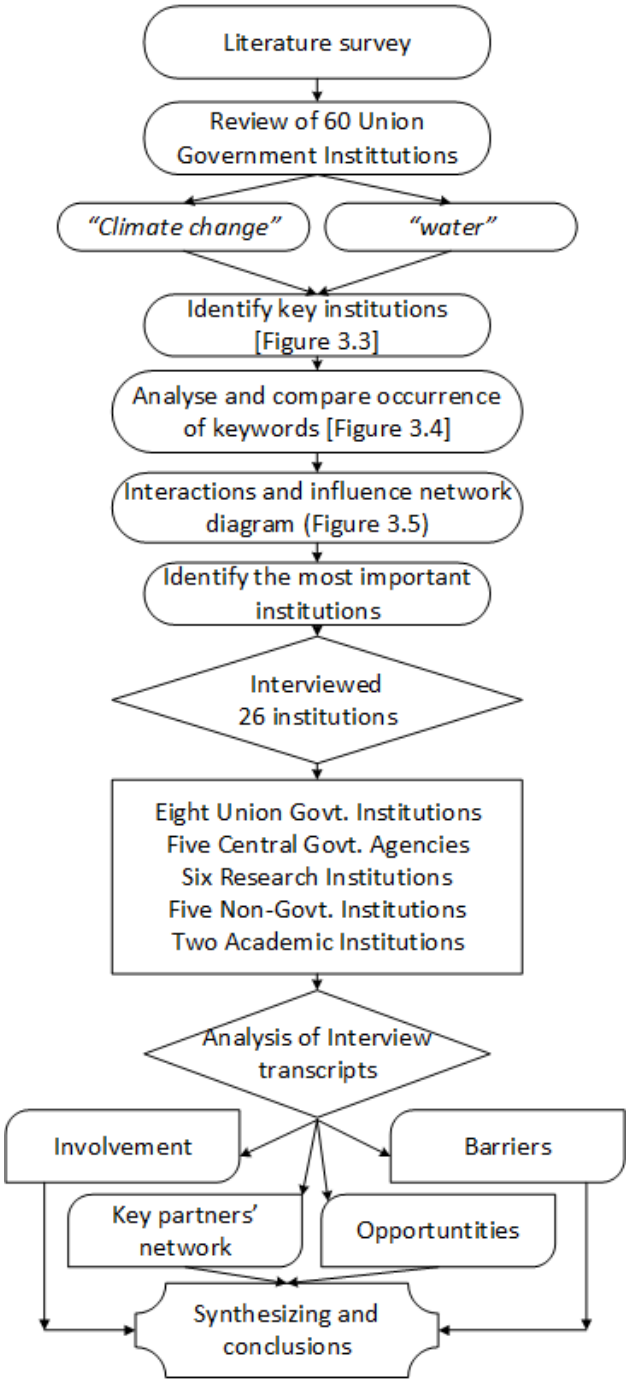


Figure 3.2: Schematic methodological diagram of the study

3.2.1 Analysis of online presence for external portrayal of interest and influence

National e-Governance initiatives in India and the Right to Information Act, 2005 (GoI, 2005) mandate government institutions to proactively make information publicly accessible. Consequently, most government reports, including documents related to the formulation and implementation of the National Water Mission, consultation workshops, trainings and seminars, funding and recruitment are available via the government websites. This enables the interest/involvement of Union Government institutions and the potential inter-actions/influence between them to be

evaluated based on their online presence and thereby identifies the key players in the national discourse on climate change adaptation for water management.

The websites of sixty Union Government institutions [listed in Appendix C] were systematically searched using the *Advanced Google* search engine (https://www.google.co.in/advanced_search) during 13-23 May 2013 to identify those institutions with the greatest public-facing interest/activity in water and climate change on the basis of the total number of webpages and downloadable PDF and Word documents (hereafter referred to as online returns) containing the keywords "*water"* or "*climate change"*. Key institutions were identified according to whether the total number of online returns or the number per thousand indexed webpages (to avoid disadvantaging smaller institutions) exceeded a threshold value denoted by a significant discontinuity in the distribution of online returns. Selection based on threshold number, instead of a mean, median or quartile, ensured that key institutions were identified on the basis of a noticeable difference in their external portrayal of interest and influence in a sample where the numbers of online returns detected were highly variable.

Within the subset of identified key Union Government institutions, two further broad searches were carried out on their websites to identify online returns based on:

- the keywords ["*adaptation*" AND "*climate change*"], ["*adaptation*" AND "*climate change* NOT "*mitigation"*], ["*Mitigation"* AND "*climate change*"] and ["*mitigation"* AND "*climate change*" NOT "*adaptation*"] to evaluate the relative institutional emphasis between mitigation and adaptation in their climate change discourse .

- the keywords [*individual name of the other 59 institutions*] AND ["*climate change*" AND "*water*"] to identify the inter-actions or potential influence between the key institutions

Results were tabulated in a matrix and network diagrams drawn, using NodeXL (Smith et al., 2010). The potential 'strength' of inter-institutional ties (as given by the number of online returns with "*institution name"* AND "*climate change"* AND "*water"*) is denoted by the width and direction of connecting arrows; and their involvement (as determined by the number of online returns for "*water"* AND *"climate change adaptation"* in their respective website) shown by the diameter of the nodes [Figure 3.5].

3.2.2 Stakeholder interview analysis for internal perception of interest and influence

Quantitative analysis of the institutional websites identified those key institutions whose outward-facing public image reflects an interest in climate change adaptation for water management and also the apparent strength of inter-actions between them. However, institutions do not function in a vacuum of human agency and dynamics of human relationships, perceptions and attitudes are complex and hard to decipher by document analysis alone. Therefore, the online analysis was supplemented by in-depth interviews with representatives from these key institutions and other institutions identified as important by these interviewees.

A semi-structured interview template [Appendix F] was designed based on a literature review and refined through two pilot interviews conducted with faculty members within Cranfield University, UK who have knowledge regarding India and climate change adaptation. The questions assess the interviewees' a) perceptions of climate change impacts for water management [not reported here], b) actions [or inactions] triggered by such perceptions, c) aspirations for and suggestions to address the climate change impacts, d) the barriers and challenges for adaptation, and e) their key partner institutions for adapting water management to climate change. The interviewees within eight key Union Ministries identified through the online analysis were chosen based on their work portfolio (such as being in-charge of the Climate Change Cell[1]), or by recommendation of other respondents. In addition, Union Government Ministries and research institutions that work closely with these Union Ministries and other institutions identified as important by at least two respondents were included. Participants were contacted first through email using a standardized letter [Appendix D] followed by phone calls to arrange appointments.

All twenty-six interviews were conducted in English and audio recorded, except for four where permission was not granted. The respondents were from eight Union Ministries (coded as UM), five government agencies (GA) [institutions that are providing particular service such as water supply or when the institution operates in a state as an 'agent' of the Union Government or State Government for data collection and monitoring such as Central Water Commission (CW), Central Ground Water Board (CGWB),

[1] Climate Change Cells are units or divisions within a government department that coordinates the activities related to climate change. The officials in the Cell also generally hold other additional job responsibilities.

National Water Development Agency (NWDA), and National Rain-fed Area Authority (NRAA)] six research institutions (RI), five non-governmental organizations (NG) and two academic institutions (AI). Respondents were coded by these acronyms along with a numerical figure to anonymise yet retain traceability. The interviews were mostly carried out with a single representative. Interviews ranged from nine to ninety minutes with an average of thirty minutes.

The interpretative approach to content analysis was guided by established methods and relied on inductive insights (Saldana, 2009). The first reading and coding of the verbatim transcripts captured the terms that respondents use in their everyday work (Saldana 2009 p.74) and identified the main topics that correspond to the research objectives. Following common practice in grounded theory (Bryant, 2014; Creswell and Miller, 2000; Merriam, 2009; Patton, 1999), the coding process led to the inductive identification of themes and sub-themes from the data set. Increased understanding of the data set led to frequent checks and re-organization of themes and sub-themes. The reliability of the coding process was ensured by verifying the coding of the transcripts from the most recently coded to the earliest which reduces the influence of the earliest coded transcripts (Saldana, 2009). The codes were arranged systematically into themes using QSR NVivo 10 (Richards, 1999), with the keyword "query" feature used to minimise omission of key points, and to enable review of the context in which the keywords occurred. Diverging from conventional content analysis approaches (Strijbos et al., 2006; Tang et al., 2013), higher frequency of codes is not considered synonymous with importance (Fereday and Muir-Cochrane, 2006). Nevertheless, the number of respondents emphasizing a particular point was recorded [Appendix G] as this constitutes an indicator of identifiable (or lack thereof) involvements and barriers.

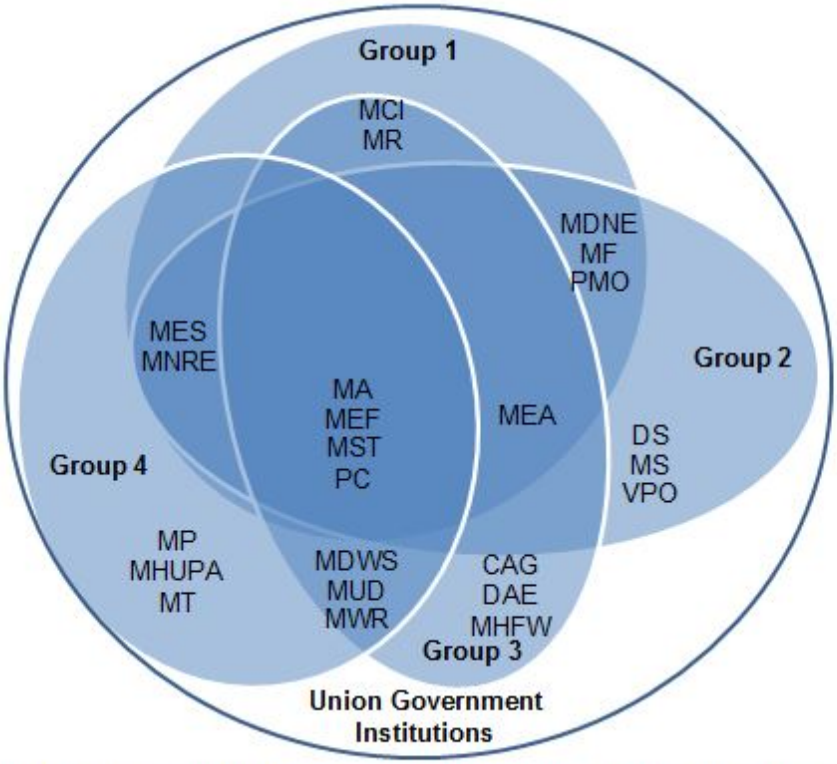
An inter-institutional network diagram [Figure 3.6] was derived from a matrix of interviewees' identified key partner institutions using NodeXL (Smith et al., 2010) and evaluated against the inter-institutional network derived from the online analysis.

3.3 Findings

3.3.1 Involvement in climate change adaptation discourse: online presence

Fifteen Union Government institutions [Figure 3.3] were identified as publicly portraying the most involvement/interest in the climate change discourse, based on having either 134 or more online returns each [Figure 3.3 Group 1] or 24 or more online returns per thousand indexed webpages [Figure 3.3 Group 2] containing the keyword "*climate change"*. The

highest number of online returns was in the Ministry of Finance (2860) followed by the Ministry of External Affairs (2260). Similarly, eighteen institutions portrayed the greatest online involvement/interest in the *water* discourse. Thirteen [Figure 3.3 Group 3] have 1602 or more online returns with the keyword *water* and twelve have 209 or more per thousand indexed webpages [Group 4]



Group 1: institutions having 134 or more online returns with *"climate change"*
Group 2: institutions having 24 or more per 1000 indexed webpages with *"climate change"*
Group 3: institutions having 1602 or more online returns with *"water"*
Group 4: institutions having 209 or more per 1000 indexed webpages with *"water"*

CAG : Comptroller & Auditor General	MHUPA: Ministry of Housing & Urban Poverty Alleviation
DAE : Department of Atomic Energy	MNRE : Ministry of New & Renewable Energy
DS : Department of Space	MP : Ministry of Power
MA : Ministry of Agriculture	MR : Ministry of Railways
MCI : Ministry of Commerce & Industry	MS : Ministry of Steel
MDNE : Ministry of Development of North Eastern Region	MST : Ministry of Science & Technology
MDWS : Ministry of Drinking water & Sanitation	MT : Ministry of Tourism
MEA : Ministry of External Affairs	MUD : Ministry of Urban Development
MEF : Ministry of Environment & Forests	MWR : Ministry of Water Resources
MES : Ministry of Earth Sciences	PC : Planning Commission
MF : Ministry of Finance	PMO : Prime Minister's Office
MHFW : Ministry of Health & Family Welfare	VPO : Vice President's Office

Figure 3.3: Union Government level institutions with the greatest online interest in climate change and water management, based on online returns using keywords "Climate change" and "water"

Based on this analysis, 9 institutions were identified as most involved/interested in the climate change and water discourse (being present in both Group 1 and/or 2 and Group 3

and/or 4) - Ministry of Agriculture, Ministry of Environment and Forests[2], Ministry of Science and Technology, Planning Commission[3], Ministry of Commerce and Industry, Ministry of Railways, Ministry of External Affairs, Ministry of Earth Sciences and the Ministry of New and Renewable Energy. They were augmented by 3 institutions which showed particularly high involvement/interest in the climate change discourse (being present in both Group 1 and 2: Ministry of Development of North-Eastern Region, Ministry of Finance and Prime Minister's Office) and 3 institutions which showed high involvement/interest in the water discourse (being present in both Group 3 and 4: Ministry of Drinking Water and Sanitation, Ministry of Urban Development and Ministry of Water Resources).

Figure 3.4 compares the online returns for *adaptation* and *mitigation* keywords in the websites of these fifteen Union Government institutions. It consistently shows that there are more online returns for *mitigation* than *adaptation* in all the websites, except for Ministry of Development of North-Eastern Region. Adaptation is rarely mentioned in isolation from mitigation, indicating an emphasis on mitigation in the government websites.

[2] Subsequently renamed as Ministry of Environment, Forests and Climate Change on 26th May 2014.
[3] "Planning Commission" is used here as the data was collected before the change to NITI Ayog (National Institution for Transforming India) was announced on 15th August 2014.

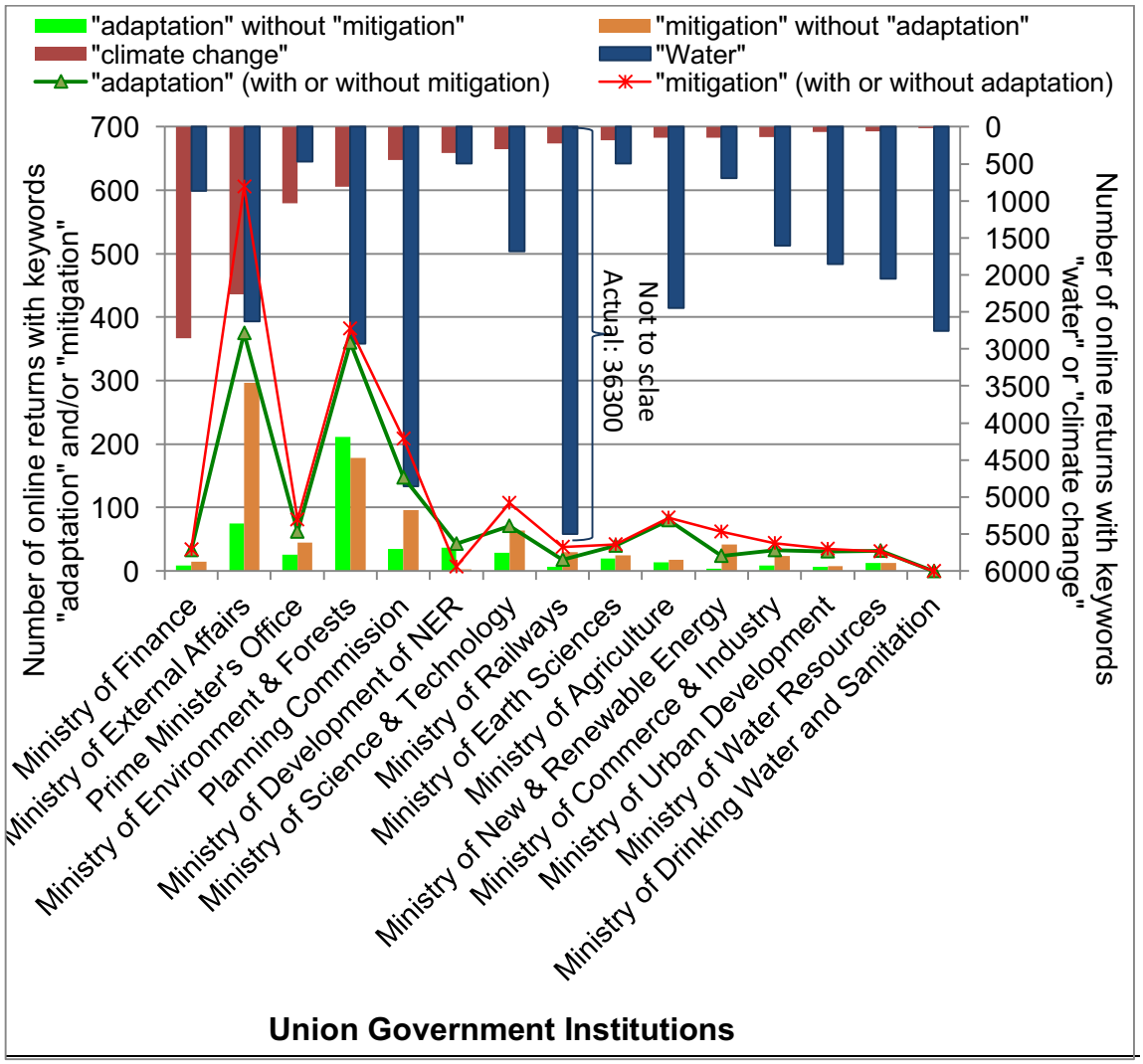


Figure 3.4: Comparison of Union Government institutions' online returns with "water", "climate change", "adaptation", and "mitigation" keywords. Search during 13-23 May 2013.

3.3.2 Quantifying involvement and influence based on online presence

Figure 3.5 depicts the online portrayal of institutional involvement (as given by the diameter of the node) and inter-institutional influence (arrow direction and width). Five Union Government institutions, viz; Planning Commission, Ministry of Environment and Forests, Ministry of External Affairs and Ministry of Agriculture portray the biggest online involvement or interest in climate change and water issues. In contrast, the Ministry of Water Resources (the key institution for formulating water policy and water resources management) and the Ministry of Earth Sciences (which heads activities relating to the weather forecasts and climate studies in India) emerge as much less involved or interested.

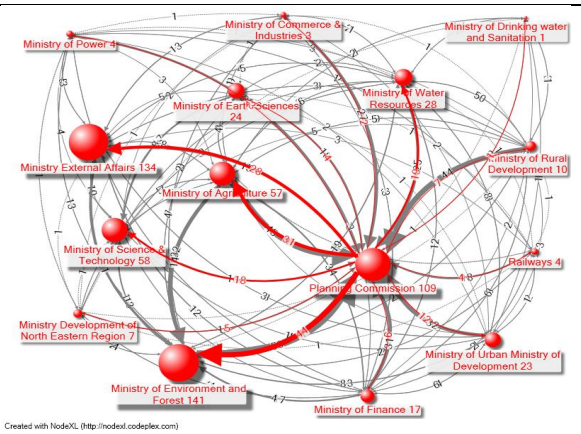


Figure 3.5.a. Institutions citing (potentially influenced by) Planning Commission

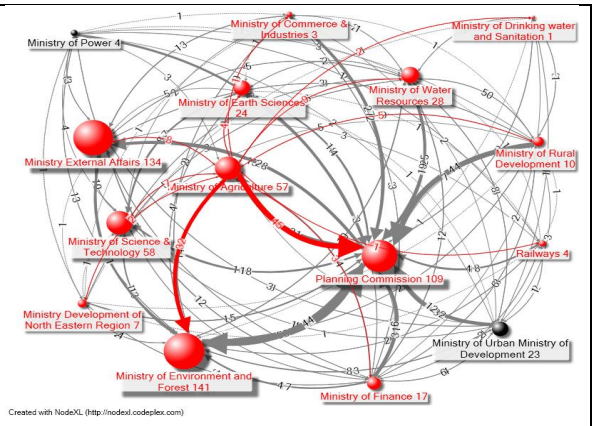


Figure 3.5.b. Institutions citing (potentially influenced by) Ministry to Agriculture

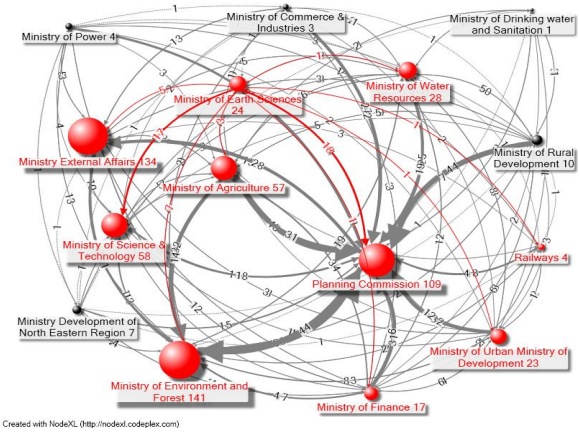


Figure 3.5c. Institutions citing (potentially influenced by) Ministry of Earth Sciences

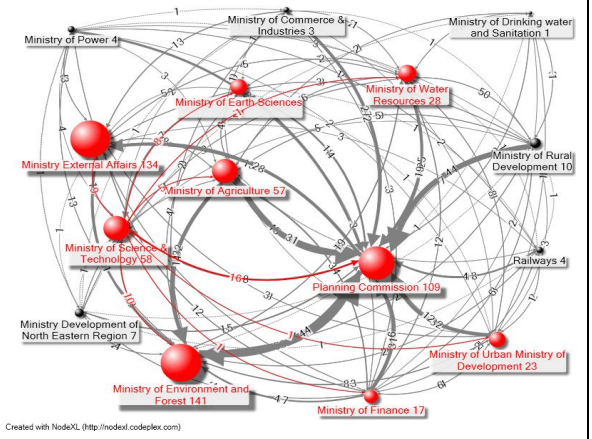


Figure 3.5.d. Institutions citing Ministry of Science and Technology

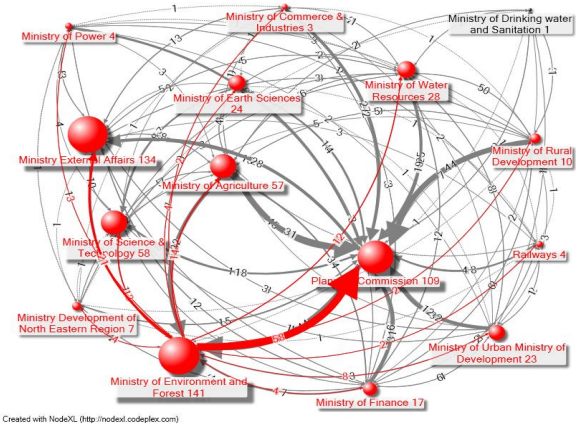


Figure 3.5.e. Institutions citing Ministry of Environment and Forests

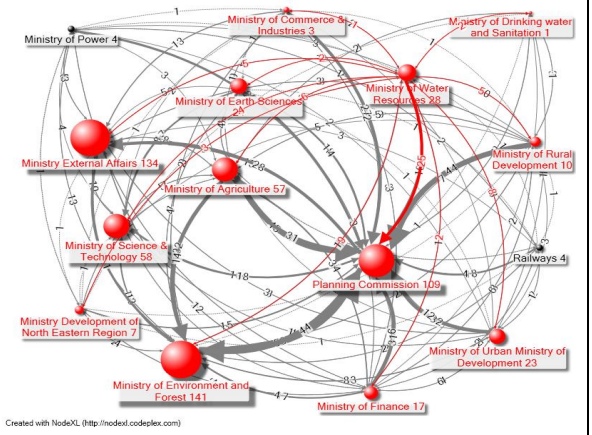


Figure 3.5.f. Institutions citing (potentially influenced by) Ministry of Water Resources

Figure 3.5: Web-based networks of involvement/interest (size of nodes and 'n' adjacent to institution name) and influence (width of arrows) in climate change adaptation for water management for six key institutions. Networks connected to a particular institution (spherical node) are highlighted in red in each sub-figure.

The Planning Commission is shown to have the greatest influence with strong ties with all the key institutions [Figure 3.5a]. This is unsurprising as it makes the major decisions regarding investments and infrastructure development in the country and is headed by the Prime Minister. The Ministries of Earth Sciences and Science and Technology appear to have a weak influence with all other institutions [Figure 3.5c and d]. Given the important role of irrigation in Indian agriculture that makes agriculture the largest consumer of water in India, the weak influences between the Ministries of Agriculture and Water Resources [Figure 3.5.b and 5.f] is surprising, especially given that the Ministry of Water Resources is involved in the development of mega irrigation projects. The lack of apparent influence between such key institutions is suggestive of the presence of barriers to information or knowledge exchange which is explored further in the interviews with representatives in the following sections.

3.3.3 Key partners informed by interview respondents

The key partners identified by the representatives of each institution are shown in Figure 3.6. Seventy-nine partner institutions with whom they have worked or are actively interacting with in relation to water and climate change were specified. Some respondents mentioned generic Indian Institutes of Technology (IITs), National Institutes of Technology (NITs) or Non-Governmental Organisations (NGOs) and each have been aggregated.

The Ministry of Water Resources and the Indian Institute(s) of Technology were most commonly mentioned as key partners (eight each), followed by the Ministry of Environment and Forests (seven respondents). Four institutions; TERI[4], National Institute of Hydrology, Ministry of Urban Development, and Ministry of Agriculture followed these with five each. The prominent importance of the Ministry of Environment and Forests and Ministry of Agriculture in Figure 3.6 corroborated the online perception of significant involvement [Figure 3.5]. However, the interviewees' assessed the importance and influence of the Planning Commission (which plays a key role for planning infrastructural development in India), Ministry of Earth Sciences and Ministry of Science and Technology, as much lower than suggested by their online presence. In contrast, the Ministry of Water Resources and Ministry of Drinking Water and Sanitation, which portray little online interest in climate change adaptation, were commonly cited by respondents.

[4] The Energy and Resources Institute but now well known as TERI

3.3.4 Findings from interviews with key representatives

The findings from the interviews are presented in three sections: (1) involvement in adaptation initiatives; (2) barriers to adaptation; and (3) creating enabling mechanisms.

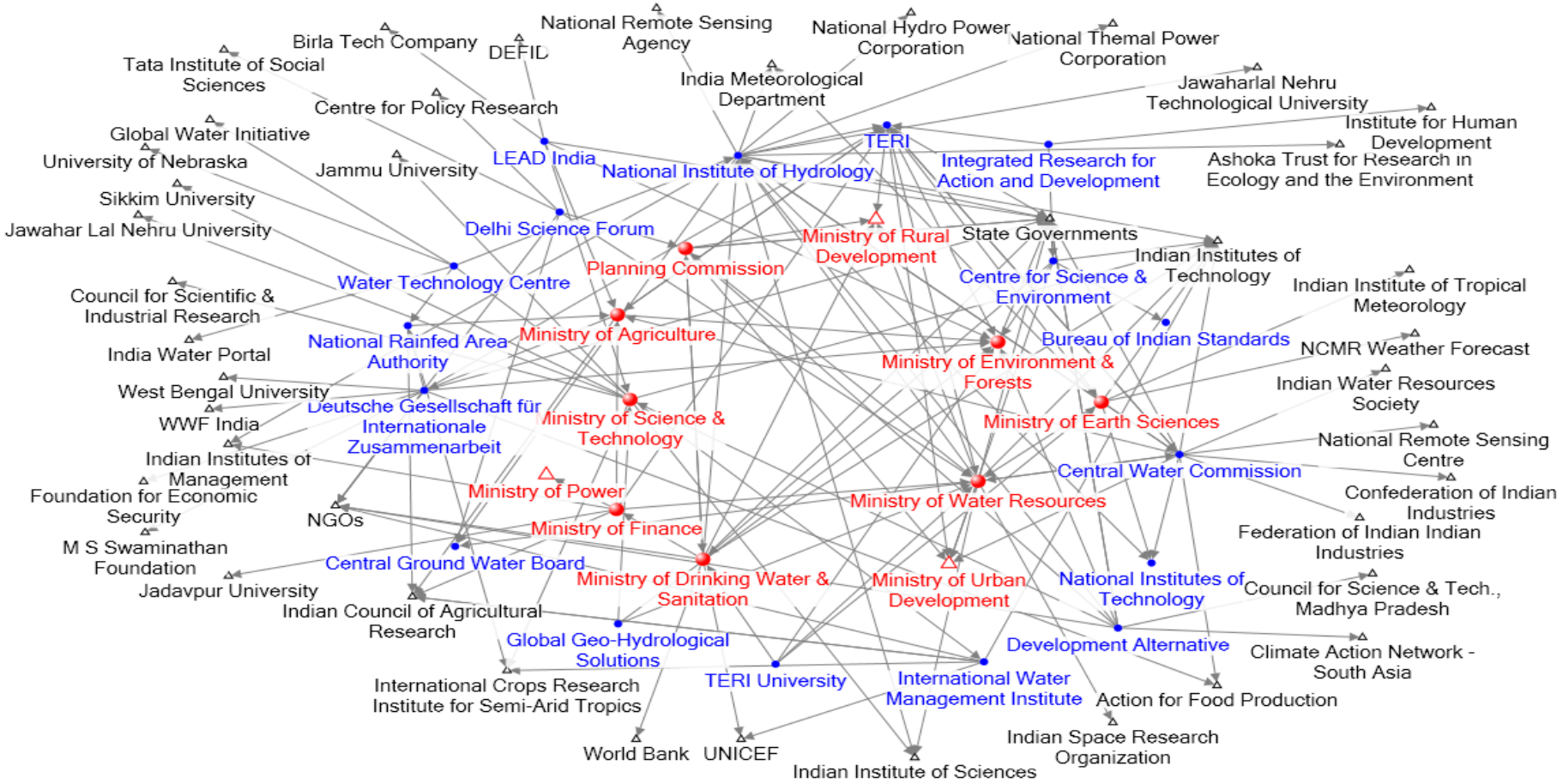


Figure 3.6: Interviewees' network of key partners. [Key: Red = Union Government institutions; blue = other key institutions; black = peripheral institutions. Spherical nodes = Institutions with whom interviews were conducted].

a) Involvement in climate change adaptation

Interviewees' involvement in climate change adaptation activities can be categorised into four broad groups (Table 3-1). The most common activity is to build the adaptive capacity of water users, municipal engineers and government officials by raising awareness through seminars, workshops, for example. These include demonstrating adaptation measures at the local level by, for example, teaching local communities to plan, design and manage rainwater harvesting structures, and local reuse of water. Research to better understand regional projections of climate change, and associated impacts and vulnerability, and the collection of hydrological data to inform analysis, research and management/policy responses, were also mentioned.

NGO interviewees described their involvement in advocacy and building inter-institutional networks for information dissemination, in contrast to the Union Government Ministries and departments. Some research interviewees also stated their involvement as brokering linkages between government institutions and departments in addition to involvement in framing policies and guidelines for reducing water demand. Most interviewees were aware of the government's recent adaptation planning initiatives within the National Water Mission and other Missions under the NAPCC, but their own activities are largely addressing current problems of increasing water demand and extreme events rather than purposefully addressing climate change adaptation.

Table 3-1. Involvement in climate change adaptation. 'N' in first column indicates the number of respondents whose transcripts contain the respective code.

Involvement	Illustrative example quotes
Building capacity [N=10]	*'We are regularly conducting training'* (GA12)
	'We organised a workshop …[with] *state government'* (GA01)
	'We train them how to plan, design and implement best management' (NG09)
	'We are involved to disseminate knowledge on the rain water harvesting' (RI07)
Vulnerability and impact assessments [N=8]	*'…works in understanding the glacial hydrology and how due to the climate it is being affected'* (AI06)
	'We have now entered into climate modelling' (RI11)
	'We are more interested in research and development of how the

	water cycle is changing' (UM18)
Building networks and advocacy [N=8]	*'We are creating a network of NGOs to disseminate information on climate change issues'* (NG14) *'We are targeting …establishing knowledge management platform for the Ministry of Agriculture to disseminate and collect …information for …adaptation'* (NG14) *'We network with a fairly wide network of group of NGOs and Civil Society organisations…fifty or sixty organisations'* (NG15) *'I was in a case … to bring in all the departments together … because they then will understand what are the linkages, cross-linkages of issues amongst them and therefore what is the need for them to actually work in a very coordinated manner'* (RI11)
Policy interventions and guidelines [N=7]	*'…involved in the draft for National Action Plan on Climate Change'* (RI11) *'We provide inputs to the National Water Mission'* (UM18) *'We have revised the National Water Policy …and now working on the implementation … of the Water Mission'* (GA01) *'One of the adaptation strategies we produced on water use* [efficiency]*... We do not have an Indian standard before. I am one of the panel members on …water efficiency'* (NG09)

b) Barriers: factors stopping institutions from adapting water management to climate change

The main barriers to adapting to climate change for water management in India are summarised in Table 3-2. A lack of capacity, which includes knowledge of climate change and lack of financial resources, technology, and infrastructure were the most cited barrier. Many respondents identified knowledge deficits as a major barrier at various levels, due to the disconnection between researchers, policy makers, practitioners and local communities. For example: '*more than ninety percent of the research that is going on in the climate change is not going to help the adaptation for community because the most important stakeholder … are not included in that planning'* (NG14).

The lack of infrastructure as well as its deteriorating state was highlighted: '*the present systems particularly in irrigation … is not in a good shape. .... Over the years systems have deteriorated – particularly the conveyance system. So a huge capital is required and that is a challenge'* (GA01). *'Our paradigm has been to build certain things ….do not manage it properly… deteriorated and then we rebuild…. we didn't have proper institutions to manage them effectively and properly'* (RI14). Deteriorating infrastructure has meant that the water institutions are occupied with addressing current deficiencies rather than future concerns.

Eleven respondents cited barriers due to bureaucratic hurdles and delays in project approvals and administrative deficiencies. Respondents expressed scepticism about the ability of existing institutional mechanisms to deliver adaptation polices and strategies being framed by the Government through the National Water Mission. Bureaucratic processes delay or render data and information (which are with government institutions) inaccessible, despite protocols to make non-restricted data accessible, hindering or delaying research and adaptation planning:

> *'You have to write to the concerned head of the department or the institute and then he will mark* [delegate] *to the concerned officer to give the relevant information. So difficulties are there and procedures are definitely not so simple'* (AI25)

Ambiguities in the responsibilities between the State and the Union and of groundwater ownership were commonly cited as resulting in institutional bottlenecks. A respondent stated that *'India is highly under prepared'* (NG15) to address climate change impacts for water management. He suggested that the challenges will become visible at the implementation stage:

> '*the proof will be in the pudding, … when the work starts… we are going to run into … institutional bottlenecks'* such as *'the jurisdictional* [ambiguities]*…between the Centre and the States... because water is by definition a "state issue"* [but] *most of these problems cannot be tackled at the state level. There has to be a basin level approach* [which requires that] *more than one state has to collaborate*, but the '*battle between one state and another... is going to be a major challenge'* (NG15).

In addition to this, ‘[the] *juridical and legal framework for groundwater.... is still a grey area… even the national water policy has not properly enunciated … States have not agreed’* (NG15). In a similar manner: ‘*… lots of debates come whether water is a state issue. … when it comes to policy making or implementation, it gets affected because there is a lack of clarity’* (UM13).

One of the main barriers to climate change adaptation is the lack of effective coordination within the ‘*unorganized’* (RI11) water sector as this was identified by respondents from government institutions, NGOs and research institutions. Many respondents from the government institutions admit that they work in silos and do not share data, which is compounded by the lack of adequate human resources that constrains effective coordination and the maintenance of active networks, even though they get ‘*good responses’* (GA01) from other sectors and institutions. Frequent changes of personnel due to departmental transfers, particularly in the government institutions, hinder the development of long-term relationships.

Table 3-2. Main barriers to adaptation. 'N' indicates the number of respondents whose transcripts contain the respective code.

Barriers	Illustrative example quotes
Lack of knowledge capacity, financial and human resources, technology, and infrastructure N=12	*‘not possible with the limited infrastructure’* (GA12) *‘government agencies lack capacity’* (NG15) *‘detailed study is not there under the climate change scenario*’(RI07) *‘The biggest challenge with climate change as of now is uncertainty’* (RI11) *‘we do not have barefoot hydrologists’* (AI06)
Bureaucratic and systemic deficiencies N=11	*‘Government systems are mammoth systems and* [laughs]… *it takes time for things to be materialised by the government’* (GA01) *‘bureaucratic processes and excesses becomes a little difficult’* (NG21) *‘the government agencies…providing that link are quite weak …there is no flow of the information from the upstream to downstream’* (RI14) *‘the mission mode implementation requires a different arrangement…total freedom to work‘* (UM13)
Poor coordination and awareness N=8	*‘It is an institutional problem of how to bring multiple agencies together’* (NG15) *‘the problem is one institution does not speak to the other and therefore the integration is not there’* (RI11) *‘the systems of collaboration is still very weak’* (RI14)

	'Many organizations, ministries …states are involved in the water resources management… So to manage all the departments … is the main challenge' (UM18)
Inadequate policies and conflicts of interests N=7	*'India is actually highly under prepared… in terms of adaptation… to build climate resilient policies'* (NG15) *'totally unorganized*' (RI11) '*when it comes to policy making or implementation… there is a lack of clarity [between Centre and State]*' (UM13)
Inaccessibility to information and data N=6	*'…you can't find the temperature and rainfall data at the block level. There is no data available there. How we can make a plan?'* (NG14) *'Unfortunately the classified region covers nearly two-third of our water resources'* (RI17)
Lack of involvement of user communities N=5	*'There is no role of community, …users* [and]*… beneficiaries. How we can conserve …*[and] *manage water* [without their involvement]*?'* (NG09)
Other challenges due to growing demands N=4	*'the challenge is to first provide them with basic amenities then talk about conserving or adapting'* (NG09)

Many of the identified barriers are inter-related and multi-layered. The weak institutional structure means that adaptation plans and strategies framed at the Union fail to be adequately implemented. This is compounded by poor monitoring and ineffective follow-up of adopted strategies: '*the subsequent follow up was not up to the mark; up to the level that it should have been'* (RI17). An NGO representative described an example of the gap between stated protocols and implementation:

> *'… every agriculture department at the block level have to record the rainfall data. … But that is only provision. We need a mechanism for monitoring also whether those data are being recorded or not. If they are not recording what is the problem they are facing'* (NG14)

The lack of a strong cohesive network among the institutions involved in water management means that:

> *'Water sector … where almost eleven ministries are already looking into water from their own perspectives and they are all in their own eyes. So the problem is one institution does not speak to the other and therefore the integration is not there'* (RI11)

Similarly, another interviewee pointed out, from her experience of working with a few State Government departments, that the Climate Change Cells are not fully integrated with the other departments and end up being non-functional:

> *'When we talk about the climate change, a lot of the states in India have Climate Change Cells but what is happening right now is that the schemes get directly implemented through different departments. … The Climate Change Cell is just becoming standalone over there'* (NG21)

c) **Creating enabling mechanisms: aspirations and suggestions**

Table 3-3 presents key strategies or opportunities suggested to overcome the identified adaptation barriers. Single respondent views were regarded as equally valid as those suggested by multiple respondents. The suggestions of many of the respondents flow out from what they are already doing. For example, those who stress the need to involve local communities and improve networking and coordination among key stakeholders are those already involved in building networks for policy advocacy:

> *'There are other stakeholders, you may call it beneficiaries, they have to be roped into the plan and in water sector it is very important for the success and sustainability of an intervention. … Therefore like we do in our projects, the stakeholder participation has to be right from the planning stage wherein you not only listen and you not only look into the science and the impacts which is scientifically driven or scientifically understood and derived'* (RI11)

Table 3-3. Strategies for removing adaptation barriers suggested by interviewees.

Suggested strategies	Representative quotes
Behavioural, cultural or attitudinal change	• *'address water as a resource and community's role in water management at the forefront'* (NG09) • *'improve the understanding of the people who are supposed to manage water'* (NG09) • *'you have to work with the community'* (NG14)
Institutional and structural changes	• *'There has to be a basin level approach.'* (NG15) • *'integrated framework of water management' (*RI11) • *'Gradually it should be part of the process where their capacity building awareness program has to be regularly sunk into their activities.'*(RI11) • *'barefoot hydrologists … who can really work in the field ...*

	collecting data and information' (AI06) • *'each state* [should] *see what is the kind of scenarios in their own states and try and link with other agencies'* (RI11) • *'integrate our state priorities and programs in line with the scientific outputs'* (RI11) • *'guidelines definitely have to be there'* (RI11) • *'the drive has to be from the top'* (RI11)
Operational and technological change	• *'use of latest technologies and tools'* (GA01) • *'need for artificial recharge'* (GA24) • *'besides increasing … efficiency…. increase … water storing capacity'* (GA01) • *'Rainwater harvesting is definitely one important thing'* (NG21) • *'we also need a lot of innovative and new technologies or low-cost technologies for irrigation'* (NG21) • *'efficient tools and technologies [for] water conservation'* (RI11) • *'capacity building has to be more intensive and more frequent'* (RI17)
Development and dissemination of knowledge	• *'incorporate climate change aspects in probable maximum flood analysis'* (GA01) • *'Guidelines … for water use efficiency'* (UM20) • *'everything* [should be] *on the website'* (RI07) • *'capacity building has to be more intensive and more frequent'* (RI17)

The need for bottom-up engagement of water user communities as key stakeholders within adaptation planning is stressed by NGOs: *'what we say is basically the need for paradigm change. The way the water is handled today … is more institutional. There is no role of community, role of users/beneficiaries. How we can conserve water…'* (NG09). In contrast, research institutions tended to suggest restructuring of water governance institutions with an emphasis on the basin level approach or integrated catchment framework, while the Union Ministries emphasise top-down: '*when the programs are made at the Central level at the highest level we are using a top-down approach. So we should do the convergence also from the top-down'* (UM16).

Since *'climate change is bottom up as well top down*' (NG21), the need for more effective vertical coordination is stressed. All respondents acknowledged the need to strengthen inter-institutional networks to enhance adaptive capacity. Inter-institutional networks, such as the Indian Network on Climate Change Assessment (MEF, 2010; Sharma and Chauhan, 2011), are being promoted in India for knowledge sharing and collaborative research and advocacy. However, it is the NGO representatives who are more actively involved in network building initiatives, such as CAN-SA (Climate Action Network: South Asia) and VANI (Voluntary Action Network India).

Most respondents stressed the importance of the State Governments' role in climate change adaptation for water management and the need for state governments to play a greater role in order to change the habits and culture of water users to achieve efficient utilisation of water. Whilst the Union level institutions analyse the system from the national perspective, they expect the actual implementation to be carried out by the state governments. The main interaction is through the allocation of financial resources from Union Government to state government institutions so that the state governments can *'establish the demonstration programs of best practices so that people will be able to replicate those kinds of practices*' (UM2).

Government agencies desired the adoption of more efficient technologies for hydrological monitoring and water use and improved water infrastructure including through increased storage capacity. The need to develop guidelines and standards for improving water use efficiency and incorporating climate change factors into flood estimation was suggested by NGO representatives, government agency practitioners and research scientists. Dissemination of information, including free access to restricted hydrological data, was desired by NGOs and research institutions. The soft skills, such as the capacity to understand risks and take appropriate contextual measures, for enabling adaptation were also emphasised: *'But more than that ...* [storage structures]*… the software part is really important …we have to improve the… software part of the management'* (RI04). In a similar manner another respondent emphasized: *'at the moment software is more important than the hardware'* (RI11).

3.4 Discussion

Water institutions are generally analysed from two perspectives, from internal institutional design principles and/or the institutional environment such as the legal laws in which the institution operates (Ananda et al., 2006; Blomquist et al., 2004; Gandhi and Namboodiri, 2009). This research goes beyond both of these and includes an analysis of the inter-institutional inter-actions necessary to understand the barriers and the opportunities for creating enabling mechanisms (Biesbroek et al., 2013). Moreover, combining quantitative assessment of institutions' outward facing online presence with in-depth qualitative assessment of the views of key institutional respondents enabled the identification of key institutions and their involvement from both perspectives but also of practitioners' perspectives of practical barriers.

Thaker and Leiserowitz (2014) report a shift in the climate change discourse in India towards recognising the co-benefits of aligning its development and climate change objectives, but this research shows that alignment with adaptation is lacking. The outward focus of Indian institutions' online presence on mitigation rather than adaptation might be due to the more recent shift in global emphasis on adaptation (Handley et al., 2006; Klein et al., 2005), but it also reflects an Indian Union-level preference for top-down mitigation activities in contrast to adaptation as a bottom-up activity.

Climate change will be particularly experienced through a changed water cycle (Goodess, 2012; Kumar et al., 2011; Mathison et al., 2012), so an understanding of their inter-relationship would be expected in government documents. The inverse correlation between the online returns for "*water"* and "*climate change"* indicates a potential disjoint in the climate impacts and vulnerability discourse at the government level. Union Government institutions such as the Ministries of Drinking Water Supply and Sanitation, Power, Water Resources, and Urban Development portray greater interest in water than climate change. This suggests that the understanding of climate change impacts on water governance (Balasubramanian and Birundha, 2012; Charlton and Arnell, 2011; Eriksson et al., 2009; Thampi and Raneesh, 2012) is being largely ignored, leading to an apparent lack of high-level concern for adaptation (Mastrandrea et al., 2010; Moors et al., 2011).

It would be expected that the quantitative online and qualitative interview analyses produce harmonised and consistent outward and inward perspectives. However, the outward-facing representation of national-level institutional interactions contrasts with the perspectives of many institutional representatives. For example, the Planning Commission has a very strong online presence due to its influential role in financial resource allocation for infrastructure development in India, but officials from the various implementing institutions do not identify it as a key partner for activities related to adapting water management to climate change. In contrast, the Ministry of Water Resources has a very limited online presence that is suggestive of a weak leadership role within the climate change adaptation discourse. Although it coordinates advisory committees drawn from different Union and State Government institutions [Figure 3.1] supporting the National Water Mission under NAPCC, the scepticism of respondents regarding the ability of existing institutional mechanisms to deliver associated

adaptation polices and strategies is suggestive of a leadership gap between the aspirational ideals within the National Water Mission and the realities of climate change adaptation.

The interviewees in this research are key officials in the important water management-related institutions in India and their understanding of potential climate change impacts on water management resonates with government documents (MEF, 2010, 2009; MST, 2010; MWR, 2011) that indicates awareness and consistency. Beliefs and perceptions of risk are an important first step towards adaptation (Adger et al., 2009; Richards et al., 2013) as they have significant impact on decision makers (Halady and Rao, 2010), potentially influencing policies and actions for creating the physical and institutional environment for adaptation (Hinkel, 2007) and shaping how organizations adapt to climate change (Berkhout, 2012; Eisenack and Stecker, 2012). Respondents from institutions operating at the national Government level believe their role is to enhance the adaptive capacity of implementing agencies at the State or local level through formulating and evolving policies that facilitate the translation of capacity into action (Eisenack and Stecker, 2012), and creating networks of institutions to share knowledge and information. Consequently, respondents predominantly stated their adaptation intent or objectives, rather than actual adaptation actions, demonstrating that perception of risk at the national (Union) level does not necessarily lead to adaptation (Lesnikowski et al., 2013).

Although cases of purposeful adaptation reported by interviewees are few, a broad range of enabling activities is being initiated to overcome barriers and develop the cross-sectoral cooperation needed to facilitate adaptation (Hinkel 2007) including capacity building, making resources available and/or fostering a conducive environment for adaptation. Climate change is a complex, multifaceted and on-going process (Adger et al. 2005; Brown et al. 2013; Moser and Boykoff 2013) that requires actions by individuals, communities, governments and international institutions across multiple sectors (Berkhout 2012; Huntjens et al. 2012; Simonet 2010), which is being recognised by the respondents from key national level institutions.

There is clear recognition of the importance of raising awareness (Tang et al., 2009), building capacity (Engle, 2013; Keys et al., 2013), information and resources sharing through effective networks. The success, or otherwise, of these activities by Union

level institutions will become visible at the local level where enhanced adaptive capacity is needed to deliver actions that are local and contextual (Halder et al., 2012). Significantly, the lack of resources, although mentioned by many respondents, is neither the most important nor the most commonly cited barrier in this study. The core issue is the lack of institutional mechanisms for facilitating the translation of existing resources into adaptation. Many of the barriers identified here are not specific to climate change alone. Overcoming these barriers is, therefore, necessary to ensure that adaptation is not constrained by the uncertainty of the magnitude of future impacts (Adger et al., 2009) but also for effective governance of water and utilization of resources. Although barriers such as bureaucratic delays, inaccessibility of available data, unclear or overlapping responsibilities and lack of post-implementation monitoring are not unique to India (Ballard et al. 2013; Biesbroek et al. 2014; Gifford et al. 2011; Hamlet 2011; Sietz et al. 2011; Sciulli 2013), they arise in India as a consequence of unique cultural and behavioural attitudes and institutional bottlenecks in addition to resource limitations.

As a consequence, the barriers identified are largely manmade and malleable (Moser and Ekstrom 2010) and hence can be overcome with sufficient political will through continual improved institutional design (Huntjens et al., 2012) that incorporates effective planning, implementation and monitoring, polycentric governance that enables active and equitable involvement of stakeholders and proper allocation and utilisation of resources. Since overcoming barriers requires time (Eisenack et al., 2014) and is difficult to confirm its success (Berrang-Ford et al., 2011), it requires continuous evaluation and iteration. Although many respondents, particularly NGOs, insist that local communities and users should be included as important stakeholders from the inception of adaptation planning, they also recognize the crucial role of government institutions through the dominant top-down process in the Indian water sector (Berkhout 2012; Butler et al. 2015). The government institutions, therefore, require visionary leadership (Wilby and Vaughan, 2011) to champion the implementation of adaptation strategies, as the aspirational goals of the National Water Mission will not be delivered unless the vertical and horizontal inter-institutional networks are strengthened to operationalize the intended adaptation.

Creating the enabling environment needed to deliver climate change adaptation in the water sector in India will require behavioural and attitudinal change, in addition to

institutional and structural changes and the availability of information, guidelines and resources. Achieving these changes should enable adaptation to be recognised as an opportunity for creative solutions to support continued sustainable development of India and not as an alternative to mitigation (Mastrandrea et al., 2010; Simonet and Fatorić, 2015).

3.5 Conclusion

This Chapter has widened the understanding of the complex, multi-layered inter-relationships between institutions involved in climate change adaptation in India through combining quantitative online data-mining analysis and in-depth interviews with key representatives from national level government and non-government (research and academic institutions and NGOs) institutions. The limited emphasis of Indian Union-level Government institutions' online presence given to adaptation reflects their preference for top-down mitigation activities in contradiction with the National Water Mission. However, the online analysis also identifies a disjoint in the climate change and water discourse at the government level as a consequence of the complex vertical institutional framework and the Union-State tension over water. Union Government institutions believe their role is to enhance the adaptive capacity of implementing institutions at the State or local level through formulating policies that facilitate the translation of capacity into action and creating networks to share knowledge and information. However, barriers such as bureaucratic delays, data inaccessibility, unclear responsibilities and lack of post-implementation monitoring arise in India as a consequence of unique cultural and behavioural attitudes and institutional bottlenecks in addition to resource limitations.

The awareness and acknowledgement of interviewees of likely climate change impacts on water management and their desire to engage constructively to improve coordination represent valuable opportunities for creating the enabling mechanisms for adaptation and for improving water management in India. Improved vertical and horizontal understanding of inter-institutional networks will support the vital role of networks for creating the necessary enabling conditions for adaptation and also for effective governance of water and utilization of resources.

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4 CONTEXTUAL CAUSES OF ADAPTATION BARRIERS: INSIGHTS FROM WATER INSTITUTIONS IN HIMACHAL PRADESH, INDIA

Abstract:

Research on adaptation barriers is increasing as the need for climate change adaptation becomes evident. However, empirical studies regarding the emergence, causes and sustenance of adaptation barriers remain limited. This research identifies key contextual causes of adaptation barriers in water institutions in the mountainous Himalayan state of Himachal Pradesh in northern India.

Semi-structured interviews were carried out with representatives from twenty-six key governmental, non-governmental, academic and research institutions in the State with responsibilities spanning domestic water supply, irrigation and hydropower generation, environmental monitoring and research. It identified low knowledge capacity and resources, policy implementation gaps, normative attitudes, and unavailability and inaccessibility of data and information compounded with weak inter-institutional networks as key adaptation barriers. Although these barriers are similar to those reported elsewhere, they have important locally-contextual root causes. For instance, inadequate resources result from fragmented resources allocation due to competing developmental priorities and the desire of the political leadership to please diverse electors rather than climate scepticism.

The identified individual barriers are found to be highly inter-dependent and closely intertwined which enables the identification of leverage points for interventions to maximise barriers removal. For instance, breaking down key barriers hindering accessibility to data and information, shaped by systemic bureaucracies and cultural attitudes, will involve attitudinal change through sensitisation to the importance of accurate and accessible data and information and building trust between different actors, in addition to institutional structural changes through legislation and inter-institutional agreements. Approaching barriers as a system of contextually interconnected cultural, systemic, geographical and political underlying factors enriches the understanding of adaptation enablers, thereby contributing to achieving a better adapted society.

Keywords: adaptation; barriers; climate change; institutions; India; water

4.1 Introduction

Climate change is expected to be experienced most through water (IPCC, 2012; Jiménez Cisneros et al., 2014). Water institutions at all levels will need to adapt to climate change (IPCC, 2014), and hence, many national and regional governments are now developing adaptation policies and plans (Krysanova et al. 2010; Mertz et al. 2009; Pittock 2011; Preston et al. 2010). However, many factors can stop, delay or divert even well planned adaptation strategies (Preston et al. 2010; Moser and Ekstrom 2010) if they are not adequately identified and addressed (Eisenack et al., 2014).

Barriers to adaptation have been defined from different aspects, with terms such as limits (Dow et al., 2013), challenges (Fünfgeld, 2010), obstacles (Bedsworth and Hanak, 2010), and constraints (Klein et al., 2014), often being used synonymously. However, building on the definition of Moser and Ekstrom (2010; p.2207) that barriers are "obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc.", there is an emerging consensus that 'barriers' relate to the challenges posed by sociological and institutional factors (Barnett et al., 2015; Biesbroek et al., 2014a; Eisenack et al., 2014).

Moser and Ekstrom (2010) proposed that resolving barriers, rather than skipping phases of the decision process, will ultimately prove beneficial for the decision outcome. This requires exposing and questioning the factors that stop, divert or delay institutions from effectively adapting (Berkhout, 2012), preventing them from becoming limits to adaptation (Barnett et al., 2015). A growing literature has identified generic barriers (Biesbroek et al., 2011; Eisenack et al., 2014; Ekstrom and Moser, 2014; Jones and Boyd, 2011; Islam et al., 2014; Mandryk et al., 2015; Runhaar et al., 2012) such as a lack of financial resources, inherent uncertainty of climate change, and lack of political will, for example. However, although some of these generic barriers have been identified, the circumstances in which these barriers arise and persist are poorly understood (Biesbroek et al., 2014b) and requires explaining (Eisenack et al., 2014). This study aims to fill this knowledge gap by identifying and expounding the underlying contextual causes of adaptation barriers within regional and local water institutions in a developing economy (India).

4.1.1 Context: Water institutions in Himachal Pradesh, India

The north-western Himalayan state of Himachal Pradesh has high sensitivity to climate change (Brenkert and Malone 2005; Mall et al. 2006), due to the importance of irrigation and hydropower from glacier-fed rivers (Jaswal et al., 2015; Rana et al., 2014). The State established the State Centre on Climate Change (henceforth, the State Centre) and formulated the State Strategy and Action Plan on Climate Change (henceforth, the State Action Plan) (DEST-HP, 2012) to address the challenges [Figure 4.1]. The Action Plan is designed to align with the eight National Missions [Figure 4.1] which the Government of India initiated under the National Action Plan on Climate Change (NAPCC) (PMCCC, 2008). Nodal Officers are appointed in each of the nine State Government Departments to co-ordinate the delivery of the Action Plan with the State Centre and information dissemination. A schematic diagram of the top-down institutional and policy hierarchy for implementation of the NAPCC in India is shown in Figure 4.1.

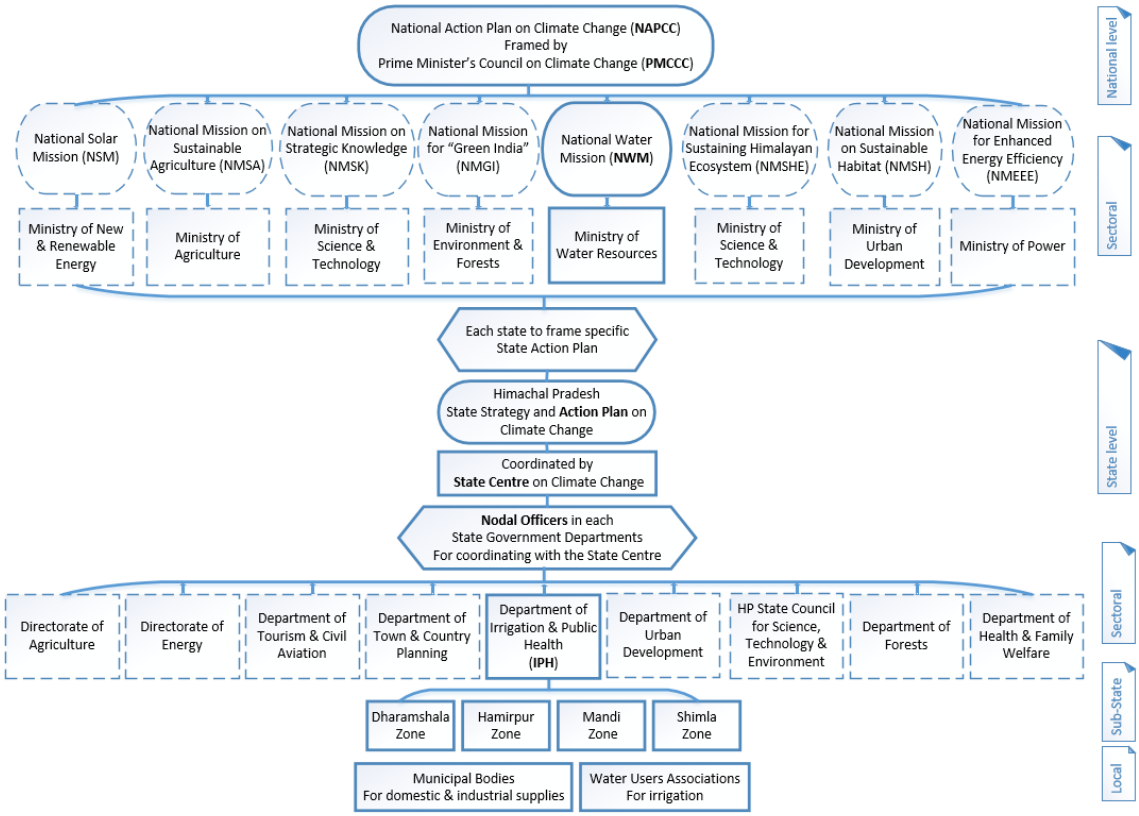

Figure 4.1: Schematic diagram of the top-down institutional and policy hierarchy for climate change adaptation. Institutions more relevant for water are emphasised with full boxes.

4.2 Methods

A semi-structured interview template [highlights of questions in Box 4.1 and detailed questions in [Appendix H] was framed to empirically assess the contextual barriers for institutions to adapt water management. It was based on a literature review, a previous study conducted with the institutions operating at the national level [Chapter 3] and refined through a pilot interview. Interviewees within twenty-six key institutions in Himachal Pradesh (henceforth, the State) [Figure 4.2] were identified based on their work portfolio or by recommendation of other respondents.

Interviewees were all mid-level officials or above, and represented nine State Government (SG) departments [shown in Figure 4.1], Regional Offices of two Central Government agencies located in the State (CG), three research and academic institutions (RA), six non-governmental and consulting organisations (NG) and the four zones [Figure 4.1] within the State Irrigation and Public Health Department (IPH). All Nodal Officers (for the State Action Plan) were interviewed, except in the Department of Health and Family Welfare. More detailed assessment was targeted on IPH as the primary institution for water management in the State. Respondents were coded by these acronyms along with a numerical figure to anonymise yet retain traceability.

Interviews were conducted in January and February 2015, lasting for an average of approximately forty minutes (range - five to eighty minutes). They were conducted in English, except in two where there was a mixture of Hindi and English and audio recorded, besides three where permission was not granted.

Figure 4.2: The study location: Himachal Pradesh

Box 4.1: Highlights of interview Questions

a) Views on climate change and likely impacts for Himachal
b) Adaptation strategies adopted or initiated
c) Involvement in the State Strategy and Action Plan on climate change
d) Guidelines and instructions received regarding climate change adaptation
e) Key partner institutions and reasons and challenges

f) Perceived role of institutions operating at different scales: Union, State and local
g) Suggestions for adaptation enablers including for improved coordination and overcoming barriers and opportunities

The interview discourses were transcribed verbatim, except the Hindi words which were translated into English while transcribing. Employing rigorous method of content analysis, which consists of classifying, organising and examining the data, inferences about the patterns were drawn and analysed (Graneheim and Lundman, 2004; Strijbos et al., 2006). They were analysed with the aim of understanding: a) perceptions of climate change impacts on water, b) actions being initiated, and c) barriers and challenges of adaptation. The qualitative analysis software *NVivo 10* (Richards, 1999) was used to arrange the data systematically. As is conventional within grounded theory literature (Mills et al., 2006; Saldana, 2009; Tang et al., 2013), categories and sub-categories are marked out during coding, and new categories created which are regrouped or renamed iteratively (Saldana, 2009) so that the coding structure evolves. Hence, it was both reflexive and iterative.

4.3 Findings and analysis

The findings are presented by first connecting the climate change risk perceptions of the respondents and existing adaptation actions to the State Strategy and Action Plan. Then the most commonly cited barriers are analysed to understand their underlying causes. Further, the relationships between the different barriers are analysed to identify opportunities for leveraging adaptation. Direct quotations are provided to illustrate the findings and are intentionally extracted from diverse respondents to bring out the richness and the prevalence of such barriers across different institutions.

4.3.1 Risk perceptions and current adaptation initiatives

There is a consensus among the respondents that a changing climate is manifest in the depletion of water sources in the State and late arrival of winter snow, for example *"Climate change indicators are very clear over here"* (RA05), although additional factors contributing to the depletion of water sources, including land use change, deforestation, mining, and increased water use were also identified.

Interviewees identified numerous water management adaptation activities being undertaken by their department. These included climate change impact research, provision of farmer advice, the creation of a Hydrology Division within IPH to collect hydrological data, long term trend analysis and preferring larger and perennial sources for new domestic water supply projects - *"…the new policy is that instead of having the present small source, we are looking for … bigger sources where we have a good level of confidence that the sources are going to survive for twenty or thirty years"* (IP06). However, many of these activities are not specifically named climate change adaptation, so that *"so far as climate change is concerned, the department is not doing anything"* (IP03) – although "*now this sustainability word is gaining importance over here that whatever we plan should be a sustainable one"* (IP07).

Initiatives such as the compulsory installation of rainwater harvesting structures in every new (Government) building and rejuvenation of catchments through watershed management are being introduced in the State Action Plan. However, some respondents are sceptical: *"hardly ten percent of the government buildings will have such structures"* (NG25). When asked how they are going to implement the Action Plan, a respondent stated that "*the Strategic document … is not a legislation … just a recommendation. It is voluntary upon all institutions whether they adopt it or not. … we don't have any implementing authority"* (RA24). Similarly, another respondent dismissed it, saying, it is "*more of a wish list of this should be done, that should be done with very little practical aspects"* (SG11) and lacked actions and responsibilities for implementation. Respondents also often used "should" rather than "is" when asked about the activities of their institutions to address climate change impacts; implying that many of the aspirations are yet to turn into adaptation actions.

4.3.2 Key generic barriers informed by the respondents

The barriers most commonly mentioned by the respondents [Table 4-1] include limited knowledge, policy implementation gaps, weak inter-institutional networks, unavailability of data and information, limited financial and human resources, normative attitudes, and geographical constraints. The most commonly cited barrier may not be the most important barrier (within or between institutions) but merely the most easily identifiable.

Table 4-1. Barriers commonly cited by interview respondents. 'N' indicates the number of respondents whose transcripts contain the respective code.

Codes	Illustrative example quotes
Knowledge capacity N=13	*"Technically, we do not have experts because climate change needs experts."* (IP08) *"Climatic change will be beyond the comprehension of many of us."* (IP03) *"We are not competent or knowledgeable."* (SG14)
Implementation N=13	*"I can come out with very good plans and very good documents but somebody else has to implement. Himachal at the moment is not equipped with that level of competence."* (SG09) *"See there is no connect between the documentation bit and the ground level bit."* (NG18) *"The research is being done … but who is the implementing authority? Who is the user of those technologies?"* (RA24)
Weak inter-institutional networks N=12	*"There is no linkage between various departments. What Forest Department is doing, Water Resources Department does not know and vice-versa."* (RA22) *"There is no coordination between the line departments. Absolutely no coordination. May be for celebration sake they will come together."* (NG26)
Systemic and governance N=9	*"All the departments have appointed the nodal officers but later on if we ask them he is either transferred or not there."* (SG09) *"In the system you have so many bottlenecks. That, at the end of the day you'll say, just forget it."* (NG18) *"As far as climate change is concerned, governance … is one of the big challenges which has not been addressed, particularly in Himalayan region."* (RA22)
Data availability and accessibility N=6	*"We don't have a very robust data. We are still groping in the dark."* (SG11) *"We don't have proper data base then all these things are hypothetical."* (IP01)
Resources limitation N=6	*"The State Centre on Climate Change for the want of funds couldn't do good projects."* (RA24) *"Give me other supporting staffs. How can I be the only to collect data from field, monitor and analyse?"* (NG25)
normative attitude N=6	*"…because the concerned person is not concerned. The person attends the meetings and conferences but he goes up to only that level."* (NG18) *"It is a behavioural attitude. The departments which are supposed to collect basic data are not able to do it."* (NG25) *"Lack of professionalism and of accountability."* (NG25)

Geophysical or local N=6	*"Whatever happens to the national policy is just copy and pasted to the state policy. The State specificity do not really come up and that is an issue."* (NG19) *"We will have to devise numerous models in order to implement those strategies."*(SG09)

The lack of knowledge capacity to plan suitable adaptation strategies is compounded by the inherent uncertainties in the likely impacts of climate change and the long time scale involved:

> *"Adaptation... very easily we use this word. But how do we adapt? Solutions for adaptations are still awaited from scientists or planners. So we need to work on adaptive research. How to adapt to a particular problem? In that too, because this problem is not scale neutral, solutions are local level. And adaptation methods are also different at landscapes, crop, peoples, societies and communities. So one solution cannot be remedy for all. There is a lack of real adaptation methodologies through which people should adapt." (*RA24)

Inadequate implementation of the existing (general) policies is closely intertwined with the lack of knowledge capacity alongside normative behaviours discussed later. Weak inter-institutional networks between stakeholder institutions were acknowledged by respondents from non-governmental, governmental, and research institutions. This is despite the State Centre being created to act as the nodal institution for coordinating climate change related activities. The weak inter-institutional networks are compounded by systemic and institutional structures, alongside normative behaviours and working culture, including the routine transfer of government officials and the bureaucratic processes of routing every communication through the Heads of the Department.

Accessibility to existing data collected by Central Government institutions and the lack of data from remote locations was a key barrier stressed by both State Government institutions and non-governmental and research institutions. Respondents linked these barriers to the long bureaucratic protocols and attitudes of officials holding such data, which are discussed later, the difficulties posed by the State's geography and the lack of technological infrastructure.

4.3.3 Identified causes of barriers

Analysis of the underlying causes of the above barriers are summarised below. Although the causes of these barriers are cross-cutting and inter-dependent, they have been categorised into the following subsections to simplify the analysis and presentation of the findings.

4.3.3.1 Socio-cultural attitude, complacency, and organisational normative behaviours

Awareness that climate is changing is insufficient to change people's attitude and normative behaviours, as complacency exists among the general public *"… here we still think that water is in abundance. ... Until and unless we realize that this is also limited … we won't be able to cope up…"* (IP06), which is the reason "*it is very difficult to sell adaptation … and* [difficult to convince] *why it is important for them"* (NG19). As a consequence *"when you talk about adaptation not many people are working towards adaptation and they don't have a clue"* (NG18). State water institutions are more concerned with meeting the current daily demands than investing time, effort and resources in assessing and planning responses to future long term impacts: *"But to understand the problems which are of long term nature and have some time and money to redefine their priorities in terms of the future events of the climate change, that is still lacking"* (RA24). This short-termism is compounded by an attitude that climate change adaptation is the work of specialists or 'experts', providing a rationale for a lack of proactive actions or sense of responsibility to act on it: *"Climate change is something not all people can understand easily. Only educated people have little knowledge about climate change. It is an elite class question not a grassroots"* (SG15).

Likewise, some officials absolve themselves of responsibilities by implying that the Department of Environment, Science and Technology (DEST) ought to carry out all activities related to climate change: "*The department which is supposed to think is doing something… Nothing can be done. We can't do anything. We only build buildings"* (SG16). This lack of interest was corroborated by a respondent from DEST: *"this overall subject* [climate change and environmental conservation in general] *is perceived usually as antidevelopment… So at the outset they are indifferent. Gradually we are reaching and telling them it is the responsibility of all of us".* Hence, a non-governmental organisation respondent blames the apathy of government institutions: "*They are very aware broadly but they don't have the implementation attitude"* (NG26).

Another respondent pointed out the disconnection between awareness, policy making and implementation: "*Government awareness is there. …. Lots of government energy, money and time is spent on talking about the climate change. But how far this has transformed into action is a different thing"* (IP06). A respondent sums this up:

> *"It is a behavioural attitude. The departments which are supposed to collect basic data are not able to do it. Therefore all these plans and strategies are pretty much hypothetical. Lack of commitment, lack of manpower and lack of willingness to shift to better technological solutions"* (NG25).

This respondent goes on to add that the Government institutions *"Lack professionalism and accountability. Communicating with these departments is terrible"* (NG25). The barriers related to data accessibility, weak inter-institutional networks and lack of motivation discussed in the subsequent sections also arise out of normative behaviours and socio-cultural attitudes. As one interviewee put it: *"…nobody wants to share the data … everybody who has the data he is the boss"* (IP06).

4.3.3.2 Leadership and motivation

The Himachal Pradesh State Government leadership initially showed greater interest in climate change issues compared to many other Indian State governments that led to the formulation of State Action Plan in 2012, in advance of many other States. However, leadership at the implementation level is not apparent due to insufficient allocation of resources, State administrative and governance structures and a lack of motivation for implementation. For example, the Nodal Officers in each State Government department, who are expected to lead the climate actions in their respective departments, are neither empowered nor provided with adequate resources to implement adaptation measures. Moreover, since many are hierarchically subordinate in their department's administrative structure, they are unable to make departmental commitments to any decisions made at the State level meetings convened by the State Centre for Climate Change actions at which they represent their department.

Many State Government officials, including some Nodal Officers, assume that actions related to climate change are the responsibility of Department of Environment, Science and Technology (DEST): "*Only the DEST can do about this. … We attend meetings whenever DEST calls for meeting"* (SG14). This assumption leads to inadequate

participation that rarely go beyond attending, or sending a representative to seminars and workshops convened by DEST. This was evident from their limited involvement in the formulation of the Action Plan document itself:

> *"It was started by DEST and then we had one meeting. They have given us a few questionnaires and what is to be done and how it is to be done and the kind of information to gather and generate. …. We have one meeting and then the second meeting unfortunately I was not there. We had only two meetings"* (SG23).

Interviewees felt that the Action Plan is yet to empower action. The Action Plan incorporated a list of potential adaptation strategies identified and proposed by IPH but does not define responsibilities for planning and implementation (leading to a lack of ownership and leadership) nor allocated specific resources, so that it is "*more of a wish list"* (SG11) and the proposed actions remain unfulfilled: *"But they are not on to the ground right now. They are just in the papers"* (IP08). The IPH believes they have fulfilled their responsibility by submitting the potential adaptation strategies, whereas the State Centre assumes that the onus for implementation lies with the relevant departments; in this instance IPH.

The lack of ownership and leadership leads to an institutional system that de-incentivises proactive learning and acquisition of knowledge in general and climate change related knowledge in particular:

> *"As of today there are no such budgets* [for research] *in my department …. Neither there is any assurance nor there any encouragement. So whosoever is doing at his level there is no contribution from the government side."* (IP02).

4.3.3.3 Governance, bureaucratic and institutional structure and management processes

Barriers related to effective coordination and accessibility to information and data are closely intertwined with the bureaucratic and institutional structure and management processes. For example, a respondent pointed to the governance in the State in general as a practical challenge to implement adaptation actions:

> *"As far as climate change is concerned, governance of climate change is one of the big challenges which has not been addressed particularly in Himalayan*

region. Governance means initiatives of the government, rules and regulation. Governance indicators are one is accountability, transparency, effectiveness, responsibility, corruption. These are the issues which have to be addressed" (RA22).

On the other hand, a Nodal Officer attributed the challenges of effective communication with other institutions to the bureaucratic process of routing every communication through the Head of Department:

"*The most and the biggest challenge is the communication gap. Because the communication challenge is so big that day to day coordination becomes just impossible. … I have to go first from bottom to top in my organization and then from top to bottom in their organization"* (IP08).

Likewise, another respondent suggested that the silo attitude which hinders effective coordination (4.3.3.6) is due to governance structure: *"[The] Co-ordination problem is always there because of the way current governance structures are. There is a compartmentalised way of thinking and that comes from governance structures"* (NG19). Due to the perceived weaknesses in the governance and institutional structure a respondent proposed to address the challenge of fragmentation and overlapping responsibilities by integrating various departments:

"…integrated watershed programme has to be started with the coordination of various departments headed by a single agency. For example, mid-Himalayan watershed programme …they are doing their work but … independent[ly]... DRDA [District Rural Development Agency] *in isolation, Forest department is doing it in isolation, Water resource department in isolation. Why not integrate all these departments?"* (RA22)

The inaccessibility of available data is also largely attributed to bureaucratic and institutional protocols that lead to an apparent disconnect between the Central Government institutions located in the State and the State Government departments:

"*Central Government … organizations like the Central Water Commission, IMD* [India Meteorology Department]*, etc. will not give the data easily. … They should start sharing the data with the state because we are in the same geographical*

area. ... The data sharing policy has been changed recently. But actually it should be freely available until and unless you have some defence interest" (IP06).

However, a respondent from one of these Central Government institutions replied:

"*Whenever they ask data we are providing them. Some format and procedure is there of how to get these data. We are just seeing the justification. Anybody can ask* [for] *the data but based on the requirement and the study for which they want to get the data and we provide the data on nominal charges*" (CG12).

Some respondents believe that part of the reason for this apparent mismatch of perspectives is either that they are not confident of their own data or indifferent towards the needs of other institutions: "*One is that everybody thinks that who has the data is the boss.*" (IP06). This respondent described the problem with an example:

"*I may not be very confident about the quality of my data whether it is correct or not. If I validate my data with some other organisation or some other data I may find my data to be totally wrong. That is another reason I don't want it to share. Whatever I have is ok. It is a common phenomenon everywhere. So this definitely is a challenge"* (IP06).

The same respondent also explained that even formal arrangements like having memorandum of understanding does not ease the difficulty adequately:

"… in our organization also we had memorandum of understanding, with various other organizations for sharing of the data. But despite of this actual transfer of data is not smooth. You have to make real efforts to get these kinds of information." (IP06).

As described in Section 4.3.3.2, the Nodal Officers do not have the administrative power to make departmental commitments or decisions so that, in most cases, they passively represent their respective departments: *"They sent their representatives. They said they will consult with the higher authorities and then let you know* [their] *views, their stand or comments on these"* (SG09)

The vaguely defined role of Nodal Officers, the regular transfer of personnel without an effective system of transition and the failure to manage staff succession hinders project continuity, loses the opportunity for organisational learning and maturity and creates a

communication gap. For example, an interviewee described the challenges of acquiring information or feedback regarding adaptation strategy formulation and implementation:

> "*Actually people get transferred.* [When] *Nodal Officers change … we have to explain everything to the new person again. It depends upon whether he is taking interest in it or not. In government departments transfer is* [a] *major difficulty. We have asked the departments to appoint their nodal officers but many of them are retired or changed or transferred."* (SG09).

4.3.3.4 Electoral politics, allocation of resources and competing priorities

The governance challenges of climate change adaptation in the State also relate to electoral politics. A respondent stated: "*the problem remains with the politicians"* (IP03) and *"excessive democracy"* hinders effective planning: "*Because it is a democratic country … every MLA* [Member of (State) Legislative Assembly]*, every Pradhan* [village chief] *wants the work to be done in their constituency"* (IP03) and *"In a democracy you have to please the voters."* (SG09). Therefore, the competing priorities and electoral politics lead to a fragmented approach whereby the limited resources are distributed widely to various areas and sectors which leads to inadequacy of resources (Section 4.3.3.6); *"there is no dearth of money but the problem is it is so thinly spread that everyone is saying "ok sir we don't have money".* [The] *question is not the lack of money.* [A] *lot of money is available. But it is just spreading has to be avoided."* (IP03). When asked about the political challenges of implementing the State Action Plan, a respondent replied that *"The first challenge is, as I said, economic development of the state."* (SG09).

4.3.3.5 Public engagement and a trust deficit

A weak relationship between the government departments and non-governmental organisations (NGO) is apparent, with many of the respondents from government institutions not trusting the motives of the NGOs:

> *"The problem with NGOs is about 75 to 80% of the NGOs are just interested in money. Only a very few NGOs really work"* (IP03) and *"The current pattern is that there are some three-four NGOs who are there in almost every forum. In every meeting you will find them, very good orators and they are acting in a way as though representing the whole community – lakhs* [hundred thousand] *of people which is not true."* (IP06).

On the other hand, many NGOs believe that the government agencies are not sincerely implementing the adaptation policies and schemes and raise doubts regarding the government data on which policies are based: *"The departments which are supposed to collect basic data are not able to do it. Therefore, all these plans and strategies are pretty much hypothetical"* (NG25). Another NGO respondent stated that government institutions usually only seek inputs from NGOs and other stakeholders to fulfil the criteria of engaging all stakeholders:

> *"For the sake of participation they put it on the website 'Those who would like to contribute can contribute in the next fifteen days or so'. There was hardly any consultation. They took one or two NGOs and specialists from this organization and that organization and they prepared that. So naturally there was not much of input at that time. When it was released a lot of people got interested into that and they saw that a lot of things were missing in that"* (NG26).

As a consequence, there is often a mismatch between the public's wishes and the government's provision:

> *"So there is a gap in between. I mean to say the government is not interested to involve all stakeholders. If they involve stakeholders … they will ask questions and they don't want to involve them… They want to give only that awareness which will serve their purpose. … That is the mismatch between the government and the people. The government is not aware about the issues of the people."* (NG27)

4.3.3.6 Power struggles between different sectors and institutions and a fragmented approach

Interviewees reported power struggles between different departments within the State Government leading to a fragmented approach in which the same or similar projects are being implemented by different departments:

> *"Here every department does everything. What happens is we are from IPH. We are doing rainwater harvesting structures, Agriculture Department is also doing it, even the Soil Conservation Department is doing it. The Block Development Department is doing it. … so many agencies are involved. … in typical government departments, no one wants to see that as a specialisation. Because no one wants leave the power."* (IP03)

This fragmented approach to implementation, intensified by electoral politics, as discussed in section 4.3.3.4, leads to an inefficient funding allocation reducing the effectiveness and efficiency of implementation due to the overlap of activities:

> *"because I wanted to please everyone, it is a political system, so I will give thirty rupees to you and thirty rupees to you and thirty rupees to him. So none of the projects, … cost*[ing] *hundred rupees … will be able to complete."* [IP03]

Additionally, it creates conflicts:

> *"This is my area. The Forest will say you can't work in my area. The Block will say no. Even I will say Water Supply scheme is my area, so I won't allow you. … what I want, the Block Development will do something else. I want [a] water supply scheme. But Block Development will simply take away the water from the upstream for the irrigation purpose.* (IP03)

As a consequence, some respondents suggested making water a Central Government subject, indicating dissatisfaction with the current water governance in the State, although this is often prompted by inter-State water disputes. To avoid these tensions between different sectors and institutions, respondents suggested *"there should be a nodal department"* (IP01) to allocate both natural and financial resources or "*… a centralised agency at the district level or may be even at the sub-division level. It should approve that."* (IP03).

4.3.3.7 Implementation and follow up mechanisms

Formulation and implementation of new Government strategies or policies are very different challenges. The State Action Plan is weakened by the lack of mechanisms for implementation and monitoring, in addition to barriers discussed previously. When asked how the Action Plan is being implemented, respondents pointed out that *"we don't have any implementing authority"* (RA24), dismissed it as a "*wish list"* (SG11) and stated *"The research is being done … but who is the implementing authority? Who is the user of those technologies?"* (RA24), indicating the absence of an institutional mechanism to implement and monitor the proposed Action Plan as a key reason for non-implementation.

Some respondents linked this to the political leadership not being serious enough to put their own policies into actions leading to a disconnection between policy and

implementation *"See there is no connect between the documentation bit and the ground level bit. There is no connection"* (NG18). On the other hand, some respondents even used strong words such as "*corruption"* (RA22)*, "incompetence, lack of professionalism and dedication"* (NG25)*,* on the part of implementing (government) institutions, to describe the root causes of barriers for effective adaptation. For example, this respondent alleged the inconsistency between the actual implementation and the documented records: *"we found that so many check dams were put in files only"* (RA22).

4.3.3.8 Interconnectedness of the barriers

Many of the different barriers [Section 4.3.2] and underlying causes [Section 4.3.3] are clearly interconnected. Figure 4.3 identifies these interconnections and inter-dependencies using the empirical evidence from the interviews summarised in Table 4-2. Commonly mentioned barriers including inadequate knowledge, ineffective implementation of policies and weak inter-institutional network, are clearly shown to be interdependent. For example, the lack of knowledge capacity leads to inadequate identification of potential risks, which not only leads to indifference to the issues but also limitations in planning and design of adequate strategies, policies, and guidelines and inadequate resource allocation for addressing those risks. Table 4-2 also summarises interviewees' suggestions for key enablers to reduce or overcome these barriers.

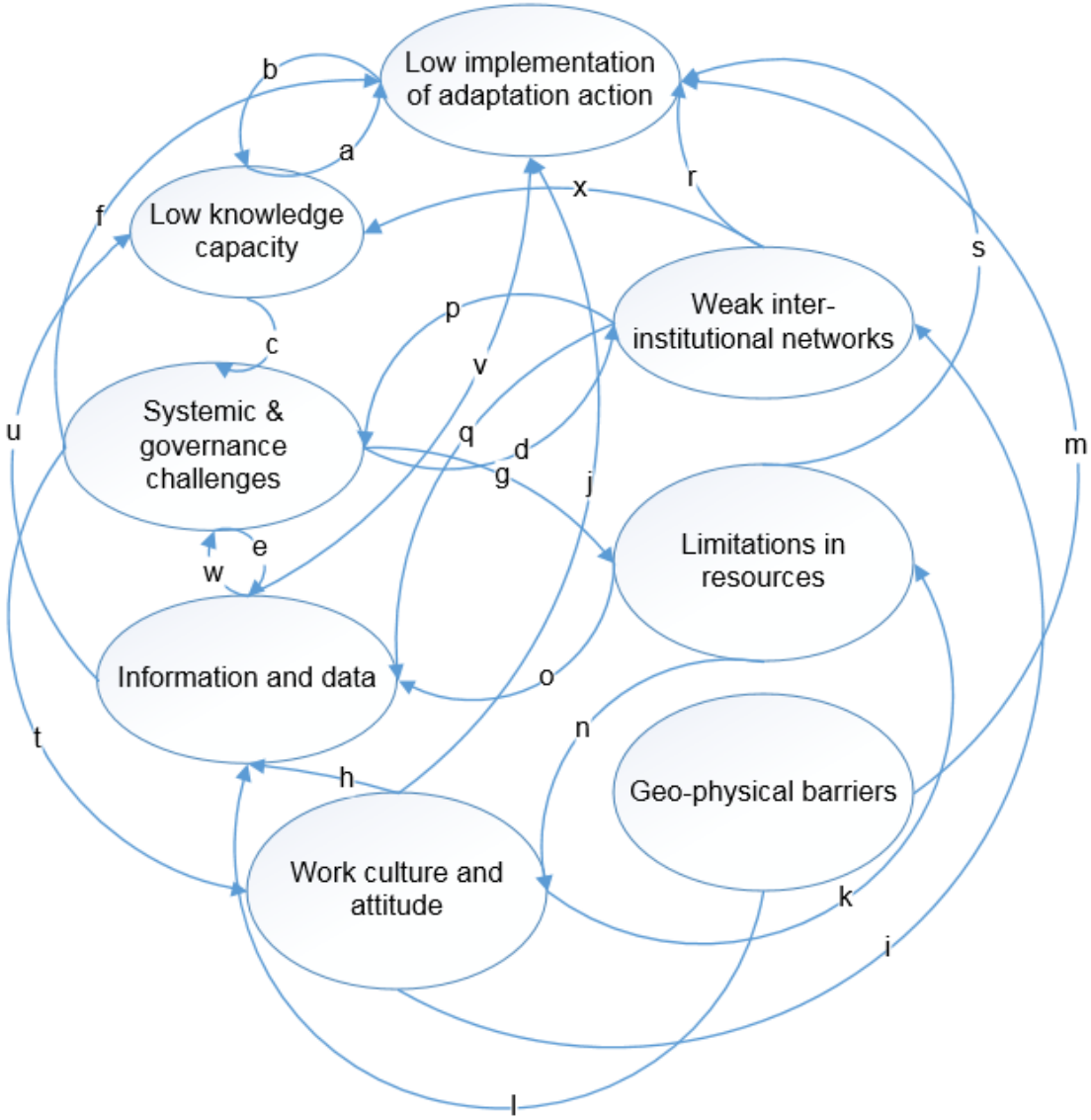

Figure 4.3: Conceptualisation of barrier inter-dependencies for climate change adaptation within water management institutions in Himachal Pradesh, India. The causes of interrelationships between the barriers are indicated with letters: a, b, c,… and empirical evidence of these is presented in Table 4-2.

1 **Table 4-2 Causes and relations of barriers and suggestions from respondents for overcoming**

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
a	Low knowledge capacity leads to low implementation	*"The major hurdle is that the impacts is of such a general nature that we cannot take specific action"* (IP08)	Inability to contextualise the challenges and frame specific actions	*"We need to know the magnitude of the problem … reliable … data and … modelling* [that] *can tell us precisely what is going to happen and then some practical easy, quick solutions. Doesn't need to be highly technical"* (SG11)
b	Low implementation of adaptation actions leads to low knowledge capacity	"*We always talk adapt, adapt, adapt but what to adapt? Who has done it?"* (RA24) *"We will only know these challenges when we are in field"* (SG13)	Adaptation being an iterative process, non-implementation of adaptation strategies leads to loss of learning opportunities.	*"Basically first is capacity building is must. It has to be an ongoing … process."* (SG11)
c	Low knowledge capacity leads to systemic and	*"As far as climate change is concerned, governance … is one of the big challenges which has not*	Inability to design institutional structures and mechanisms due	*"We need to scale it down … to make* [local government institutions] *understand … long term impacts"* (RA24)

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
	governance failures	*been addressed...."* (RI22)	to inadequate knowledge	
d	Systemic and governance deficiencies leads to weak inter-institutional networks between different institutions and sectors	*"What Forest Department is doing, Water Resources Department does not know and vice-versa. …policy … should be holistic ..."* (RA22)	The current institutional structure is not able to adequately deliver effective coordination between different institutions	*"We must have a central agency even at district level"* (IP03) *"should set up a nodal agency which can coordinate with different organisations"* (IP02)
e	Systemic and governance deficiencies leads to unavailability of information and data	*"Research work is not a priority. We do not want to invest in these things because the results are not discernible"* (IP08)	More focus on the immediate developmental needs than investing for long term needs	*"Research wings should be opened in each and every organizations, and people who are interested in research and development activities should be encouraged"* (IP02)
f.	Systemic and governance challenges leads to low	*"… we plan nicely on paper, but as far as implementation is concerned we lack"* (IP02)	Inadequate monitoring and follow-up mechanisms	*"We must establish such mechanisms that can deliver whatever we plan"* (IP02)

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
	implementation of adaptation actions			
g	Systemic and governance challenges leads to resources limitations	*"The defect* [is] *in planning* [fragmentation of financial resources] *not only implementation. … So none of the project is complete"* (IP03) *"So it's a repetition of what A has done B is also doing the same thing"* (NG18)	Inadequacies in resources allocation	*"At every district level you should have an agency … whatever proposals are there for water harvesting* [for example]*… that agency should approve that"* (IP03) *"the multiplicity of these departments should be avoided"* (IP03)
h	(negative) work culture and attitudes leads to inaccessibility to information and data	*"Nobody wants to share the data … everybody who has the data he is the boss"* (IP06)	Indifference becomes a normative attitude.	*"Union Government itself doesn't want to share. … let them have their information shared. … with the State … it should be freely available … they have the main role and the initiative has to come from them."* (IP05)
i.	(negative) work culture	*"Every Director of different*	Unwillingness to	*"that officers attitude 'I am the boss' has to go"*

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
	and attitudes lead to weak coordination	*departments have ego clashes… stops the whole integration process"* (NG26)	cooperate with other institutions and sectors.	(IP03)
j.	(negative) work culture and attitude leads to low implementation of adaptation actions	*"*[The] *typical mind-set is that 'my job is secured and I do not need to do anything' kind of attitude. The lack of dedication"* (NG22)	Indifferent attitude by some government officials leading to negligence	*"Government should make some statutory authority … whatever they plan,… should be implemented and there must be some sincere and honest efforts for delivering."* (IP02)
k.	(negative) work culture and attitude leads to resources limitations	*"There must be some sincere and honest efforts for delivering. Only then, can this be achieved"* (IP02)	Inefficient utilisation of existing human resources	*"The government has to act first what they are saying"* (NG25)
l.	geographical challenges leads to unavailability of information and data	*"because of geographical reason also, we have problem in forecasting …"* (RI21)	Difficulties due to geophysical conditions	*"I think we really need to go in a GIS solutions which can quickly give you some answers"* (SG11)
m.	geographical challenges hinders	*"Due to physiographic factor like sloppy terrain we cannot go for*	Overall infrastructural development being	

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
	implementation of adaptation actions	*good water harvesting structure so that is a challenge to this region"* (RI21)	more difficult in the mountainous region	
n	Limitations in resources leads to a work culture and attitude which is apathetic to the challenges	*"He angrily asked me, "can't you see that I am the only one here? Tell the Director to give me other supporting staffs. How can I be the only one to collect data from field, monitor and analyse?"* (NG25)	Demotivation due to lack of adequate resources	*"Allot them some money and some targeted work. Let them come out up to one year, two year or three year some innovative adaptation methodologies"* (RI24)
o	Limitations in resources also leads to unavailability of information and data	*"Research work is not a priority. We do not want to invest in these things because the results are not discernible"* (IP08)	Limited resources allocated for immediate needs than investing for understanding long term impacts.	*"The Centre should stop giving directions to the States. Rather they should give funds with accountability. This will help the state government to plan according to their needs"* (NG25)
p	Weak inter-institutional network leads to	*"All the departments have appointed the nodal officers but*	Changes of responsibilities, when	*"People need to understand each other first and then come out with some common*

Causes and interconnections	Quotes from interview	Implications	Suggested enablers
systemic and governance challenges	*later on if we ask them he is either transferred or not there"* (SG09) *"There is no linkage between various departments ..., strategies are not evolved in an integrated way or holistic way"* (RI22)	not communicated to other institutions, disrupts the system of monitoring and follow up.	*strategies and this sector is still not explored much. … they need to understand each other's operational aspects and where we can intervene with each other. So that's still required"* (RI24)
q Weak inter-institutional network leads to inaccessibility to the existing information and data	*"should set up a nodal agency which can coordinate with different organisations. So that everybody … can exchange views …*[and] *data, what steps, what contingent plans we need to adopt and how we implement it"* (IP03)		*"We must understand … how the other related sectors are influencing us or we are influencing them …. If this understanding comes then second step is coming together like people are coming and create certain infrastructure and then if we have the money and there is a team of good workers who can work together"* (RI24)
r. Weak inter-institutional network leads to low implementation of adaptation actions			

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
s.	Resources limitation leads to low implementation	*"The State Centre on Climate Change for the want of funds couldn't do good projects"* (RI24)	The lack of adequate resources hinders implementation	*"So in my view, first is the money, good team of workers and identification of inter-sectorial problems"*(RI24)
t.	Systemic and governance challenges leads to negative work culture and attitude	*"In the system you have so many bottlenecks. That, at the end of the day you'll say, just forget it"* (NG18)	Challenges due to day to day system of functioning	*"Meeting after every six months or three months has no meaning. …Let the Nodal Agency have some money and come up with some targets and then assess those targets. Not otherwise."* (RI24)
u	unavailability of information and data leads to limitations in knowledge capacity	*"We don't have a very robust data. We are still groping in the dark"* (SG11)	Ability to understand the system constrained due to lack of information and data	*"I think one should go for proper data base."* (IP01) *"use Open Data Kits which could reduce both costs and labour"* (NG25)
v.	Information and data inaccessibility and unavailability leads to	*"Nothing can be done if they don't give you the data"* (NG25) *"You have to tell them about the*	Implementation is constraint when the required information	*"There should be a mechanism for direct involvement. We should be able to communicate directly with the specific agency.*

	Causes and interconnections	Quotes from interview	Implications	Suggested enablers
	low implementation of adaptation actions	*gravity of the situation. That you won't be able to tell unless and until you have some concrete data, some facts with you"* (IP06)	and data are limited or unavailable	*Data sharing should be a routine job"* (IP08)
w	Information and data unavailability leads to creation of systemic and governance challenges	*"The departments which are supposed to collect basic data are not able to do it. Therefore all these plans and strategies are pretty much hypothetical"* (NG25)	Governance decisions are influenced by the quality and availability of information and data	
x	Weak inter-institutional networks leads to low knowledge capacity	*"The inter-sectorial linkages, that's very week… We must understand … how the other related sectors are influencing us or we are influencing them"* (RI24)	Oblivious of the interconnected challenges	*"People need to understand each other first and then come out with some common strategies and this sector is still not explored much"* (RI24)

4.4 Discussion

The responses from various governmental and non-governmental institutions in this study demonstrated the complex challenges of adapting water management to climate change in a developing economy with rapidly changing socio-economic conditions and competing priorities for infrastructure development. These additional challenges make it more difficult to translate awareness of the changing climate into tangible adaptation (Eisenack et al., 2014) and illustrates that awareness of the changing climate does not necessarily lead to adaptation actions in contrast to Marshall et al. (2013).

The barriers identified in this study are not unique to Himachal Pradesh (e.g. Biesbroek et al. 2013; Islam et al. 2014; Jantarasami et al. 2010; Sciulli 2013). However, this study shows that the occurrence, emergence, and persistence of adaptation barriers are contextual, dependent on the socio-economic and cultural factors and dynamic (Eisenack et al., 2014), and thus can emerge from different factors in different contexts. For example, lack of financial resources is reported across studies on barriers (Biesbroek et al., 2013; Moser and Ekstrom, 2010), but arises in developed economies from the inability of local institutions to articulate budgetary requirements for adaptation (Eisenack et al. 2014), overall austerity measures (Porter et al., 2015), the lack of legal financial autonomy for the local authorities to acquire financial resources from lending agencies (Crabbé and Robin, 2006), to climate scepticism among councillors (Baker et al., 2012; Engle, 2012). However, in Himachal Pradesh, the fragmented approach of splitting the financial allocation to all sectors, issues and locations based on public pressure, such that each ended up with an inadequate budget, was a key factor compounded by the overall economic condition and competing priorities for short-term developmental activities; thereby pointing to a departure from the causes prevalent in high income countries.

Adaptation barriers due to normative behaviours and nonchalant attitude by specific actors within the government institutions are rarely mentioned in other cases such as reported by Baker et al. (2012), Burch (2010) and Shemdoe et al. (2015). This study illustrates that indifference and nonchalant attitude to the potential climate risks, in spite of the acceptance that climate might be changing, can be due to socio-cultural normative behaviour in addition to low knowledge capacity. The lack of knowledge regarding adaptation options also breeds an indifferent attitude of ‘nothing can be

done'. Lack of implementing agencies, inaccessibility to appropriate information and trust deficiency between different agencies are also cited as common barriers in other developing economies such as Chile (Clarvis and Allan, 2013). Other overwhelming issues and competing priorities can also lead to staff apathy and indifference to the potential risks (Bierbaum et al., 2013; Klein and Smith, 2003; Picketts, 2014). However, awareness raising of potential climate change risks needs to be accompanied by allocation of resources and effective institutional arrangements for implementation to avoid them being reinforced by systemic and governance failures and inadequate follow-up mechanisms. Therefore, this study illustrates the need for taking into consideration the contextual socio-economic and cultural backgrounds of the region while studying the adaptation barriers and points to the need to go beyond general institutional design principles for successful adaptation (Oberlack, 2016).

Recent studies have shown that policy paralysis can occur both due to the unavailability of scientific knowledge (Hanger et al., 2013) and the inability of the demand side to access the available knowledge (Archie et al., 2014; Dilling et al., 2015). Making the scientific knowledge accessible to and usable by policy makers and practitioners requires close interaction between the suppliers and users of knowledge. However, an emphasis on the need for more research can also arise from an unwillingness of policy makers to act on a particular issue (Gardiner, 2011; Oreskes, 2004). The UK Government invested in policy-focused adaptation science to overcome the informational access and cognitive barriers (Porter et al., 2015) associated with the 'climate information usability gap' (Dilling and Lemos, 2011). However, adaptation did not follow as expected due to other barriers including institutional fragmentation, lack of visionary leadership and statutory adaptation obligations and inadequate budgetary allocations (Porter et al., 2015). This suggests that improving the production and dissemination of usable knowledge, such as through the National Mission on Strategic Knowledge for Climate Change (MST, 2010) in India, will have to be accompanied by additional reforms such as overcoming the inter-related barriers associated with institutional fragmentation, bureaucratic processes, and socio-cultural attitudes .

Overcoming the identified constraints in Himachal Pradesh, such as lack of technically skilled staff and other resources to address climate change challenges (Asian Development Bank 2010), will require collaboration with institutions operating beyond the State as the assumption that adaptation is the responsibility of local bodies is being

questioned (Nalau et al., 2015). Moreover, as additional financial resources often come from the Union Government or other external agencies, understanding the vertical interaction with the Union Government or other agencies operating at different scales will provide additional knowledge regarding enabling adaptation (Chaffin et al., 2016; Juhola and Westerhoff, 2011). Therefore, further studies to understand the role of institutions operating beyond the State agencies such as the Central Government agencies are required for formulating enabling mechanisms of adaptation.

4.5 Conclusion

Climate change is an additional driver of change to the pre-existing challenges of meeting increasing water demand due to population growth, economic development and land use changes in developing countries. This research has enriched the understanding of the causes and inter-dependencies of barriers to climate change adaptation for water management institutions in a complex top-down bureaucratic system of governance involving multiple sectors and institutions competing over limited resources. It has identified and highlighted the importance of under-acknowledged aspects of adaptation barriers, including socio-normative attitudes of implementing agencies and the influence of a democratic governance on short term priorities at the expense of long-term strategic issues. This study has also empirically substantiated an otherwise largely theoretical understanding that barriers are interconnected and demonstrated how barriers emerge and persist in particular contexts by exploring their root causes. Consequently, the contextual significance of adaptation barriers need to be taken into consideration while framing adaptation policies to enable the identification of intervention leverage points that maximise barrier removal, thereby contributing to achieving a better adapted society.

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5 ADAPTATION ATTRIBUTES AND INTER-INSTITUTIONAL NETWORKS ACROSS SCALES: INSIGHTS FROM NATIONAL AND STATE LEVEL WATER MANAGEMENT INSTITUTIONS

Abstract:

Successful adaptation to climate change, particularly in water management from local to national and basin level, requires cohesive networks between governmental institutions operating at different scales, besides with non-governmental and research institutions. Through such cross-scale and cross-sectoral networks, data, information, knowledge, learning experiences and even social practices that enable adaptation are expected to be transferred and shared. However, the implications of the prevalence or lack of adaptation attributes at one scale on another is poorly understood due to inadequate knowledge regarding inter-institutional networks.

This study integrates analysis of semi-structured interviews from 26 institutions operating at the national level in India and 26 institutions operating within a state – Himachal Pradesh, in order to address this key knowledge gap. The prevalence or lack of commonly identified adaptation attributes at the two scales is compared and the inter-institutional networks across scale is analysed for understanding its implications on other institutions at other scales.

The capacity to frame guidelines, standards and regulations for practitioners with better accessibility to resources and information available with the institutions operating at the national level coupled with involvement of bridging institutions across scales are opportunities for creating adaptive capacities at other scales. On the other hand, learning experiences from the low regret adaptive measures being implemented by institutions at the State level are opportunities for informing policy strategies at other scales and locations. However, the currently fragmented inter-institutional network is a bottleneck for the smooth devolution of adaptation attributes. This study suggests that the way water officials are recruited and deployed is causing a silo-attitude among water institutions in India, which is why data and information accessibility, and sharing of knowledge and experiences – essential determinants of adaptation – is not effective despite the wide recognition of its need. It therefore, brings a fresh perspective for understanding inter-institutional network barriers for enabling adaptation.

Keywords: adaptation, barriers, climate change, cross-scale, institutions, water

5.1 Introduction

Climate change is regarded as a global phenomenon today (IPCC, 2012). Therefore, institutions such as the United Nations Framework Convention on Climate Change lead the discourse on adaptation in addition to mitigation at the international level (Mimura et al., 2014). Within a country, National Adaptation Programs of Actions (NAPAs) are generally planned (for e.g., Bisaro et al., 2010; Hardee and Mutunga, 2010) by institutions operating at the national level often to build the capacity of local institutions (Measham et al., 2011). Institutions operating at the national level generally plan adaptation strategies based on the global projections or scaled down global climate models and impact projections (Butler et al., 2015). However, adaptation being contextual, institutions operating at a more local level are expected to implement them (Agrawal, 2010; Argyriou et al., 2012; Baker et al., 2012). On the other hand, learning experiences from local and pilot implementation projects are expected to inform national adaptation policies (Chu, 2015; Schreurs, 2008). Therefore, institutions operating at different levels; from national to regional and local have both distinct and complementary roles in formulating and implementing adaptation strategies (Adger et al., 2005; Fidelman et al., 2013; Nalau et al., 2015). It is increasingly realised that adaptation need to be addressed at multiple levels (Amundsen et al., 2010) by multiple sectors and actors (Vedeld et al., 2015) as the extent to which the various stakeholders involved in the design and implementation of adaptation measures is expected to shape its outcome (Juhola and Westerhoff, 2011).

Both public and non-governmental institutions – including research and academic institutions – play a crucial role in enabling adaptation through knowledge production and exchange, policy making and enforcement (Adekola, 2012; Agrawal, 2010; Wang et al., 2013) at multiple scales (Kirchhoff et al., 2015; Pahl-Wostl, 2009). Water management institutions operating at various levels, therefore, need to interact with various institutions and sectors for adapting their management to climate change for which certain key characteristics of adaptation are essential (Berkhout, 2012; Wilby and Vaughan, 2011). The processes of perceiving the climate change risks, evaluating the different options regarding priorities of investments, enacting the decisions and the processes through which it learns determines an institution's adaptive responses (Berkhout, 2012). Therefore, characteristics of an adapting institution includes the ability to recognise the threats and accordingly make plans to either avert them or take advantage of the changed/changing scenario with the available resources or acquire

additional resources. Lonsdale et al. (2010) and Wilby and Vaughan (2011) have detailed a list of attributes or hallmarks of adapting institutions from recent studies. These characteristics include; a) awareness and access to information, b) ability to identify risk and vulnerability, c) access to resources, d) effective and visionary leadership, e) motivation for adaptation, f) effective management processes, g) high level adaptation objectives, h) availability of guidance for practitioners, i) organisational learning and mainstreaming, j) low regret anticipatory measures, and k) monitoring and review of progress; not necessarily in sequential order or degree of importance.

However, it is poorly understood as to whether or not the adaptation attributes existing at one level, such as the national level, can have an influence over the institutions operating at the state or local level or how the learning experiences and challenges of the local implementing agencies can inform formulation and planning of adaptation strategies at the national level. Although inter-institutional networks are expected to transfer these adaptation attributes, due to the inadequate knowledge regarding the interaction between institutions at different scales, this knowledge remains largely obscure to policy makers and researchers alike. Here, scale refers to the national and State level of administration in a federal structure of governance.

Significant gaps generally exist between institutions operating at different scales both in terms of risk perceptions and availability of adaptive capacity (Butler et al., 2015). However, despite this emerging consensus, knowledge regarding how institutions operating at different levels; national, regional, and local, operate and inter-act with one another, or how such inter-actions, or the lack of, create enabling mechanisms or barriers is limited (Amundsen et al. 2010; Dannevig and Aall 2015; Vedeld et al. 2015). This is due to the scant critical attention from adaptation researchers on the key issue of the relationship between institutions operating at different levels (Wyborn, 2015). Empirical knowledge regarding the implications of the lack of adaptive capacity for institutions operating at one scale being circumvented by the presence at another level or the absence of adapting attributes at one level causing bottleneck for adaptation at another is poorly understood although studies across scales exists (for example, Pahl-Wostl, 2009; Wyborn, 2015). This is particularly so for adapting water management to climate change from basin level management institutions to national, regional and local authorities (Bisaro et al., 2010; Finger et al., 2006; Lebel and Garden, 2008; Mollinga et al., 2006; Pittock, 2011; Wilby and Wood, 2012). Using the context of the institutions

operating at the national level (ION) and institutions operating within a state (IOS) in India, Himachal Pradesh (HP), hereafter referred as 'the State', this study addresses this key knowledge gap to understand the adaptation attributes of institutions operating at different scales.

5.2 Context and Methods

5.2.1 Context

Water governance in India provides an ideal case for exploring this multi-layered and multiple institutional complexities for adapting to climate change. At the Union Government level, Ministry of Water Resources[5] (MWR) in conjunction with other government agencies such as Central Water Commission (CWC) and Central Ground Water Board (CGWB) play a key role in formulating national water policy and other major water infrastructure development strategies in addition to monitoring the state of water availability and usage in the country (Ananda et al. 2006). On the other hand, irrigation being a major water consumer in India, Ministry of Agriculture has an important stake in the water infrastructure along with Ministry of Power for hydropower generation. Due to environmental concerns major irrigation and hydropower projects are required to be cleared by the Union Ministry of Environment and Forest[6] (MEF) (CWC, 1998). Union Government is increasingly involved even in drinking water and sanitation services in the recent decades through the Union Ministry of Drinking Water and Sanitation while Union Ministry of Environment and Forests coordinates the climate change activities in the country although National Water Mission (NWM) under the National Action Plan on Climate Change (NAPCC) is being implemented through the Ministry of Water Resources.

Similarly, within a State, parallel institutions analogous to the Union Government institutional structure exists as water is considered a state subject in India. Within the State of Himachal Pradesh, Irrigation and Public Health Department (IPH) play the key role in formulating and implementing the state water policy, development of water infrastructure and delivering water services. Similar like the Union Ministry of Environment and Forest at the national level, Department of Environment, Science and

[5] Renamed as Ministry of Water Resources, River Development and Ganga Rejuvenation in 2014 when the new government was formed but retained the old name as the data for this research was collected before the ministry was renamed.
[6] Similarly, renamed as Ministry of Environment, Forest and Climate Change in 2014

Technology (DEST) coordinates the State Climate Change activities. This multi-layered and multi-institutional involvement for water governance in India increases the complexity such that it requires the exploration of the interdependence of adaptive capacity across scales for enhancing adaptation.

In the light of this multi-institutional involvement at multiple scales, this study addresses the complexity of adapting water institutions to climate change by a) evaluating the variations in the adaptation attributes at the two scales, and b) the causes for its variations through the perspective of the inter-institutional network operating at the two scales to draw knowledge regarding the factors that enhance the transference of adaptation attributes across scales.

5.2.2 Application of Social Network Analysis

Social structures emerging from the interaction of actors (usually designated as points or nodes) connected by relationships (denoted with lines or ties) are known as Social Networks (Scott, 2012). Actors may be individuals, groups, institutions (organisations), or groups of institutions tied (connected) together by one or more types of relationships such as by legislation, common interests in a particular issue, exchange of resources, or friendships (Wasserman and Faust, 1994). Social Network analysts assume that through such ties behaviours, attitudes, information, or goods are transmitted across groups, institutions or countries just as between individuals (Nooy, Mrvar and Batagelj, 20011). As such, Social Network Analysis involves the analysis of patterns formed by the nodes (points representing individuals or institutions as actors) and ties (lines indicating relationship) between individuals or institutions, mathematically or visually, in order to assess their effects on others members of the network formed by the intersecting lines that connect them (Scott, 2012).

The social network perspective provides a method for analysing relationships from whole to part (Wasserman and Faust, 1994). In a given set of actors (individuals or institutions) Social Network Analysis is used to study the nature and behaviour of how they exchange resources, beliefs and influences (Carrington, P. J., J. Scott, and S. Wasserman, 2005). It enables to identify local and global patterns, locate influential entities, and examine network dynamics. Precisely because many types of relations form these networks it is being applied to a broad range of research enterprises including diffusion of knowledge (Valente, 2005), natural resources management

(Bodin and Crona, 2009), coastal zone management (Ernoul and Wardell-Johnson, 2013), and construction management (Pryke, 2012) among others.

In this chapter, Social Network Analysis is applied to analyse inter-institutional relations between institutions operating at two governance levels in a federal structure; national and state level in India. Although formal administrative structures and legislations explicitly stated in policy documents and laws provide the framework for institutions to relate to one another, everyday reality of water resources managers, users and policy makers and their behavioural interactions can be very different. As such, Social Network Analysis between key actors (individuals or institutions) can provide valuable information regarding the effectiveness of coordination between the actors which may not be apparent when viewed individually (Stein, Ernstson and Barron, 2011). In this study, institutions having a specific mandate and operating in a specific geographical location, ranging from government institutions that are monitoring the availability and use of water resources or developing water infrastructure or involved in disaster management, non-governmental organisations (NGO), and educational and research institutions represents actors. Following the suggestion of (Stein, Ernstson and Barron, 2011), that the option of analysing at the individual level (using individual members of the each institution as nodes) for such a large cross-scale social complexity as water resources governance and climate change adaptation is deemed both unrealistic (too many persons to visit) and unfeasible (impossible to list all individuals involved), this study adopts the institution as the unit of analysis. Hence each institution represents a 'node' in Social Network Analysis terminologies in this respect.

5.2.3 Data collection

Semi-structured interview data was collected in two phases: a) respondents from 26 institutions operating at the national level (hereafter referred as ION) during January - April 2014 and b) 26 institutions operating within the State of Himachal Pradesh (hereafter referred as IOS) during January – February 2015. Following purposeful sampling strategy (Creswell, 2007), the Union Government institutions involved in the climate change and water management were identified through a wide survey of the government documents available in their websites and the remaining respondents through the recommendations of other interviewees. This includes Union Government Ministries and its agencies [institutions that are providing particular service such as water supply or when the institution operates in a state as an 'agent' of the Union

Government or State Government for data collection and monitoring such as Central Water Commission (CW), Central Ground Water Board (CGWB), National Water Development Agency (NWDA), and National Rain-fed Area Authority (NRAA) [Figure 5.1] whose functions ranges from water policy formulation to infrastructure development to environmental regulation and monitoring. Similarly, IOS include State Government departments such as Departments of Environment, Science and Technology, Forests, Agriculture and Irrigation and Public Health (IPH) and two Central Government agencies: Central Water Commission (CWC) and Central Ground Water Board (CGWB) located and operating in the state of Himachal Pradesh besides non-governmental and research and academic institutions [Figure 5.1]. IPH being the primary institution for water infrastructure development and services delivery in the State and operates from State to sub-state/zonal to local level, responses were collected from all the four zones into which Himachal Pradesh is divided. For the purposes of this study, 'institutions' refer, in general, to government ministries and agencies, research institutions, non-governmental organisations and State Government departments operating in different office locations.

Table 5-1: Institutions interviewed

Union Government Ministries (UM)	8	-
Central Government Agencies (CG for IOS and GA for ION)	5	2
Research Institutions (RI)	6	-
Academic Institutions (AI)	2	-
Academic and research institutions (AR)	-	3
Non-governmental or consulting (NG)	5	6
State Govt. Departments (SG)	-	9
Department of Irrigation and Public Health (IP)	-	6
Total	26	27

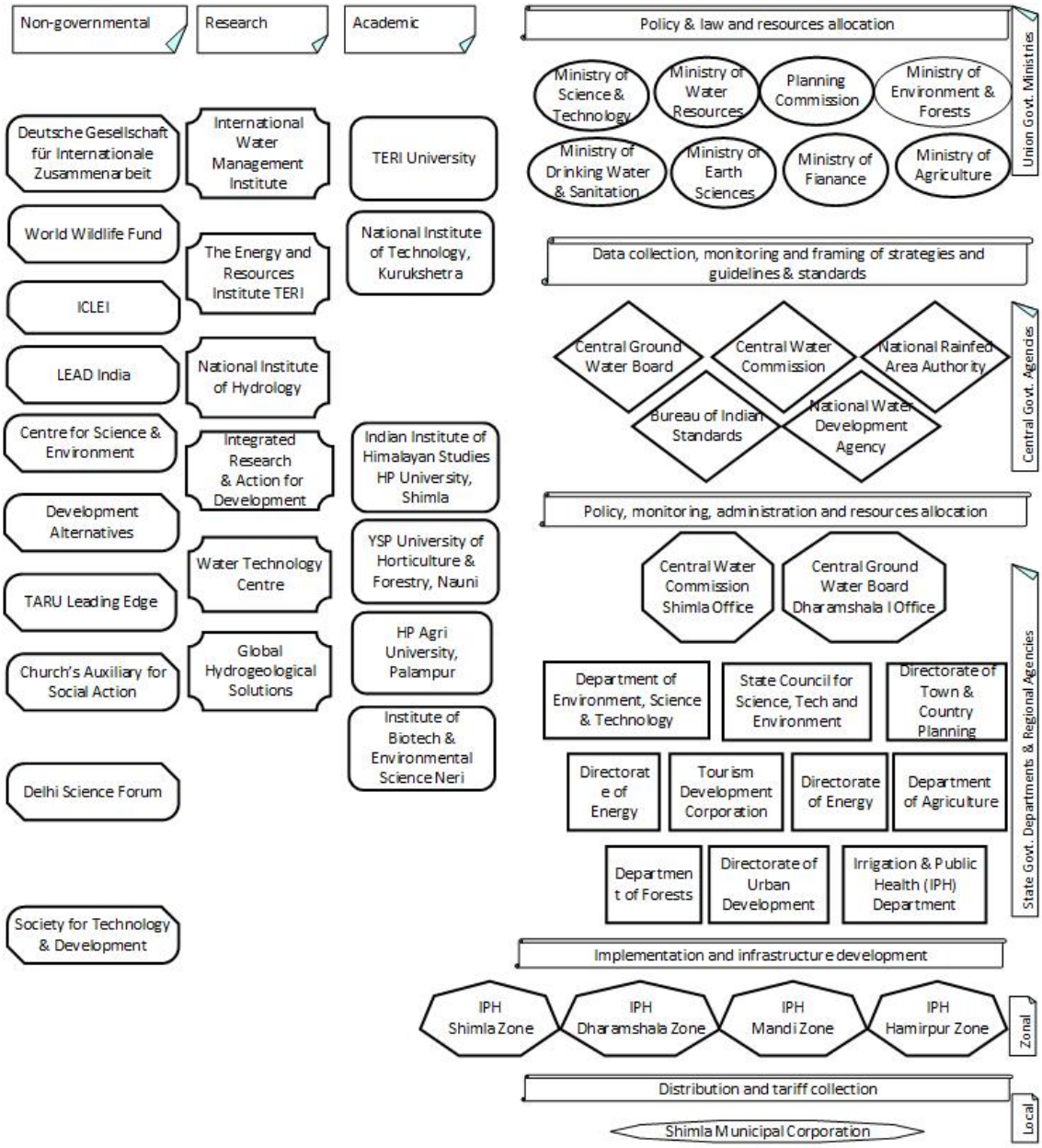

Figure 5.1: Institutions interviewed and their approximate level of operation and functions.

The semi-structured open-ended questions [Appendix F and H] were framed after wide reading of the government websites and iterated after three pilot interviews to collect data regarding the respondents' awareness of climate change, initiatives being taken, challenges and their key partner institutions. Values, beliefs and attitudes that form the core of qualitative research are not normally distributed and people are not equally good at observing, understanding and interpreting their own or other people's

behaviour' (Marshall, 1996). Therefore, meticulous identification of key informants from each of the principal institutions was an important feature in this regard. This was ensured by investigation the profile of the interviewee which enabled to provide deeper insights into the perspectives of the principal actors in the key institutions.

The interview ranged from 10 – 80 minutes, averaging 40 minutes depending on the response as the open-ended questions allowed respondents to address and respond a variety of perspectives as possible. The respondents were free to deviate from the questions and the interviewer intervened only to clarify issues or probe the discussions deeper. The interviews were mostly conducted with a single respondent in their offices and audio recorded after obtaining permission and transcribed during analysis.

5.2.4 Evaluation of adaptation attributes

A thematic approach, which is a robust method for policy analysis (Braun and Clarke, 2015; Fereday and Muir-Cochrane, 2006) was used in analysing the semi-structured interviews. Focussing primarily on the availability of key attributes of adapting institutions as identified from literature, such as the list compiled by Lonsdale et al. (2010) and Wilby and Vaughan (2011) were used as the key themes for approaching the data and responses that served as supporting (or negating) the prevalence of adapting attributes at the two levels are noted (Fereday and Muir-Cochrane, 2006). Direct quotations wherever possible are provided with the intention to provide empirical evidence, without the distracting use of [*sic*], and corrections [within square brackets] are introduced only to shorten the quotation and/or provide clarity. In order to maintain anonymity and yet retain traceability, each quotation is cited with the acronyms in Table 5-1 accompanied by a numerical figure allotted based on the sequence of interview conducted.

5.2.5 Inter-institutional networks analysis

The vertical relationships between the institutions operating at the two scales were analysed based on the perceived role and importance of the institutions being played (or ought to play) by the institutions operating at the State level or vice-versa. This was mostly drawn from the interview question: '*what is the role of ION/IOS and with which institutions at the national/state level do you interact for adapting water management to climate change?*' The vertical relationship and perceived role of institutions at different scales were analysed with the aim to explore if the lack of adaptation attributes at one

scale can be circumvented by the prevalence at the other scale or the lack of adaptation attributes at one scale is a bottleneck for adaptation at other scales.

Drawing from Social Network Analysis theories (Ahuja et al., 2012; Kilduff and Tsai, 2003), inter-institutional networks between key institutions involved in climate change adaptation and water management was used to examine the network components between the water institutions to reveal the implications of the existences of formal and informal ties. As data, information, knowledge, learning experiences and social practices that shape the outcome of adaptation planning and implementation, is known to flow through the networks of institutional interactions (Caniato et al., 2014; Chaffin et al., 2016), particular attention was focused on the network cohesion and fragmentation between the key water institutions. Although data was collected from all key institutions involved in adapting water management in India, particular focus was emphasised on the key water institutions; 1) Ministry of Water Resources (MWR) along with 2) Central Water Commission (CWC) and 3) Central Ground Water Board (CGWB) operating at the national level with its branch offices across the country and 4) State Water Department (IPH) in a particular state, which is Himachal Pradesh in this case, and the relations between them. Therefore, particular attention is focused on the responses from these four institutions and the relation between them.

5.3 Findings and analysis

The findings are presented in two sub-sections. The first sub-section presents the results of the analysis of whether or not the Indian institutions operating at two different scales exhibit attributes of adaptation. The second sub-section focuses on the network between the institutions horizontally and vertically. This is mainly drawn from the perceptions of respondents about the role of the institutions operating at the scale other than the level at which they are operating. That is, the respondents from ION are asked about the role of IOS for adapting water management to climate change and vice-versa. Finally, the implications of the prevalence or absence of the adapting attributes and the vertical relations are analysed and discussed in the section that follows.

5.3.1 Attributes of adapting institutions: Do Indian institutions have them?

The prevalence or lack of adapting attributes for institutions operating at national and state level are tabulated and compared in Table 5-2 and each of the adapting characteristics are further elaborated and discussed.

Table 5-2: Attributes of adaptation: prevalence and absence deduced from interviews

Attributes	National	State
Awareness and access to information	*"Aware, but not sensitised enough."* (AI06)	*"Our State Government is very much aware of climate change"* (RA21) *"but … might not be of that level so that can make changes."* (SG10)
Ability to identify risk and vulnerability	*"References are there but detailed study is not there under the climate change scenario."* (RI07)	*"As on date, the impacts have not been studied or structured in detailed manner."* (IP08)
Access to resources	*"There are some issues … many departments are not willing to share the data."* (RI17)	*"Here we do not have the knowledge and human resources. They are the major hurdle."* (IP08)
Motivation for adaptation	*"There have been some additional funds…* [which] *is for climate change adaptation but at the end of the day it is also meant for development."* (NG10) *"We have to follow a little cumbersome procedure. That's a deterrent."* (RI17)	*"There is no such budget in my department ... Neither there is any assurance nor there any encouragement* [for knowledge acquisition]*."* (IP02)
High level adaptation objectives	*"National Water Missions has very right goals for adaptation …"* (GA01)	*"We have … very good State Strategy on climate change that includes water also."* (SG09)

Attributes	National	State
Effective and visionary leadership	"*One missing link is … leadership. … who are genuinely interested* [is lacking]*. …cannot be only through speeches."* (RI17)	*"We are not clear about what practically can be done."* (SG10) *"Government should make some statutory authority where leading experts and whatever they write ...plan …think, should be implemented."* (IP02)
Low regret anticipatory measures	*"Very recently… organised one seminar on … incorporate*[ing] *climate change aspects in analysing probable maximum flood* [and]*… design of irrigation infrastructure to accommodate the impact of climate change. … on the other hand we have this criteria of 75% dependability for planning of the irrigation projects… we are thinking to decrease it to 60 or 50% dependability so that the variation of the climate change can be accommodated."* (GA01)	*"Earlier for providing drinking water our focus was ... to find the nearest source."* (IP02) *"We are now taking from… perennial bigger sources, where the impact is on the lesser side."* (IP01)
Organisational learning and mainstreaming	*"Government systems are mammoth systems and …*[laughs] *…it takes time for those things to be materialised."* (GA01)	*"The government set up is such adaptation takes long, long time."* (IP02) *"I think we are much aware now of the problems which*

Attributes	National	State
	"Earlier water is …[understood] *only in terms of irrigation. But now we are looking at water in a holistic manner."* (UM02) *"They* [Government agencies] *still think that it is more of a hungama* [commotion] *and alarm but their first priority is to meet the demand and supply gap. So I would say that the government is still not that serious at least at the state level I would say."* (NG09)	*we are likely to face. … So now we don't go for short term projects. We go for long term plans. May be it is not cost effective today. But we see after many years it will be sustainable. So that things have definitely changed. ... We are now planning for twenty thirty years."* (IP03)
Guidance for practitioners	*"I think there are frameworks of climate change adaptation guidelines which are coming out and I am one of the members."* (RI11) *"We already have standards for earth quake designs…but we do not have any standards related to climate change yet."* (AI06)	*"The major hurdle is that the impacts are of such a general nature that we cannot take specific action."* (IP08) *"We are not clear about what practically can be done."* (SG10) *"Guidelines and policy are not there to adapt in water management, only then I can implement it. … We have to evolve some mechanism to incorporate these impacts of climate change on water resources."* (IP07)

Attributes	National	State
Effective communication of risks and opportunities	*"We have formal meetings quarterly, half yearly, yearly, depending upon the requirement we keep meeting them."* (UM02) *"This is a process that we are evolving."* (GA01)	*"I think climate change is more or less being dealt by the Science and Technology Department. Whenever they plan some workshop or some deliberations they definitely call us. From here, there is no specific Nodal Officer or a wing which looks after it."* (IP07)
Management processes	*"We are in a kind of… neglect and rebuilt…. our paradigm has been to build ….do not manage it properly… deteriorated and then we rebuild… This has been happening and we didn't have proper institutions to manage them effectively and properly …we have to … improve …the management."* (RI04)	*"You have one idea when you are not into the system. … another when you are inside... Outside … everything is doable. In the system you have so many bottlenecks. That, at the end of the day you'll say, just forget it."* (NG18)
Monitoring and reporting progress	*"There was a …hydrologic project. …to review the networks* [of rain gauges] *and* …[identify] *… the duplicacies and … missing stations or protocols … and then redesign the whole network. They did that also. But subsequently the follow up was not up to the mark, up to the level that it should have been."* (RI17)	*"Actually all these things are being done in a piecemeal manner – something here …"* (IP07)

5.3.1.1 Awareness and ability to identify climate risks and vulnerability

There is arguably general acceptance of the changing climate among the respondents from both ION and IOS. The respondents from the IOS relate to the changing climate mostly through their everyday experiences: *"climate change indicators are very clear over here"* (RI05) and *"depletions in water sources …is mainly attributed to the climate change"* (IP01) whereas the respondents from the ION mostly relate to potential impacts of climate change in terms of aggravating the overall situation: *"climate change is going to aggravate the situation"* (UM03). Few respondents from ION pointed out that the government institutions, particularly at the state level, are *"not ….sensitised enough in terms of the threats"* (AI06) and *"the states and the line agencies on the ground … are not really aware about the challenges itself."* (RI11). This was corroborated by a respondent from an IOS: *"as on date, the impacts have not been studied or structured in detailed manner"* (IP08) although he stated: *"We are totally aware about the climate change and its impacts"* (IP08) in the initial part of the interview. On the other hand, some other respondents claim that they are aware about the impacts but adaptation takes time to implement (IP02). Therefore, although there is a general acceptance that climate is changing, the details regarding its impact and consequential actions that need to be taken are largely unidentified, unclear or ignored by water infrastructure agencies.

A researcher from an IOS stated that "*vulnerability index*… [to] *see how in the near future … the increase in temperature would happen*" (AR05) and assessments *"to find the different indicators of climate change"* (AR05) are being developed. However, the State water infrastructure development agencies such as the IPH and Municipal Corporation are at an early stage of collecting hydrological data to understand the long term trends. This was stated by one respondent: *"Actually all these things are being done in a piecemeal manner …data acquisition and some awareness program*…" (IP07) and hence are yet to initiate incorporating climate risk factors into infrastructure planning and design; although low regret adaptive measures are being taken into account while selecting water sources by preferring larger and perennial sources. Respondents from IOS, such as IPH, are unaware about the impact studies carried out by other institutions or research institutions. They find the State specifics to be unclear and cited this to be a primary challenge to plan or implement adaptation strategies: *"the major hurdle is that the impacts are of such a general nature that we cannot take specific action. This is the main problem"* (IP08).

5.3.1.2 Access to resources and motivation for adaptation

Access to and availability of resources; financial, human and knowledge were found to be closely linked to the motivation for adaptation. Most of the respondents relate resources mainly to financial, technological and human rather than natural or physical when discussing the availability and accessibility of resources. For many respondents, both from ION and IOS, inaccessibility or unavailability of resources was a key demotivation for adaptation: *"resource is a major constrain"* (RI04); *"financial support is also not forthcoming as well as at the right time"* (GA01) and *"it is not possible with the limited infrastructure"* (GA12). Some others mentioned the inadequate human resources, particularly at the implementation field: *"we do not have barefoot hydrologists"* (NAI06) and *"The government is not replacing whatever the retirements are happening"* (IP03). Similarly, another respondent narrated an example; *"How can I be the only to collect data from field, monitor and analyse"* (SNG25). Regarding the technological resources, while a respondent from a government agency suggests *"technologies…* [such as] *SCADA system or GIS based irrigation management system"* (GA01), a researcher stressed more on the human aspect; "*at the moment software* [skill and motivation] *is more important than the hardware* [infrastructure or technology] *… the kind of knowledge has to … sunk in"* (RI11) and therefore, *"the important thing is capacity … of the agencies"* (RI11).

The inaccessibility to data and information is a major difficulty reported by both ION and IOS. The lengthy bureaucratic protocols for accessing information and data and forming partnerships with other institutions, especially with overseas institutions, and the absence of a system that encourages and incentivises learning, was a major demotivating factor for many of the respondents. Inadequate infrastructure, staff and funding are other additional disincentives of motivation for adaptation prevalent particularly among government institutions operating at the national as well as regional/State level institutions.

For many respondents, the motivation for adaptation is drawn mainly from the hope that it will also improve the current water infrastructure if adaptation is mainstreamed into development. For example, a respondent stated: "*with this climate change… attention of the people, policy makers, decision makers have been there on more serious notes. … the* [water] *sector is given attention … this will turn into more and better systems…"* (GA01). He believes the current attention to climate change is an

opportunity to highlight "*the deteriorating and inadequate water infrastructure"* (GA01) and draw the attention of decision makers to allocate additional resources to integrate the adaptation implementation into the overall infrastructure development. Similarly, another respondent stated: *"there have been some additional fund. … The funding is for climate change adaptation but at the end of the day it is also meant for development."* (NG10). Improvement in water use efficiency, technology, and agricultural practices, which are expected to be brought about through the climate change adaptation actions, such as National Water Mission, are factors of motivation for many respondents: "…*if you improve the water use efficiency, which is anyway required because of the sectoral increase in competing demand, will anyway benefit or aid adaptation in the climate change"* (RI11).

5.3.1.3 High level adaptation objectives, visionary leadership, low regret adaptive management and organisational learning and change

Government of India has initiated a high level climate action plan with specific targets through the Prime Minister's Council on Climate Change with eight national missions. The National Water Mission (NWM) under the National Action Plan on Climate Change (NAPCC) has laid out adaptation strategies including comprehensive water data base in the public domain, promotion of multi-stakeholder involvement, and improving water use efficiency. A respondent commended that the *"National Water Mission has very right goals for adaptation"* (GA01). Similarly, another respondent from an IOS is confident that they *"have … very good State Strategy on climate change that includes water"* (SG09) to link with the National Missions. However, respondents indicated the lack of leadership both at the national and state level when it comes to implementation: "*One missing link is I think our leadership. We are not able to have leadership who are genuinely interested. …. leadership has to demonstrate that they are genuinely and really interested in."* (RI17). At the local implementation stage, the Nodal Officers (for the State Strategy and Action Plan on Climate Change), are unable to assume leadership roles of adaptation implementation even within their respective departments or institutions due to various barriers including, organisational structure, lower position in the administrative hierarchy, and climate change being a non-priority and low knowledge capacity.

Improving water use efficiency to reduce water demands and reuse of water was stressed: "*We have developed a road map for mainstreaming water efficient fixtures in*

India... Indian Standards …for water efficiency [is being framed]*"* (NG09). Development and formulation of national standards and guidelines for improving water use efficiency is being developed by a few Central Government institutions with the assistance of non-governmental and research institutions. Most low-regret adaptive management was aimed towards meeting supply demand and much less comments related to averting flood and drought risks. However, most of these are aimed towards water users rather than adoption by water management institutions themselves.

Organisational learning involves a flexible structure and a system that encourages its personnel to experiment and innovate. At the individual level, some respondents pointed out that this was not there. When asked about the changes happening within the government institutions, over the past decade, there were mixed reactions from the respondents. Some respondents believe a considerable change has occurred within the government institutions, although these changes are not necessarily driven by climate change alone: "*we now are looking water as a resource…* [realising] *it also has some limitations. So that is the reason we want to use the water more efficiently. This is just like ore and mineral. This is just like any other resource*" (UM02). Moreover, *"earlier water is* [understood] *only in terms of irrigation but now we are looking at water in a holistic manner"* (UM02). Some others believe that this change in the valuation of water is not necessarily due to climate change (UM18) but indeed the limitations of water as a resource is being realised. Some others added that although individuals in the government recognises the changing scenario, *"Government systems are mammoth systems and …*[laughs] *…it takes time for those things to be materialised by the government. The pace is not that fast ... Nevertheless the thinking is there…changes are there."* GA01). While on the other hand, another regrets: "*No, unfortunately not"* (NG15).

Over the past few years there have been a few changes in the management of water in India including revising the National Water Policy in 2002 and 2012 (MWR, 2012, 2002). When ask about these changes some respondents believe that the change is

> *"…not on a smaller time scale* [but] *yes on a longer time scale say, last thirty years fifty years.* [Earlier]… *we have sufficient amount of water. The population was less. But … climate is changing … this only has resulted in the formation of these eight National Missions. So there is a more focus from the government side towards these climate change impacts."* (UM18)

Others pointed out to the more stringent regulation of ground water, particularly, in the recent past as an indication of change:

> *"There are so many changes… it has come in different ways. One is in the shape of regulations. Certain things like ground water which was anybody's baby anybody could dig a well and start pumping and take it as per requirement. Those things have changed. Because of this the government have realized this have to be regulated. So regulatory part of the government is more noticeable now"* (IP06).

Other changes occurring in the Indian water management philosophy as perceived by the respondents includes the recognition of the need for involvement of water users as key stakeholders:

> "*… previously the Government manages the whole system but now the public is being involved in the management by way of Water Users Associations or even Rural Water Supply Schemes. Even in Urban water supply schemes the Government have a clear mandate that at least the operation needs to be transferred to the local bodies. The reason behind this change can be so many – financial is one ... Secondly, a good sense is prevailing that let people be involved and perhaps it is a general trend across the country."* (IP06)

5.3.1.4 Availability of guidance and effective communication

Standards and guidelines for improving water use efficiency and incorporating climate change factors into water infrastructure are under various stages of development as many respondents pointed the need. For improving the water use efficiency; *"new institutional mechanism…. National Bureau of Water Efficiency…"* (UM02) is being created besides developing Indian Standards: *"one of the adaptation strategies … I am going for a meeting …with BIS* [Bureau of Indian Standards] *…. We do not have an Indian Standard … for water efficiency"* (NG09). Regarding incorporating climate change factors into mega water infrastructures; "*we do not have any standards related to climate change yet"* (AI06). However, *"…there are frameworks of climate change adaptation guidelines … coming out and I am one of the members ..."* (RI11). Another respondent from an ION mentioned the new initiatives for incorporating climate change aspects in analysing probable maximum flood and dependability in drought situations (GA01) and capacity building of water infrastructure development agencies.

Water engineers from IOS cited the non-availability of such guidelines as a key barrier for incorporating climate change risk factors into their planning and designing of infrastructure: *"… guidelines and policy is not there to adopt then how I can comment on the challenges for successful implementation"* (IP07). Similarly, another respondent stated: *"Until and unless very specific end action plans are given for particular area, region with effective mandate and funds. Then only it is possible to tackle the climate change"* (IP08). However, another engineer respondent cited the (general) difficulty of implementing Central Government guidelines without taking the local challenges into context:

> *"There are some guidelines which are made generally for the entire city* [for example] *that do not keep in mind the hill states. And there, when you design a water supply system … for eight hours pumping and one third of the water demand needs storage. But here the case is different. … you need to have a buffer storage for one day. Then the arithmetic really changes. One third is as per the Govt. of India mandate. Here you require almost the double. The Government of India suggests for low cost pipes. May be HDPE* [high density polyethylene pipes] *or any other plastic pipes. But hilly terrain needs DI* [ductile iron] *or steel pipes. These are the challenges faced by hill states."* (SG11)

Therefore, a respondent suggested building the capacity of State agencies so that they can make their own specific decisions:

> "…*the most important step is capacity building of these organisations. … people with the requisite background, who are aware and who sort of take these works as part of their duty. They have to be internally activated. It is not that you go and tell him that 'look water is going to be crucial' and they will start doing it."* (RI17).

Similarly, another respondent elaborated the lacunae and suggested:

> *"The guidelines …may not necessarily …* [be] *very specific like create these kinds of infrastructure, these volumes of storage. …. the guidelines are required in terms of how should procedurally we involve the climate scientists in our other activities to see what is the additional impact … and therefore if at all there is some additional interventions required, investments required and we take our informed decision"* (RI11)

This respondent went to stress the role of other non-governmental institutions: *"rope in some local NGO and it creates knowledge transfer or capacity building to that NGO it enables that location to respond to climate change*" (RI11). Likewise, another respondent added that the adaptive capacity of local institutions need to be enhanced so that they can take into account their own specific local challenges: "*there are bodies with expertise, technical expertise, they can prepare broad blueprints but which of course need to be understood and modelled to suite local …by the state governments and their respective organisations,"* what is required is *"… to build proper capability, in order to get it done correctly. order of safety needs.. what kind of local needs."* (NG15).

The channels of communication at the Union Government are evolving as the respondent from the Union Ministry suggested that they are in constant touch through regular meetings. However, this is not corroborated by other respondents and is possibly a one way communication. At the State level, effective channels of communication between different departments within the government were less apparent. For example, many of the respondents from other departments are unaware about the State Action Plan. Another communication gap that was observed was the transfer of officials, within short notices, and the failure to communicate such changes to other departments was pointed out as major hindrance for effective passage of information. Effective communication from the Nodal Officers to the other personnel within the same departments is not yet visible. For example, respondents from the other three zones of IPH are unaware about the Nodal Officers being appointed for State Action Plan on Climate Change: "…*not specifically that we have to plan a document on climate change. There is no specific* [Climate Change] *Cell".*

Town and Country Planning Department on the other hand stated to be carrying out publicity awareness campaigns regarding flood zones, planning and designing of rooftop rain water harvesting structures: *"We are distributing these pamphlets which are written in Hindi"* (SG15). Similarly, respondent from the Department of Agriculture stated that climate information and forecasts are being transmitted to farmers through the use of mobile phone messages and internet with the help of research institutions and non-governmental institutions.

5.3.1.5 Management processes and monitoring and reporting of progress

Respondents pointed out that there is inadequate follow up regarding implementation of identified strategies in India. For example, a respondent stated that although the

government might initially start off well, a lot of important projects are not implemented adequately due to weak monitoring. A respondent cited an example of this ineffective follow up regarding the rain gauge network (RI17):

> "*One of the objectives* [was] *to review the networks and find out … the duplicates and where the missing stations or protocols or something and ... redesign the whole network. They did that also. But subsequently the follow up was not up to the mark, up to the level that it should have been."* (RI17)

Others pointed out the poor management of existing infrastructure

> *"… we are in a kind of … neglect and rebuilt… our paradigm has been to build certain things ….do not manage it properly… deteriorated and then we rebuild… this has been happening and we didn't have proper institutions to manage them effectively and properly so if we want to make very good use of these structures or these kinds of infrastructures which helps in adaptations… then we have to improve the software part of the management"* (RI04)

Similarly, at the State level also, there were instances where due to lack of monitoring some of the adaptation plans were not being effectively implemented. The climate change adaptation in the State is currently at an initial stage and hence monitoring and reviewing will be required to be embedded in the adaptation strategies itself to benefit from the learning experiences as well as enforce the identified strategies which is currently lacking in India.

5.3.2 Interaction between institutions at multiple scales

The importance of a vertical coordination between the State Government departments and Central Government agencies, besides horizontal cross-sectoral relations, was acknowledged by most respondents. These respondents stressed the importance of building capacity of local implementing agencies besides making national and state strategies. Smooth coordination among the different institutions, vertically as well as horizontally, is found to be a major challenge in operationalising the adaptation strategies being planned by the institutions operating at the national level and the State Centre on Climate Change in Himachal Pradesh. The need for converging various programs such as water conservation and rural employment schemes, which are currently being implemented through different institutions, and link up with climate change adaptation was also emphasized by some respondents. For example, a

respondent from an IOS suggested that the Union Government should use the administrative power to ensure that different institutions work together or even set up an institutional structure to bring them together:

> *"Government should set a nodal agency which can coordinate with different organisations. So that everybody work in tandem and there is a perfect coordination. We can exchange our views, exchange our data, what steps, what contingent plans we need to adopt and how we implement it. There must be some nodal authority who can coordinate with all the stakeholder." (IP02)*

On the other hand, the vertical relations between the institutions operating at the national level and the State level and the link between the policy-making bodies and the implementing institutions apparently have a wide gap. A respondent from a research institution pointed out the weakness of government institutions which are expected to provide the connecting link between research, policy and implementation:

> *"We have high level research institutions like IWMI [International Water Management Institute] or IIT [Indian Institutes of Technology] or ….NIH [National Institute of Hydrology] ….and they have important findings and bearings ….and then we have local level agencies …to help people adapt but they require knowledge …[and] technologies …Since the government agencies …providing that link is quite weak …there is no flow of the information from the upstream to downstream" (RI04)*

Likewise, another respondent contended that *'there is no dearth of research in India'* (RA24) and the need is transferring those knowledge capacities to the practitioners and enabling them to implement with adequate financial support. In view of the weak knowledge capacity of implementing agencies, such as the State water department, many respondents suggest capacity building measures such as workshops and trainings. When asked about the expected roles of the Central Government institutions in enabling the State agencies to adapt to climate change, a respondent from a State Government department stated:

> *"Union Government is the key and if they give directions … States would follow ... Because … we want fund from them ..., if they give us directions …[to] change this DPR [Detailed Project Report], and incorporate … climate change then definitely we have to follow it. Otherwise they will not provide the fund." (IP07)*

From the interview responses collected, some of the key roles the respondents from IOS expect the ION can be summarised as a) funding, b) capacity building, c) conflict resolutions, d) international mediation, particularly in transboundary basins e) information and data gathering and dissemination, f) nodal agency of bringing together different sectors and institutions, and g) formulation of policy regulations and guidelines. Many of the engineers believe water should become a Central Subject instead of the current State subject because they believe that will ease the inter-state water conflicts and improve water management.

5.3.3 Inter-institutional relations

Figure 5.2 below shows the inter-institutional network based on the interview data collected by asking the respondents their key partner institutions; with/from whom they obtain/share data, information and knowledge pertaining to adapting water management to climate change (hereafter referred as partner institutions). Although in total, respondents from 52 institutions were interviewed, institutions that do not mention having direct links with the state government institutions are omitted in the figure as the focus here is to investigate the relations between the ION and IOS. The direction of the arrows in the figure point to the institutions that the respondents referred as their partner institutions. The reciprocated relations between two institutions are indicated in double lines (arrows pointing both sides) in the figure while the institutions that stated to be working with the state governments (in general and not specific to Himachal Pradesh Government alone) are indicated in dotted lines. Institutions connected by virtue of administrative setup are indicated in thick lines.

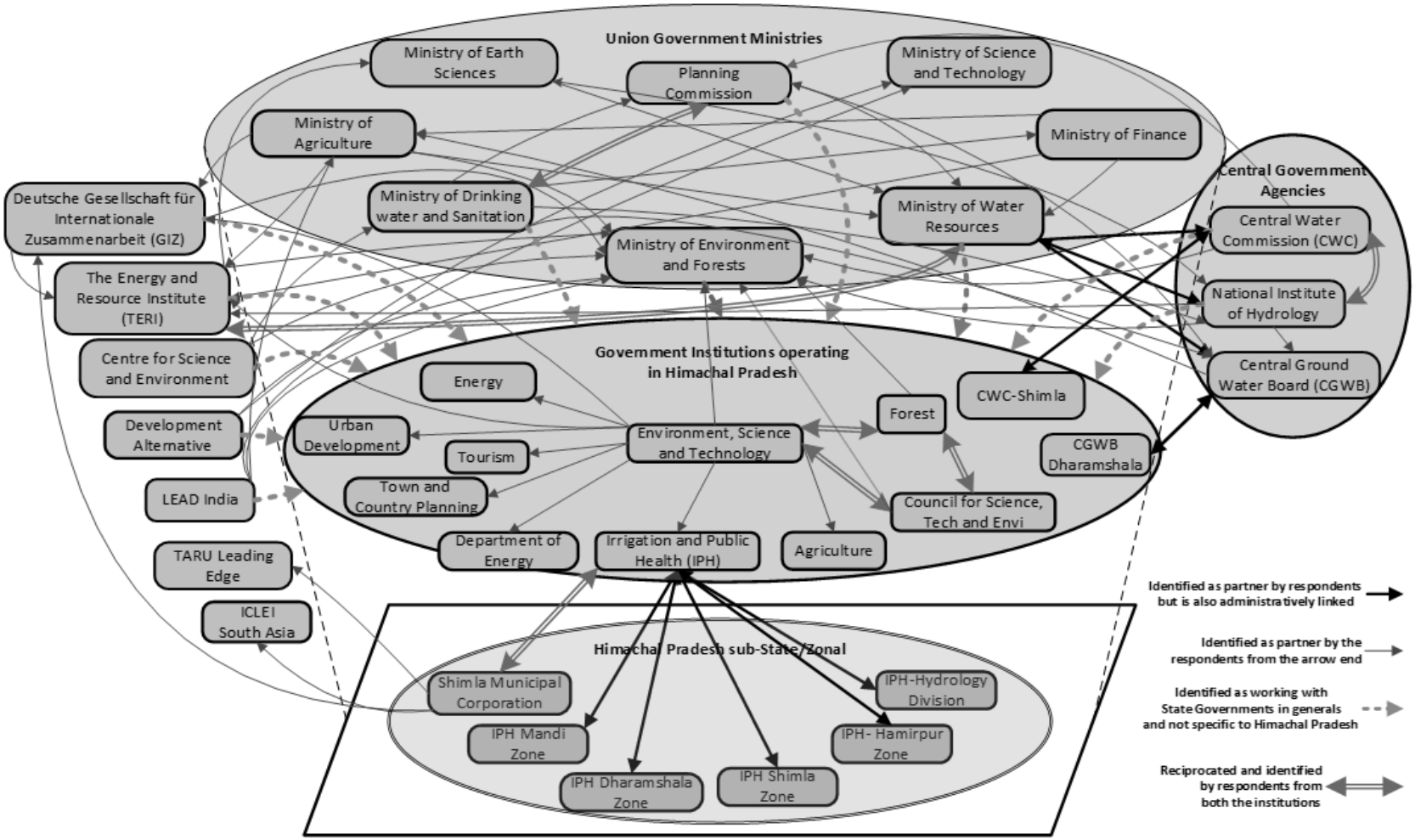

Figure 5.2: Institutional relations as derived from interviews with representatives from each of the institutions.

Respondents from four, out of the eight Union Government Ministries interviewed, stated to be working with the State Governments in general (not specifically with the State Government of Himachal Pradesh). These are Planning Commission and Ministries of Drinking Water Supply and Sanitation, Environment and Forests, and Water Resources. National Institute of Hydrology and Central Water Commission, both of which come under the Ministry of Water Resources, although operating somewhat independently, also stated to be working with the State Governments. From among the non-governmental consulting and research institutions, The Energy and Resources Institute (TERI) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) are notable. Their role was acknowledged by both the Central Government institutions and State Government departments. Other non-governmental organisations such as Centre for Science and Environment, and Development Alternatives also stated to be working actively with the State and Union Government institutions but are not mentioned by the respondents from the HP State Government departments.

In Himachal Pradesh, since the Department of Environment, Science and Technology (DEST) coordinates the formulation and implementation of the State Action on Climate Change, it has to coordinate with all other state government departments where Nodal Officers for State Action Plan on Climate Change have been appointed. However, the relation between the DEST and other state government departments are more of a one-way information dissemination, rather than two-way 'consultation' or 'collaboration'. The inter-departmental relations in the state are highly centralised, with DEST at the centre, as Figure 5.2 above shows. However, a notable affinity is observed between DEST, Forest Department and the State Council for Science, Technology and Environment (SCSTE). The respondents from these three institutions have frequent interaction and they have higher knowledge of each other's work as a result. Moreover, respondents from these three institutions alone, from among all the State Government Departments, have direct access to a Union Government ministry – Ministry of Environment and Forest. A similar reciprocated relation is reported between the Municipal Corporation and the IPH.

The respondent from Central Water Commission (CWC) at the Head Office in Delhi emphasized the importance of the State Government departments in adapting water management and how his institution is working with the later for capacity building of State water agencies. However, the respondent from CWC at the regional office

located in Himachal Pradesh does not indicate a close relation with the State Water agency (IPH) and instead indicate only a reactive approach in hydrological data sharing: *"Some format and procedure is there … to get these data. We are just seeing the justification. Anybody can ask the data but based on the requirement ... we are providing the data"* (CG12). The state government agencies instead mentioned the difficulty of accessing (hydrological) data from Central Government agencies:

> *"Nobody wants to share the data. We had memorandum of understanding, with various other organizations for sharing of the data… despite of this actual transfer of data is not smooth. You have to make real efforts to get these kinds of information. This is an area where a lot of effort is required. It is a big challenge although all the departments are government departments" (IP06).*

Interaction of the State Government departments and academic and research institutions in Himachal Pradesh was limited with the exception of a strong working relation between the Department of Agriculture and the HP Agriculture University, Palampur for dissemination of climate information to farmers.

5.4 Discussion

Three insights can be drawn from this study in relation to climate change adaptation for water management at multiple scales; a) institutions operating at different scales having different spheres of involvement can contribute to adaptation of institutions operating at another scale, provided b) bottlenecks of inter-institutional networks are overcome, and c) institutions collaborating with agencies at different scales bridge the gap. These are discussed in the following sections.

5.4.1 Variable and similar adaptation attributes and barriers across scales

Comparisons of the perspectives of the respondents from institutions operating at the national level (ION) with the institutions operating at the state level (IOS) indicate high climate change awareness across the two scales. A high level adaptation objective through the National Water Mission under National Action Plan on Climate Change (MWR, 2011; PMCCC, 2008) at the national level being complemented by the State Strategy and Action Plan on Climate Change (SSAPCC) (DEST-HP, 2012) is a strong incentive towards adaptation as awareness and high level adaptation goals are necessary attributes of adapting institutions (Wilby and Vaughan, 2011). Emphasis on the sustainability of water sources by the State water agencies is an indication of the

growing awareness of the changing scenario. However, although the ION respondents mentioned about incorporating climate change factors into infrastructure design and planning, no such initiative was reported by IOS respondents thereby indicating such an initiative is yet to proliferate to institutions operating in the State.

The respondents from ION indicated a better knowledge regarding the risk and vulnerability assessments as compared to the respondents from the IOS possibly with better accessibility to information. While the respondents from IOS reported the lack of impact studies that can inform them of the potential risks and vulnerability, respondents from ION indicated these studies are being initiated and thus implies a higher capacity and accessibility to information among the ION respondents. The ability to identify risk and vulnerability being key determinants of adaptive capacity (Engle and Lemos, 2010), respondents from research ION emphasised the need for building the capacity of IOS. Adaptation guidelines for incorporating flood risk factors into infrastructure design that can cope with higher flood risks and more reliable margins for drought planning are being initiated by ION. Respondents from IOS consider the lack of standardised guidelines for incorporating specific factor of climate change impacts to be a key challenge for making climate change allowances within their system. This quest for standard guidelines is of course challenging due to the uncertainty in climate change. However, making adaptation options, guidance and standards supplemented with building greater knowledge capacities will improve the overall adaptive capacity as has been shown in the context of the UK (McKenzie Hedger et al., 2006). The ability to access and interpret climate change uncertainties for local and contextual planning and implementation are additional capacity that is required of beyond making prescriptive guidelines available.

Similar challenges of inadequate leadership for adaptation implementation, which is often referred as adaptation champions in literature (Meijerink and Stiller, 2013), was apparent at both the national and state level. This is why one of the respondents asserted that examples of adaptation are lacking from which adaptation models can be developed. Climate change champions are not necessarily leaders with government authority but are required for enabling institutions to not only identify the potential risks and plan adaptation strategies but also to implement them. It goes beyond having expertise and knowledge to understand and implement the needs and measure the outcomes. Ekstrom and Moser (2014) therefore, propose the recruitment of climate

champions. They are usually individuals who musters supportive coalitions across institutional silos (Daniell et al., 2014) with strong motivations. Motivation is what drives actors beyond what the rules and legislations requires one to do and hence an important factor in enabling adaptation (Ekstrom and Moser, 2014). Respondents from the ION indicated a higher interest for adaptation due to the perceived opportunities that will likely improve the overall water infrastructure besides combating the climate change risks with the additional funding coming in view of climate change.

Weak management and inadequate follow-up of the planned initiatives and strategies at both the scales was observed which indicates a weak coordination. Setting achievable targets and adequate monitoring and reporting processes are essential for holding adaptation implementing agencies accountable and also to improve the learning experiences which can feed back into the loop for reviewing processes and future policy making. Currently, monitoring progress of implementation is limited since the adaptation plans are at an initial stage of implementation, although the National Water Mission has some specific targets. Management processes include how day to day decisions are made and implemented by an institution which includes the setting of goals, planning, executing and reviewing the outcome of such actions besides the daily administrative system.

Variations in the availability of adaptation attributes across the two scale is expected because of the difference in responsibilities and functions. However, determinants of adaptive capacity being similar, it is expected that the characteristics of adaptation available at one scale affects the adaptation at another scale. Therefore, having evaluated the availability (or lack) of adaptation attributes in the institutions operating at the national and at the state level, and the inter-institutional networks between the institutions operating at the two levels, the following section examines how the adaptation attributes are enhanced (or limited) by the inter-institutional networks.

5.4.2 Inter-institutional network challenges

Since the institutions operating at different scales have different roles and responsibilities they require different capacities to adapt to climate change. Nevertheless, certain traits of adaptation such as the ability to identify climate risks, accessibility to information and knowledge and the capacity to plan adaptation strategies at their level are required. In this study Social Network Analysis is employed

to assess why variations of adaptive capacity exists across scales and if such attributes can be transferred through inter-institutional networks. As accessibility to data and information was repeatedly highlighted as a key adaptation barrier by many respondents, inter-institutional networks among the key water institutions [Figure 5.3] is evaluated. Contrasting the relationships between the four key water institutions: a) Union Ministry of Water Resources (MWR), b) Central Water Commission (CWC), c) Central Ground Water Board (CGWB), and d) State Irrigation and Public Health Department (IPH) with that of the four Environment institutions: a) Union Ministry of Environment and Forest (MEF), b) Department of Environment, Science and Technology (DEST), c) Forest Department, and d) State Council for Science, Technology and Environment (SCTE), provides insight regarding the silo-attitude between the water institutions in India.

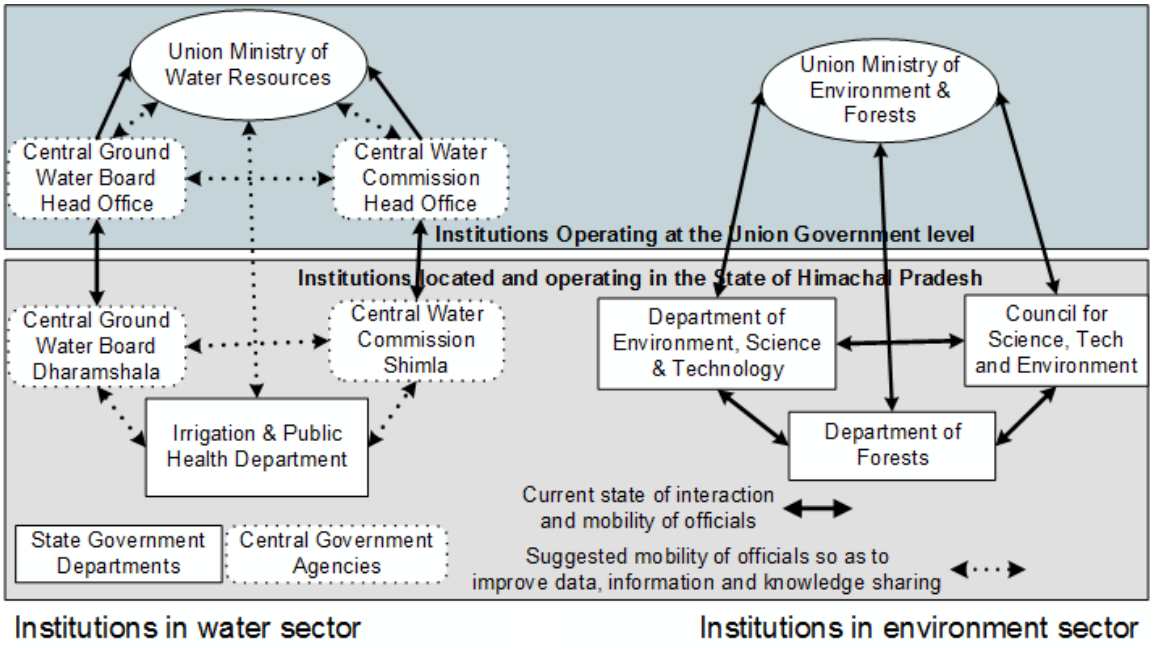

Figure 5.3: Comparison of the inter-relations between the institutions in water sector and environment sector and suggestion for improving the network.

As Figure 5.3 above shows, the relationship between the State Irrigation and Public Health Department and the two Union Government agencies; Central Water Commission and Central Ground Water Board indicated a weak link although they are all operating within the same geographical area, Himachal Pradesh. On the other hand, the DEST, CSTE and the Forest Department in the State have close coordination between them and also with the Union Ministry of Environment and Forest; such a

close interaction was not evident between the water agencies. The doted arrows in Figure 5.3 indicate the links that require a stronger coordination and the researcher suggests that even mobility of personnel in these water agencies may be necessary to improve exchange of data, information, knowledge and learning experiences that ultimately leads to greater adaptation implementation. The close affinity between the environment institutions, contrary to its absence in the water institutions, is notable because they all operate in the same geographical area – the state of Himachal Pradesh – with similar socio-cultural and political environment. This can perhaps be explained by the way the officials in the two sectors are recruited and deployed. While the officials in the four environment institutions are recruited through the same all India Services Examination, Indian Forest Services, and have the mobility to move from one institution (department or ministry) to the other (vertically from State to Union and horizontally from one department to another) the water officials (mostly Civil Engineers and Applied Geologists and Hydrologists) are recruited through four separate exams and retire within the same institution into which they have been recruited, except the bureaucrats in the Union Ministry of Water Resources who are from the all India Administrative Services. Therefore, an institutional silo has been introduced through the way the water cadre is structured unlike the Indian Forest Services cadre in environment institutions. Restructuring the water services cadre in India along the lines of Indian Forest Service can be one possible solution to improve coordination between the water institutions.

While previous studies have pointed out the challenges of data accessibility in India (Prasai and Surie, 2015) and therefore the need for greater coordination across scales, this study identified a key factor that is contributing towards this challenge and hence able to suggest a remedy to overcome this challenge. This means the important policy implication of the study is; the manner in which the water officials are recruited and deployed requires restructuring by providing water officials the provision for mobility from one institution to another as is done in the case of Indian Forest Service cadres. Availability of networks or channels of coordination does not, of course, in itself ensure the flow of information, knowledge or resources across institutions. On the other hand, strong social network ties between a few actors have the potential for holding onto redundant information and reduced likelihood of being exposed to new ideas and thus less innovative (Prell et al., 2009). However, accessibility to hydrological data and information (collected by different institutions in this context) being key to adaptation

planning and implementation, inter-institutional network barriers end up becoming adaptation barriers. Inter-institutional network barriers and inaccessibility to data and information is not unique to the Indian context and is reported in other developing countries such as Bangladesh (Prasai and Surie, 2015) and Cambodia (Dany et al., 2014) which also attributed to trust deficits between actors in different institutions. The inter-relations between two institutions or departments within the government also depend on the personalities of individual key officials.

Earlier studies (Corfee-Morlot et al., 2009, 2011; Jogesh and Dubash, 2015), have pointed out the need for "building in incentives for performance and creating accountability and transparency in bureaucracy" (Narain, 2008, 2000; p.432-433) through both top-down and bottom-up approaches of incorporating best practices through a two-way learning process. Yet, empirical studies that highlight the critical points of interventions are lacking to date. The current study establishes that the fragmentation of coordination can also be due to the way water officials are recruited and deployed – not just the lack of legislations that prescribe the need for integrated coordination or recognition of the need. Although earlier studies (Ananda et al., 2006; Narain, 2000; Saleth, 2004) have argued the weaknesses and the lack of coordination among water institutions in India, it does not diagnose the root causes for this lack of coordination.

5.4.3 Bridging institutions

In addition to the inter-institutional networks between government institutions, the study shows the key role being played by the bridging institutions. Bridging institutions act as connecting links between different sectors and institutions operating at different scales and broker knowledge and information in addition to acting as the passage through which the learning processes occur. In this study, the critical role these bridging-institutions are playing in not only providing the connecting link between government institutions operating at different levels but also in knowledge generation and dissemination of information and broadening of bottlenecks is evident. Other studies, such as Wyborn, (2015) have shown how the absence of brokers and/or structural linkages between different arenas of governance constrained the adaptive capacity and how broader socio-political contexts shape its capacity to coproduce knowledge. In this study, a few institutions interacting with both national and state level institutions are playing an important role in enabling adaptation. Their active involvement enhances or

expand the bottleneck between the institutions operating at the national level and the other institutions that are operating at or below the State/regional level.

Other than the Union Government Ministries, the institutions which are working very closely with the state governments are Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Central Water Commission, National Institute of Hydrology, The Energy and Resources Institute (TERI), Development Alternative, and Centre for Science and Environment. Central Water Commission being a Union Government agency, working directly within the Ministry of Water Resources and having regional offices in the different regions/states, for hydrological data collection and monitoring, it is expected to be working as the connecting arm between the Union Ministry of Water Resources and State governments. State Government institutions are also dependent on Central Water Commission for their expert in flood forecasts and other hydrological data. TERI and GIZ are two non-governmental institutions playing a key role not only in creating adaptation capacity for State government institutions but also in bridging the relation between the state governments in India with the Union Government institutions in the country. GIZ was instrumental in consulting the State governments to frame the state action plan on climate change including formulating the State Action Plan for at least twelve states. While TERI was acknowledged as a consultant or partner in five of the State Action Plan for Climate Change and hence was instrumental in the climate change discourse in the country and playing a leading role in developing knowledge regarding the impact.

As far as building awareness and planning climate change adaptation strategies in general (not specific to water alone) is concerned, the bridging institutions are playing a crucial role of connecting the institutions at the Union level with the States. But in the case for adapting water management to climate change, which requires effective coordination and sharing of data, knowledge and experiences between government institutions, prescriptive legislations alone that prescribes institutions to coordinate and share data and resources is unlikely to achieve desirable outcomes unless the network between the water institutions is drastically improved. For example, Prasai and Surie (2015) have shown that accessibility to hydrological data in India has not improved in spite of the Right to Information Act 2005, and both National Water Mission (MWR, 2011) and National Water Policy (MWR, 2012) committed to making hydrological data available in public domain. As corroborated by one of the interview respondents,

although his department has memorandum of understanding with other institutions, hydrological data accessibility remains an issue. This points to the need for taking other measures beyond mere legislations to make data and information available in public domain and integrated water resources management approaches being advocated in National Water Policy (MWR, 2012).

5.5 Conclusion

This study illustrates that institutions operating at the national level have the potential to create adaptation enabling opportunities for institutions operating at other scales which are implementing national strategies or developing and operating water infrastructure. However, this can be limited due to the inter-institutional fragmentation that reduces accessibility of data and information and sharing of knowledge and learning experiences. While national adaptation strategies and goals can inspire adaptation at the lower scales, bottlenecks between institutions need to be addressed. In order to improve inter-institutional networks between different water institutions – thereby improving data accessibility, information, knowledge and experiences sharing across institutions that ultimately enhance adaptation – this study shows that Social Network Analysis theories can provide knowledge regarding the bottlenecks between government institutions. This study thereby demonstrates that our ability to understand adaptation by water institutions will depend on politics, social networks between officials in different government institutions and other factors that affect perception of climate change risks, opportunities and implementation strategies. This study raises important questions regarding the adaptation being affected by several factors outside of the particular institution that affects its ability address climate change impacts on water management.

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6 CONCLUSION

This thesis evaluates the involvement of Indian institutions operating at the Union Government and State Government levels for adapting water management to climate change in order to identify factors and circumstances that enhance or hinder adaptation. This concluding chapter summarises the key findings from the preceding four chapters and highlights how the thesis addresses the aim and objectives. It finally concludes by discussing the implication of the findings for policy implementation and identifies further research needs.

6.1 Summary of key findings and reflections

The review of literature in Chapter 2 reveals that the current discourse on adaptation focuses mostly on natural systems and vulnerable communities but rarely on water institutions that manage societal and ecological needs for water. Since climate change is experienced mostly through the medium of water, institutions across administrative scales need to adapt through an improved coordination. Social Network Analysis (SNA), a nascent tool for stakeholder engagement and adaptive management of natural resources, is beginning to be applied at the individual level but rarely at the inter-institutional level.

As climate change adaptation research progresses to implementation, adaptation barriers are emerging. However, the current literature fails to identify why certain barriers emerge and are sustained; this is due to the limited number of empirical studies that demonstrate how adaptation is successfully implemented [Section 2.4.3]. Few studies that have identified attributes of well adapting institutions, from water companies and municipal bodies in industrialised countries, have little relevance to water management in developing economies, such as India, where public water supply for domestic, agricultural and industrial use, besides flood control and inland navigation, is the responsibility of the government institutions.

Current literature regarding the relationship between a) adaptation enabling characteristics, b) adaptation barriers and c) manifestation of adaptation is fragmented. In order to understand the relationship between these three components, a conceptual diagram [Figure 2.1] is proposed. This [Figure 2.1] also provides the framework and the connecting thread to the three chapters that followed the literature review. Based on the empirical findings in Chapters 3, 4 and 5, the conceptual diagram is updated [as presented below in Figure 6.1] which also demonstrates how this research has extended the knowledge of adaptation for water management. These findings are further elaborated in the succeeding sub-sections.

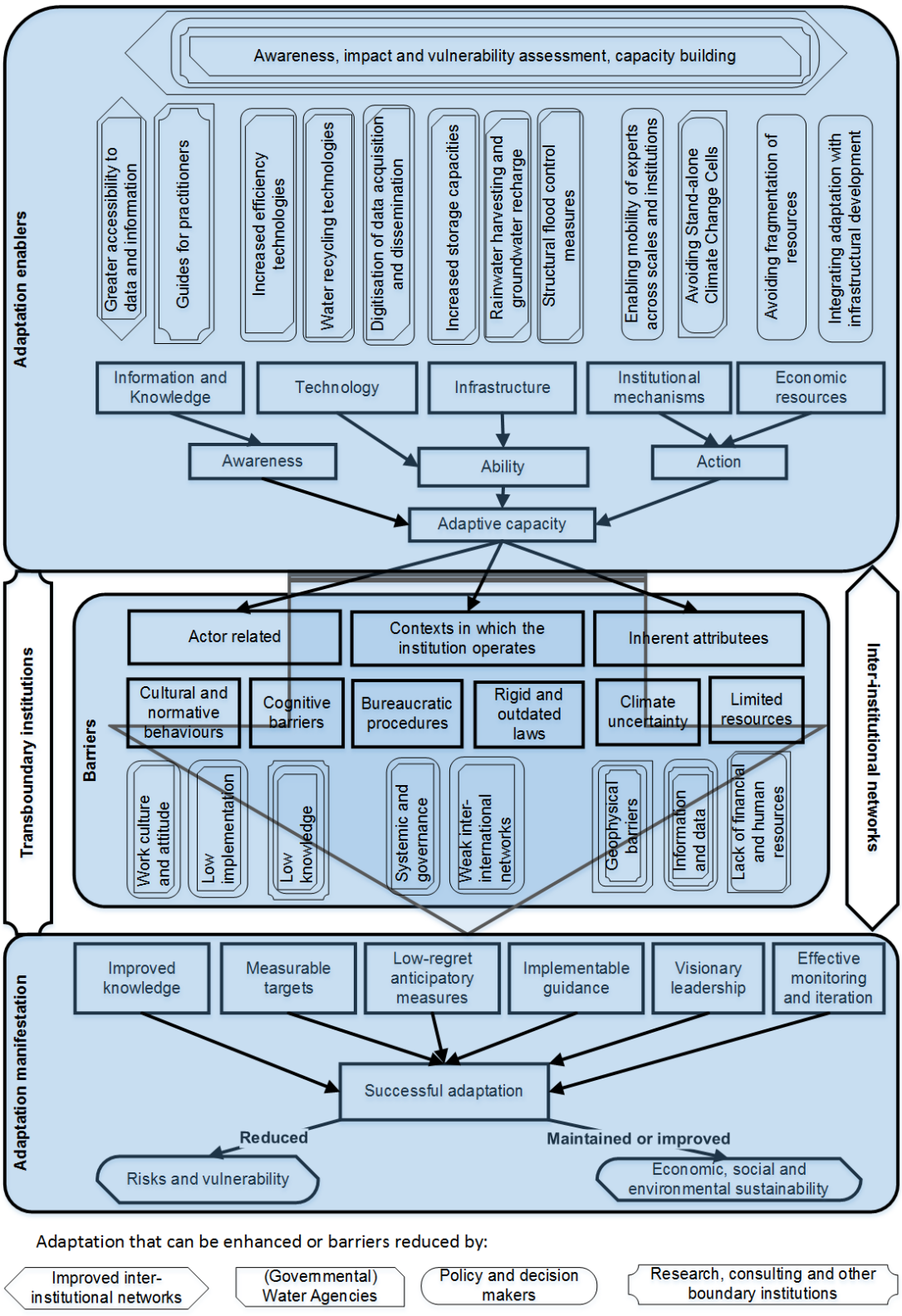

Figure 6.1: Conceptual diagram indicating the various components that shape adaptation enablers and barriers.

6.1.1 Involvement of institutions at the national level for adaptation

Having identified the key knowledge gaps in literature and established a framework to evaluate and identify adaptation enablers and barriers, Chapter 3 includes an investigation of the activities, policies and strategies of climate change adaptation for water management in India initiated by Union Government institutions. Government documents, available online, provided the basis for interview questions besides systematically identifying the key institutions with whom interviews were carried out. Interviews with officials from key institutions revealed that the adaptation initiatives and the inter-institutional networks online are but a partial record of how the key Union Government institutions are involved in climate change adaptation for water management. Key barriers to implementing adaptation strategies became apparent when examined with the actors and decision makers within these key institutions.

The key findings of Chapter 3 can be summarised as follows:

- Union Government institutions actively involved in water management, both for resources development and water-related-risk reductions, are not as involved as other institutions such as Ministries of External Affairs and Finance, which are less climate sensitive institutions, in the climate change discourse [Figure 3.4]. This indicates the need for greater involvement by the former as climate change impacts are experienced most severely through the medium of water. It could also mean that climate change impacts on water management are largely ignored or at an early stage of understanding the implications [Section 3.3.1].
- Online documents of key Union Government institutions and the perspectives of respondents from these institutions, supplemented by responses from other key institutions, present diverging perspectives regarding who is involved and how adaptation of water management for climate change is taking place in India. As such, the two need to be reconciled [Section 3.4].
- Climate change is rarely the sole motivation for adapting water management to climate change in India. The main motivation is towards meeting the growing demands of water supply and averting floods and droughts and hence adaptation need not be justified by climate change alone. The perceived opportunities that climate change bring to the Indian context lie mainly on drawing the attention of policy makers when allocating additional (financial and human) resources to develop water infrastructure rather than taking advantage of the changes in physical water system [Section 3.3.4].

- Institutional and systemic challenges that hinder smooth coordination and accessibility to data, information and knowledge need to be addressed besides other competing infrastructural and technological developmental priorities [Section 3.4].

Thus chapter 3 contributes to the aim of the thesis through addressing objective 2 which is *to evaluate the involvement and inter-institutional networks among the key institutions operating at the national level in India for evaluating the factors that enhance, share or create characteristics of adaptation*.

6.1.2 Barriers of adaptation implementation at the local level

Having gained key information regarding the initiatives being taken for climate change adaptation by institutions operating at the Union Government level, Chapter 4 proceeds to examine the challenges of implementing adaptation at the State level, with Himachal Pradesh as a case study. Through a careful scrutiny of the in-depth interview responses of representatives from twenty-six institutions, this chapter examines how barriers emerge and are sustained by a range of other overriding socio-economic-politico and cultural contexts. They illustrate that similar adaptation barriers can emerge from different backgrounds, thereby providing empirical evidences for grounding adaptation strategies contextually [Section 4.3.3].

Comparison of the barriers identified in this study with those reported in other studies, in other contexts, shows that although some of the barriers illustrated in this study bear resemblance to those identified by other researchers, the causes for the emergence of those barriers differ due to the variations in socio-economic-political context [Section 4.4]. For instance, whilst other studies have identified 'political barriers' to adaptation due to the climate scepticism of decision makers, this study illustrates that the political leaders in Himachal Pradesh showed interest in climate change issues. However, they introduced a reactionary resource allocation mechanism – allotting financial resources on the basis of public pressure to all sectors, issues and locations. This resulted in fragmentation of the resources. The allocation of resources is largely determined by the immediate needs in a developing economy; the long term consequences are often considered to be secondary and hence the limited resources are often deployed for immediate and visible needs.

Breaking and overcoming these inter-connected barriers will involve an approach from a systemic perspective. For instance, institutional structural changes and inter-institutional agreements for sharing of data and information need to be accompanied with capacity building regarding utilisation of climate information. For barriers that emerge from socio-

cultural normative behaviour, such as inaccessibility to data and information, or the low quality of collected data, and indifference to the impacts to other sectors or institutions, this research demonstrates that prescriptive rules and legislation alone are inadequate. In addition to formal inter-institutional agreements and legislation for data and information sharing, attitudinal change and alterations in working paradigms, such as switching from the paper based data management to digitisation, will be essential.

Thus Chapter 4, in addition to contributing to the aim of the thesis by addressing objective 3 which includes *identifying the underlying causes of adaptation barriers and the inter-relationships between them*, also highlights key policy measures that are required to be implemented for enabling adaptation which are succinctly listed in Section 6.2.3.

6.1.3 Cross-scale inter-institutional networks

Having examined the initiatives for adaptation and challenges both at the National and State levels, Chapter 5 examines the two scales together focussing on the vertical relationships between the two. By evaluating how and if adaptation characteristics are being manifested at the two scales of water governance in India, this chapter examines how the adaptation characteristics at the national level are impacting the state level institutions through the inter-institutional networks. The weak collaboration between the Central Government institutions and the State Government institutions is noticeable as a key barrier to data accessibility and sharing of learning experiences. This also leads to duplication of data acquisition activities in some instances and unavailability in others, thereby leading to adaptation barriers. Initiatives to build the adaptive capacity of local implementing agencies are constrained by the weak vertical inter-institutional relations between the institutions operating at the national level and state level. This is where the role of bridging institutions that are collaborating with the National as well as the State institutions becomes crucial in enabling adaptation.

Thus, Chapter 5 contributes towards the aim of the thesis by showing that the enhancement of adaptive capacity of institutions operating at different scales is constrained by inter-institutional bottlenecks while also demonstrates the key role played by bridging institutions that narrow the gap between government institutions operating at different administrative scales. This also means the study has important policy implications for improving transference of adaptive capacity across institutions operating at other administrative scales.

6.2 Implications of research findings

In the light of the above highlighted research findings, the following conclusions regarding

contribution to knowledge and policy implications for adapting water management, can be drawn.

6.2.1 Methodological contribution

This thesis employed a novel method to systematically identify key institutions involved in a particular discourse; in this case water and climate change. The complexity of adapting water management to climate change in India with multiple institutions involved means that the interrelations between the different institutions are hard to decipher; also it is difficult to identify the key players. Social Network Analysis is employed innovatively to analyse the inter-institutional interactions by using data already available in the public domain – websites of government institutions. This analytical approach provided a means of identifying the key institutions and their contribution towards climate change adaptation discourse in a vast, complex, inter-disciplinary and inter-sectorial context. This simplified the understanding of a complex system where multiple institutions are involved.

Mapping the inter-institutional dynamics between the key institutions and tracing the potential influence of these dynamics provided an insight into the discourse of the likelihood (or unlikelihood) of adaptation strategies, framed by a national government, being implemented successfully across scales. This resulted in an understanding of the weak linkages between specific key institutions. The systematic online document evaluation provided a framework for understanding who is involved, interested and with whom; although this is only a partial projection of how key institutions are involved in climate change adaptation. This evaluation was complemented with qualitative in-depth interviews with key officials within these institutions. Online documents and webpages are particularly important in an information technology era in which websites, rather than buildings, of the institutions present a public image where people 'visit' and draw conclusions as to what the institution's mandates and responsibilities are and their key involvements and interests.

Although the online documents analysis led to the identification of key institutions and the evaluation of their involvement and interactions, the internal dynamics of institutions and the challenges of effective inter-institutional networks are difficult to be ascertained by the analysis of online documents alone. Interviews with key representatives overcame this limitation. The use of semi-structured interviews enabled the researcher to probe for more detailed responses where the respondent is asked to clarify what they have said (Robson 2011). It was particularly helpful where the respondent enjoyed talking about their work rather than filling in questionnaires (Gray 2004). For instance, in-depth discussion of the

results of the quantitative online documents discussed with representatives from a few key institutions, individually, brought out perspectives that could not be drawn out otherwise [For example, respondents were surprised to note that Ministry of Finance and Ministry of External Affairs has more documents mentioning climate change than Ministry of Environment and Forest or Ministry of Water Resources. Figure 3.4]. These discussions resulted an understanding of the nuances of the involvement in climate change adaptation and the network dynamics in a much richer way than what was projected by their websites. Also, such in-depth discussion is not possible without first examining their documents.

Qualitative research does not claim to generate general theories of phenomenon for universal application from representative samples (Wyborn and Bixler 2013). Its strength lies in the possibility of providing insights from the perceptions and interpretations of key selected individuals (Wyborn 2015). Perceptions of key players in the climate change adaptation are a crucial element in framing and strategizing adaptation options and policies. These key players provide specific insights because of their position, experience, association and attitude. Quantitative online document surveys complemented qualitative analysis by identifying important institutions for climate change adaptation.

Social Networks Analysis (SNA) is only beginning to be applied in environmental and adaptive management studies and mostly applied at the individual level. This study demonstrates that SNA can supplement qualitative evaluation of multi-stakeholder involvement. By demonstrating [Section 5.4.2] that a primary cause for data and information inaccessibility among water institutions in India relates to the way water professionals are recruited and deployed, through a social networks perspective, this study not only identified the need to approach adaptation holistically but also the applicability of SNA in climate change and water governance studies.

6.2.2 An improved understanding of adaptation process:

This research identifies and expounds adaptation enablers and barriers and extends knowledge for water institutions to adapt to the changing climate. Figure 6.1 above elucidates the various components involved in adaptation. In the figure, factors that enable or hinder adaptation [and dependent on a particular type of institution] are enclosed within a symbolic figure; components that are required to be acted or affected by two or more types of institutions are indicated concentrically.

A survey of existing literature [discussed in Chapter 2] identifies that information and knowledge, availability of technology, infrastructure and economic resources and a

conducive institutional mechanism determines adaptation implementation. These factors influence the awareness of the potential risks and opportunities and the ability of water institutions to plan and execute adaptation measures and hence make up their adaptive capacity. This, of course, assumes the availability of human resources and a willingness to act based on these determinants.

Empirical findings from this study indicate that these adaptive capacity determinants are in turn fed by various other elements which are not necessarily independent of each other. The elements listed in Figure 6.1, such as the accessibility to data and information, guidance for practitioners, availability of alternative technologies and resources, are not an exhaustive list. Nevertheless, the figure illustrates that these elements add up to the adaptive capacity and that various actors have distinct and complementary roles to enhance adaptive capacity creation and utilisation. Awareness raising, evaluation of potential risks and opportunities and building capacity, require collaborative efforts between various actors, illustrated concentrically at the top in Figure 6.1, encompassed by inter-institutional networks. While there are specific roles to be acted upon by particular institutions, there are overlapping roles which need to be executed by various actors, often at different administrative scales. For example, while fragmentation of resources depends largely on policy makers, development of adaptation alternative technologies, assessment of potential risks and opportunities and guidance for practitioners are developed through the collaboration of research institutions and water agencies. This is favourable if surrounded by a conducive institutional environment to be largely enhanced by policy makers.

While the absence of these adaptive capacity determinants become obstacles to adaptation, and their availability reduces adaptation barriers, enablers and barriers are not mutually exclusive mirror of each other. Findings in this thesis point to the evidence that adaptation barriers can continue to thrive even in the presence of (certain) adaptive capacity determinants. For example, this research shows that acceptance of a changing climate does not necessarily lead to proactive adaptation action nor the existence of prescriptive legislations leading to smooth accessibility of data and information. Understanding and prioritizing adaptation is shaped by many political and socio-economic developmental priorities.

This thesis therefore, demonstrates that the path from awareness and acceptance of climate change to adaptation planning, implementation and successful outcome is a long and winding one. It requires overcoming many barriers and encounters various challenges and crosses paths with various other non-climatic challenges that are shaped by socio-economic

and political factors as much as geophysical features. This is evident from the findings in Chapters 3 and 4 that direct correlation between awareness of climate change impacts for water management and the adaptation actions being initiated is not evident. Further analysis of the challenges in these two chapters established that, due to the contextual nature of adaptation and the hiddenness of adaptive capacity, adaptation barriers are often not obvious and closely interconnected to other socio-economic and political factors. These findings corroborates earlier studies (Amundsen et al. 2010; Biesbroek, et al. 2014; Eisenack et al. 2014) that posited the potential linkages between institutional factors and adaptation barriers. Therefore, this thesis argues that adaptation to climate change for water management has to take into account these various socio-economic and cultural factors. Thus it contributes towards a more nuanced understanding of the adaptation process from awareness to adaptation planning and implementation winding through various barriers [Figure 6.1].

a) Adaptation enablers

Findings in this thesis suggest that these adaptation enablers can be enhanced and the barriers reduced through inter-institutional networks that provide accessibility to the available information and knowledge while also generate additional information and knowledge through the interaction. Transboundary institutions – institutions that collaborate with government agencies at different administrative scales and also between science, policy and implementation [Section 2.3.3] – play a key role in enabling adaptation but cannot entirely circumvent the inter-institutional fragmentations within government institutions, agencies or departments. Although transboundary bridging institutions can narrow the gap between water institutions operating at different administrative and geographical scales as well as between science, policy and implementation, inter-institutional networks between public institutions have their own distinct roles in enabling adaptation. Thus, as Figure 6.1 above illustrates, transboundary institutions and inter-institutional networks are two pillars of adaptation and also bridge the gap between adaptive capacity and adaptation manifestation that enables water institutions to cross the chasm of adaptation barriers.

Whereas previous works on institutional analysis (Dinar and Saleth, 2005; Reddy and Reddy, 2002; Ananda et al., 2006; Gandhi and Namboodiri, 2009) tend to focus more on ‘institutional components’ such as water law, water policy and water administration and their abilities, this research addresses the networks that bind various institutions together, not exclusively on their internal qualities or abilities. This thesis therefore, complements the earlier institutional analysis dynamics frameworks (Gandhi and Namboodiri, 2009; Gandhi et

al., 2009) that are more inward looking and narrowly focused on individual institutions (although the importance of interconnection is well recognized) and add a critical dimension that captures the connecting nerves of the whole body as a system. This thesis, therefore, captures the opportunities for improving the adaptive capacity of the institutions from different sectors and across scales.

The perspectives collected empirically from different types of stakeholders, ranging from representatives from Union Government ministries that make policies, to government agencies that collect hydrological data, monitor and implement developmental projects to research and academic institutions and non-governmental organisations, led to an identification of the practical barriers based on the ground reality. This rich perspective, coupled with a critical analysis of the different roots of adaptation barriers, provides a unique position to understand the factors and/or circumstances that enable, enhance, share or generate adaptation enabling characteristics.

The empirical study regarding the Himachal Pradesh Irrigation and Public Health Department supports the idea that adaptation is context specific and contingent upon such factors including aptitude and attitude of implementing agencies towards risks (Wilby and Vaughan 2011), political and circumstantial priorities (Haddad 2005) besides the availability of resources and technology. However, it also raises doubts regarding the assumption that water administration in India is the responsibility of State Government institutions. It clearly points to the need for involvement of other institutions such as research and non-government institutions besides the Central Government agencies operating at the regional and State level to national authorities. This study shows that the State Government institutions alone are incapable of addressing the water management challenges which are being exacerbated by the changing climate.

b) Adaptation barriers

This study identifies specific, contextual key barriers at the National, State and local level that slow down or hinders adaptation while also identifying the key opportunities for removing those barriers and creating enabling mechanisms. It went beyond identifying specific barriers of adaptation implementation and identified the underlying causes of these barriers and the intricate relationships between them. This knowledge of identifying the underlying causes of different barriers and the relationships between the barriers brings us closer to understanding the dynamics of how barriers emerge and are sustained due to a range of interconnected causes.

As discussed in Chapter 2, Section 2.2.3 and Section 2.4.4, Figure 2.1, barriers can be broadly categorised into a) actor related barriers such as the cognitive capacity and the cultural attitudes towards risks, b) the contexts in which the institution operates such as the laws and legislations that binds the institution or the normal bureaucratic procedures of decision making and execution, and c) inherent attributes such as the complexity and uncertainty of climate projections and the limited availability of technological, human and financial resources. Findings based on the responses from the institutions operating at the national level in Chapter 3 (Table 3.2) and responses from institutions operating at the state level in Chapter 4 (Table 4.1) suggest that among the actor related barriers, lack of knowledge capacity, poor coordination and awareness and inaccessibility and incomprehensibility to existing data and information are some of the key factors. Another key factor leading to the actor related barrier is the normative attitude and complacency among institutions which are expected to implement adaptation strategies or collect key data. Some of these factors leading to the barriers are highlighted in Figure 6.1 although it is only an indicative sample of the factors leading to such barriers.

Among the factors that are related to the way in which the institution operates are the traditions of long bureaucratic procedures of decision making and obtaining data and information, and the general governance issues. There are other inherent challenges such as the local geophysical challenges that contributes towards adaptation barriers. As indicated by Figure 4.3 the various factors leading to the adaptation barriers are closely intertwined and dependent on one another. Nevertheless, categorising these various causes of adaptation barriers and further analysis of who should do what to reduce the adaptation barriers, as is indicatively shown in Figure 6.1, will be helpful for identifying potential solutions. Since overcoming barriers requires the understanding of the causes of its emergence, regular evaluation and assessment of what worked and what did not, is crucial. More research is necessary for disentangling the different causes of barriers and the inter-relationship between them so that solutions for overcoming the barriers can be evolved. Although adaptation to climate change is highly local context specific, the support of national governments, international donors and research institutions is necessary for identifying adaptation strategies, funding and to prevent maladaptation.

The interconnectedness of barriers has been articulated in Chapter 4. Nevertheless, categorisation of the adaptation barriers will enable the identification of adaptation strategies more efficiently. For this, further research as to how best the barriers can be categorised and a typology of barriers is required to be developed so as to assist towards understanding the barriers better as well as in articulating more efficient adaptation strategies.

6.2.3 Implications of the research for policy making

Findings from this research points to a few important policy implications that needed to be addressed by policy makers in India. Other developing countries facing similar governance and climate change challenges will also be able to draw important lessons:

a. 'Business as usual' cannot be considered as 'mainstreaming adaptation'

In order to translate statements of good intentions into operational realities, adaptation barriers identified in this thesis need to be addressed. The findings in this thesis challenge the continued subscription among policy makers in India to the idea that climate change adaptation could be achieved through a bureaucratic institutional procedure. The thesis highlights the necessity for new institutional approaches that need to be evolved if the collaboration among government institutions, that are playing the key role in water management, are to be improved.

Water flows across political and administrative boundaries. Global climate change impacts affect everyone irrespective of who caused it. Therefore, information and knowledge regarding its management need to cross watertight institutional boundaries. The need for inter-institutional and inter-sectoral collaboration is not new in the context of climate change adaptation and water management. However, this study, bringing a distinctive perspective from Social Network Analysis theory, suggests the need for providing mobility to water officials in key government institutions through whom knowledge and experience can flow across institutional boundaries as discussed in Chapter 5.

Some respondents in this study [Section 5.2] argued for centralising the governance of water in India by making water a Central (federal) Subject, instead of the current State Subject. However, transferring water governance responsibility entirely to the Central Government is not politically feasible because of the federal structure of India and the different power games involved between the States and Union Government. Instead, this research argues that the challenges of inter-institutional networks needs to be addressed by providing

mobility to the water officials in key government agencies which allows them to move vertically and horizontally from the State to the Centre and vice-versa and between States [Section 5.4.2]. Discussion in Chapter 5 has not only argued the need for implementing this proposition but has also shown that prescriptive legislation has not worked and hence requires a shift in understanding of how water institutions perform.

The National Water Policy and the National Water Mission both clearly recognise the need for cross-institutional and cross-sectoral collaboration and the need for providing accessibility to the available data and information. However, recent studies (Prasai and Surie 2015) have clearly pointed out that it is not happening in spite of the repeated endorsement from the top. Fundamental changes, not only in how water is allocated, planned and managed, need to be undertaken but there is also a need to change the manner in which water officials are recruited and deployed in order to enhance mobility of data, information, knowledge and learning experiences across institutions.

b. Aligning adaptation strategies with development to deliver co-benefits

The findings of this study show that adaptation actions inconsistent with developmental pathways may face greater resistance of implementation. Therefore, in circumstances of infrastructure development deficits, adaptation strategies are required to be introduced through co-benefits of development. The interconnectedness of barriers, identified in Chapter 4, means that policy makers have to approach adaptation holistically by taking into consideration the various underlying causes of adaptation barriers.

c. Stand-alone Climate Change Cells/Units need to be avoided

In order to mainstream adaptation effectively, it is necessary to go beyond the environmental institutions (such as the Ministry of Environment and Forest at the national level and Department of Environment, Science and Technology in the Himachal Pradesh State). Stand-alone units or departments and Climate Change Cells should be avoided although such units are required to monitor the progress and coordinate. As this thesis stresses in the Introduction, water institutions themselves need to adapt, not just enable individuals and society to adapt.

d. Guidance for practitioners

The practitioners' quest for 'precise' guidance from researchers and policy makers is unlikely to be feasible due to the uncertainty of climate change. However, making adaptation options, guidance and standards available to practitioners, supplemented with building greater

knowledge capacities, will improve the overall adaptive capacity of water institutions.

e. Restructuring the cadre system of water officials

Restructuring the way water professionals in governmental water institutions are recruited and deployed needs to reconsidered by the government. It should be structured in a way to enhance networking between officials in different government departments and institutions so that accessibility to available data and information and exchange of learning experiences is enhanced. Instituting an Indian Water Services cadre, along the lines of Indian Forest Services (IFS), who have the flexibility to work in any of the government water related institutions, just as the IFS cadres can be deployed in various forest and environment related institutions, will perhaps improve the inter-institutional networks as was observed among institutions in the environment sector in Chapter 5 (Section 5.4.2 and Figure 5.3).

f. Need for leadership on climate change adaptation

There is a clear need for leadership on climate change adaptation in India both at the National level and State level of water governance. The lack of guidance from the Union Government institutions, who are expected to have more resources and capacity, also came out very strongly in the interview discussions with the State respondents. The Government needs to promote inter-disciplinary water professionals.

g. Need for building knowledge and technological capacity

Effective mainstreaming of adaptation requires knowledge capacity for accessing and utilising climate information and new tools and models for risk assessment need to be made accessible and available to practitioners. Some of these technologies and techniques are highlighted [in Chapter 3] by some of the respondents in this study.

h. Relevance for the Paris Agreement implementation

Findings in this research (Figure 3.3) indicates that adaptation lags behind mitigation at the country level in terms of political leadership and resources allocation in India. The need for inclusion of adaptation as a national agenda emphasized by the Paris Agreement (Article 7) (UNFCCC, 2015) boosts the establishment of the processes and structures necessary to accelerate the adaptation momentum set out in the National Water Mission (MWR, 2011) under the National Action Plan on Climate Change (PMCCC, 2008) in India. The findings in this research exposes the state of involvement by various institutions in India in the climate change adaptation discourse which the Paris Agreement sought to involve. This research contributes to the three challenges of realising the Paris Agreement goals which Lesnikowski

et al. (2016) highlighted; although, admittedly, further research is required in this aspect. Firstly, by identifying the context specific nature of the existence of adaptation barriers it enhances knowledge regarding the challenges of 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability' (Article 7, para 2) which provides additional knowledge for framing context specific adaptation strategies. Secondly, the research shows that adaptation barriers are deeply intertwined with other governance and developmental issues that interferes with decision making on resources allocation and setting priorities for the government. Consequently, adaptation strategies in developing economies, such as India, need to be aligned with developmental activities. Thirdly, by indicating that the fragmentation of resources allocation contributes to reduced available funding for adaptation, this research informs decision makers of the need for identifying judiciously where the spending should be focused.

The widened understanding of the complex, multi-layered inter-relationships between institutions involved in climate change adaptation in India (Chapter 3) provides valuable knowledge for knowledge generation and sharing of experiences that the Paris Agreement emphasises. The state of the inter-institutional networks between the institutions operating at the national and state level (Chapter 5) also provides valuable knowledge for understanding the need for putting in place certain institutional structures including the suggestion for revamping the way water officials are recruited and deployed in India. This will go a long away into improving the knowledge network in India which the Agreement espouses.

Tracking the progress of adaptation being attained by Developing Country Parties and identification of financial, technology transfer and capacity-building supported needed being important components of the implementation of the Paris Agreement, the findings in this research is particularly valuable. The evaluation of the state of involvement in the adaptation discourse by various institutions in India, through the analysis of online government documents supplemented by perspectives of officials working within these institutions, also provides a transparent method of evaluating the state of involvement which other studies can adopt for evaluating the state of involvement by different parties. Nevertheless, further studies are required to keep track of the progression being made and how the initiatives being currently made (by various institutions in India) contributes towards 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change' (Article 7, para 2). Moreover, as the adaptation implementation progresses, new barriers and challenges are also likely to emerge. These new and emerging challenges will require constant evaluation and reiteration in the adaptation process.

6.3 Need for further research

The findings of this study have identified a number of other areas of research that need further investigation. For example, the learning opportunities from adopting larger sources of water supply, which are perceived as low regret adaptive measure, being initiated by the State agencies in Himachal requires further evaluation. Further research is required to understand whether these examples can be replicated in other contexts as it is necessary for scientific knowledge, economic development and maladaptation avoidance. The economic viability of investing in a larger source and potential conflicts with other sectors and stakeholders require further investigation.

Secondly, this research indicates that resources are allocated based on the demand of the public. How then does democratic governance affect adaptation implementation in various contexts needs further investigation? This knowledge is required to understand if further sensitization of the potential climate change risks will enable the electorate to influence decision makers to address climate change challenges.

Thirdly, this study indicates that the key actors in the government institutions recognise the need to engage with institutions from other sectors as well as the general public. But, as pointed out by some respondents, few engagements are occurring. Therefore, studies about the difficulties of engaging with other institutions and the general public will lead to understanding of the barriers of translating the adaptation plans into implementation, particularly in the light of the increased recommendations for participatory approaches in water management. Most importantly, different actors perceive stakeholder engagement differently. For example, some government institutions perceive issuing government orders, particularly from Union Government institutions to State Government institutions, as engaging with other stakeholders while literature indicates the necessity for a bi-directional flow of information and knowledge.

Finally, in the interviews with the representatives from key government institutions, while there is a possibility of positive bias, for example, regarding initiatives being taken by them and the wide network they have, the range of constraints and barriers highlighted by the respondents indicated a desire to engage constructively with the research. However, four of the respondents refused to be audio recorded which might relate to cultural prejudices or past experiences. Understanding the role of cultural attitudes of transparency and trustworthiness will be an added value to the knowledge of climate change adaptation albeit beyond the scope of this research. There were issues of trust-deficit when it comes to

sharing of data and information between governmental institutions and non-governmental institutions. Further studies to understand the underlying causes for such trust-deficit will be an added advantage to addressing climate change adaptation barriers.

6.4 Epilogue

This research was carried out at a time when water governance in India was going through a sea change among which climate change is one of the drivers. Although the scope of the research is confined to addressing climate change adaptation, its findings are useful and relevant to the current discourse on reform of water governance in India. Moreover, many State Governments that are in the process of framing their State Action Plan on Climate Change will also find the insights from this research useful for adaptation implementation. Other developing countries facing similar challenges of adapting water management will probably resonate with some of the barriers identified here and hence policy implications and further research needs, highlighted here, will be of importance.

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APPENDICES

Appendix A : National Action Plan on Climate Change. Government of India, Prime Minister's Council on Climate Change[7]

1. Overview

India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, anthropogenically generated through long-term and intensive industrial growth and high consumption lifestyles in developed countries. While engaged with the international community to collectively and cooperatively deal with this threat, India needs a national strategy to firstly, adapt to climate change and secondly, to further enhance the ecological sustainability of India's development path.

Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected changes in climate.

India's development path is based on its unique resource endowments, the overriding priority of economic and social development and poverty eradication, and its adherence to its civilizational legacy that places a high value on the environment and the maintenance of ecological balance.

In charting out a developmental pathway which is ecologically sustainable, India has a wider spectrum of choices precisely because it is at an early stage of development. Our vision is to create a prosperous, but not wasteful society, an economy that is self-sustaining in terms of its ability to unleash the creative energies of our people and is mindful of our responsibilities to both present and future generations.

Recognizing that climate change is a global challenge, India will engage actively in multilateral negotiations in the UN Framework Convention on Climate Change, in a positive, constructive and forward-looking manner. Our objective will be to establish an effective, cooperative and equitable global approach based on the principle of common but differentiated responsibilities and respective capabilities, enshrined in the United Nations Framework Convention on Climate Change (UNFCCC). Such an approach must be based

[7] Available at http://www.moef.nic.in/sites/default/files/Pg01-52_2.pdf accessed last on 09/08/2016. The Technical Document portion has been not been included. Reproduced verbatim

on a global vision inspired by Mahatma Gandhi's wise dictum—The earth has enough resources to meet people's needs, but will never have enough to satisfy people's greed. Thus we must not only promote sustainable production processes, but equally, sustainable lifestyles across the globe.

Finally, our approach must also be compatible with our role as a responsible and enlightened member of the international community, ready to make our contribution to the solution of a global challenge, which impacts on humanity as a whole. The success of our national efforts would be significantly enhanced provided the developed countries affirm their responsibility for accumulated greenhouse gas emissions and fulfil their commitments under the UNFCCC, to transfer new and additional financial resources and climate friendly technologies to support both adaptation and mitigation in developing countries.

We are convinced that the principle of equity that must underlie the global approach must allow each inhabitant of the earth an equal entitlement to the global atmospheric resource.

In this connection, India is determined that its per capita greenhouse gas emissions will at no point exceed that of developed countries even as we pursue our development objectives.

2. Principles

Maintaining a high growth rate is essential for increasing living standards of the vast majority of our people and reducing their vulnerability to the impacts of climate change. In order to achieve a sustainable development path that simultaneously advances economic and environmental objectives, the National Action Plan for Climate Change (NAPCC) will be guided by the following principles:

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of greenhouse gas emissions.
- Devising efficient and cost-effective strategies for end use Demand Side Management.
- Deploying appropriate technologies for both adaptation and mitigation of greenhouse gases emissions extensively as well as at an accelerated pace.
- Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.

- Effecting implementation of programmes through unique linkages, including with civil society and local government institutions and through public-private-partnership.
- Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that facilitates technology transfer to developing countries under the UNFCCC.

3. Approach

The NAPCC addresses the urgent and critical concerns of the country through a directional shift in the development pathway, including through the enhancement of the current and planned programmes presented in the Technical Document.

The National Action Plan on Climate Change identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively. It outlines a number of steps to simultaneously advance India's development and climate change-related objectives of adaptation and mitigation.

4. The Way Forward: Eight National Missions

In dealing with the challenge of climate change we must act on several fronts in a focused manner simultaneously. The National Action Plan hinges on the development and use of new technologies. The implementation of the Plan would be through appropriate institutional mechanisms suited for effective delivery of each individual Mission's objectives and include public private partnerships and civil society action. The focus will be on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation.

There are Eight National Missions which form the core of the National Action Plan, representing multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change. While several of these programmes are already part of our current actions, they may need a change in direction, enhancement of scope and effectiveness and accelerated implementation of time-bound plans.

4.1. National Solar Mission

A National Solar Mission will be launched to significantly increase the share of solar energy in the total energy mix while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy and biomass.

India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as future energy source. It also has the advantage of permitting a decentralized distribution of energy, thereby empowering people at the grassroots level. Photovoltaic cells are becoming cheaper with new technology. There are newer, reflector-based technologies that could enable setting up megawatt scale solar power plants across the country. Another aspect of the Solar Mission would be to launch a major R&D programme, which could draw upon international cooperation as well, to enable the creation of more affordable, more convenient solar power systems, and to promote innovations that enable the storage of solar power for sustained, long-term use.

4.2. National Mission for Enhanced Energy Efficiency

The Energy Conservation Act of 2001 provides a legal mandate for the implementation of the energy efficiency measures through the institutional mechanism of the Bureau of Energy Efficiency (BEE) in the Central Government and designated agencies in each state. A number of schemes and programmes have been initiated and it is anticipated that these would result in a saving of 10,000 MW by the end of 11th Five Year Plan in 2012.

To enhance energy efficiency, four new initiatives will be put in place. These are:

- A market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded.
- Accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable.
- Creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings.
- Developing fiscal instruments to promote energy efficiency

4.3. National Mission on Sustainable Habitat

A National Mission on Sustainable Habitat will be launched to make habitat sustainable through improvements in energy efficiency in buildings, management of solid waste and modal shift to public transport. The Mission will promote energy efficiency as an integral component of urban planning and urban renewal through three initiatives.

i. The Energy Conservation Building Code, which addresses the design of new and large commercial buildings to optimize their energy demand, will be extended in its application and incentives provided for retooling existing building stock.

ii. Recycling of material and Urban Waste Management will be a major component of ecologically sustainable economic development. India already has a significantly higher rate of recycling of waste compared to developed countries. A special area of focus will be the development of technology for producing power from waste. The National Mission will include a major R&D programme, focusing on bio chemical conversion, waste water use, sewage utilization and recycling options wherever possible.

iii. Better urban planning and modal shift to public transport. Making long term transport plans will facilitate the growth of medium and small cities in ways that ensure efficient and convenient public transport.

In addition, the Mission will address the need to adapt to future climate change by improving the resilience of infrastructure, community based disaster management, and measures for improving the warning system for extreme weather events. Capacity building would be an important component of this Mission.

4.4. National Water Mission

A National Water Mission will be mounted to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. The Mission will take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water use efficiency by 20% through regulatory mechanisms with differential entitlements and pricing. It will seek to ensure that a considerable share of the water needs of urban areas are met through recycling of waste water, and ensuring that the water requirements of coastal cities with inadequate alternative sources of water are met through adoption of new and appropriate technologies such as low temperature desalination technologies that allow for the use of ocean water.

The National Water Policy would be revisited in consultation with states to ensure basin level management strategies to deal with variability in rainfall and river flows due to climate change. This will include enhanced storage both above and below ground, rainwater harvesting, coupled with equitable and efficient management structures.

The Mission will seek to develop new regulatory structures, combined with appropriate entitlements and pricing. It will seek to optimize the efficiency of existing irrigation systems, including rehabilitation of systems that have been run down and also expand irrigation, where feasible, with a special effort to increase storage capacity. Incentive structures will be designed to promote water-neutral or water-positive technologies, recharging of

underground water sources and adoption of large scale irrigation programmes which rely on sprinklers, drip irrigation and ridge and furrow irrigation.

4.5. National Mission for Sustaining the Himalayan Ecosystem

A Mission for sustaining the Himalayan Ecosystem will be launched to evolve management measures for sustaining and safeguarding the Himalayan glacier and mountain eco-system. Himalayas, being the source of key perennial rivers, the Mission would, inter-alia, seek to understand, whether and the extent to which, the Himalayan glaciers are in recession and how the problem could be addressed. This will require the joint effort of climatologists, glaciologists and other experts. We will need to exchange information with the South Asian countries and countries sharing the Himalayan ecology.

An observational and monitoring network for the Himalayan environment will also be established to assess freshwater resources and health of the ecosystem. Cooperation with neighbouring countries will be sought to make the network comprehensive in its coverage.

The Himalayan ecosystem has 51 million people who practice hill agriculture and whose vulnerability is expected to increase on account of climate change. Community-based management of these ecosystems will be promoted with incentives to community organizations and panchayats for protection and enhancement of forested lands. In mountainous regions, the aim will be to maintain two-thirds of the area under forest cover in order to prevent erosion and land degradation and ensure the stability of the fragile eco-system. 4.6. National Mission for a Green India

A National Mission will be launched to enhance ecosystem services including carbon sinks to be called Green India. Forests play an indispensable role in the preservation of ecological balance and maintenance of bio-diversity. Forests also constitute one of the most effective carbon-sinks.

The Prime Minister has already announced a Green India campaign for the afforestation of 6 million hectares. The national target of area under forest and tree cover is 33% while the current area under forests is 23%.

The Mission on Green India will be taken up on degraded forest land through direct action by communities, organized through Joint Forest Management Committees and guided by the Departments of Forest in state governments. An initial corpus of over Rs 6000 crore has been earmarked for the programme through the Compensatory Afforestation Management and Planning Authority (CAMPA) to commence work. The programme will be scaled up to

cover all remaining degraded forest land. The institutional arrangement provides for using the corpus to leverage more funds to scale up activity.

4.7. National Mission for Sustainable Agriculture

The Mission would devise strategies to make Indian agriculture more resilient to climate change. It would identify and develop new varieties of crops and especially thermal resistant crops and alternative cropping patterns, capable of withstanding extremes of weather, long dry spells, flooding, and variable moisture availability.

Agriculture will need to be progressively adapted to projected climate change and our agricultural research systems must be oriented to monitor and evaluate climate change and recommend changes in agricultural practices accordingly.

This will be supported by the convergence and integration of traditional knowledge and practice systems, information technology, geospatial technologies and biotechnology. New credit and insurance mechanisms will be devised to facilitate adoption of desired practices.

Focus would be on improving productivity of rain-fed agriculture. India will spearhead efforts at the international level to work towards an ecologically sustainable green revolution.

4.8. National Mission on Strategic Knowledge for Climate Change

To enlist the global community in research and technology development and collaboration through mechanisms including open source platforms, a Strategic Knowledge Mission will be set up to identify the challenges of, and the responses to, climate change. It would ensure funding of high quality and focused research into various aspects of climate change.

The Mission will also have, on its research agenda, socio-economic impacts of climate change including impact on health, demography, migration patterns and livelihoods of coastal communities. It would also support the establishment of dedicated climate change related academic units in Universities and other academic and scientific research institutions in the country which would be networked. A Climate Science Research Fund would be created under the Mission to support research. Private sector initiatives for development of innovative technologies for adaptation and mitigation would be encouraged through venture capital funds. Research to support policy and implementation would be under-taken through identified centres. The Mission will also focus on dissemination of new knowledge based on research findings.

5. Implementation of Missions

These National Missions will be institutionalized by respective ministries and will be organized through inter-sectoral groups which include in addition to related Ministries, Ministry of Finance and the Planning Commission, experts from industry, academia and civil society. The institutional structure would vary depending on the task to be addressed by the Mission and will include providing the opportunity to compete on the best management model.

Each Mission will be tasked to evolve specific objectives spanning the remaining years of the 11th Plan and the 12th Plan period 2012-13 to 2016-17. Where the resource requirements of the Mission call for an enhancement of the allocation in the 11th Plan, this will be suitably considered, keeping in mind the overall resources position and the scope for re-prioritisation.

Comprehensive Mission documents detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria would be developed and submitted to the Prime Minister's Council on Climate Change by December 2008. The Council will also periodically review the progress of these Missions. Each Mission will report publicly on its annual performance.

Building public awareness will be vital in supporting implementation of the NAPCC. This will be achieved through national portals, media engagement, civil society involvement, curricula reform and recognition/ awards, details of which will be worked out by an empowered group. The Group will also consider methods of capacity building to support the goals of the National Missions.

We will develop appropriate technologies to measure progress in actions being taken in terms of avoided emissions, wherever applicable, with reference to business as usual scenarios. Appropriate indicators will be evolved for assessing adaptation benefits of the actions.

These Eight National Missions, taken together, with enhancements in current and ongoing programmes included in the Technical Document, would not only assist the country to adapt to climate change, but also, importantly, launch the economy on a path that would progressively and substantially result in mitigation through avoided emissions.

5.1. Institutional Arrangements for Managing Climate Change Agenda

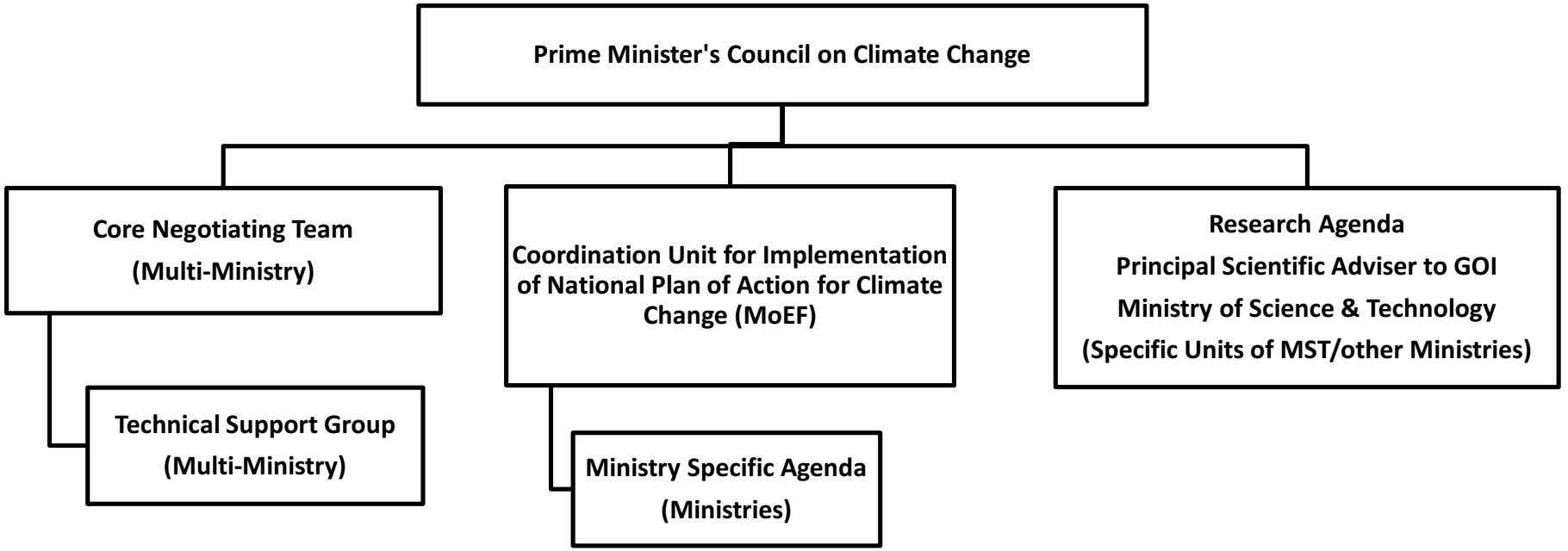
In order to respond effectively to the challenge of climate change, the Government has created an Advisory Council on Climate Change, chaired by the Prime Minister. The Council has broad based representation from key stake-holders, including Government, Industry and

Civil Society and sets out broad directions for National Actions in respect of Climate Change. The Council will also provide guidance on matters relating to coordinated national action on the domestic agenda and review of the implementation of the National Action Plan on Climate Change including its R&D agenda.

The Council chaired by the Prime Minister would also provide guidance on matters relating to international negotiations including bilateral, multilateral programmes for collaboration, research and development. Details of the institutional arrangement are at Annexure 1.

The NAPCC will continue to evolve, based on new scientific and technical knowledge as they emerge and in response to the evolution of the multilateral climate change regime including arrangements for international cooperation

Institutional arrangement (*Source:* National Action Plan on Climate Change)



Appendix B : [8]National Water Mission: Executive Summary

The main objective of the National Water Mission is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". The five identified goals of the Mission are: (a) comprehensive water data base in public domain and assessment of impact of climate change on water resource; (b) promotion of citizen and state action for water conservation, augmentation and preservation; (c) focused attention to vulnerable areas including over-exploited areas; (d) increasing water use efficiency by 20%, and (e) promotion of basin level integrated water resources management.

Various strategies for achieving the goals have been identified which lead to integrated planning for sustainable development and efficient management with active participation of the stakeholders after identifying and evaluating the development scenario and management practices towards better acceptability on the basis of assessment of the impacts of climate change on water resources based on reliable data and information.

Relatively very large temporal and spatial variation in rainfall and consequently in the river flow and ground water aquifers is an important feature of the water resources in India. Although the impact of climate change on water resources has not been accurately quantified, various studies indicate that the likely impact of climate change on water resources could contribute to further intensification of the extreme events. Further, the features of water resources – both the availability and the quality may also be considerably affected by the changes in the land use in the form of urbanization, industrialization and changes in the forest cover. Realizing that the various processes which influence the hydrologic cycle are of dynamic nature, precise quantification of the impact specifically due to climate change may not be a simple task and it would be necessary to make suitable assumption at the initial stages and undertake detailed simulation studies with more and more data as they become available with time. However, the likely impact of climate change on water resources could be in the form of:

[8] Full document available at http://wrmin.nic.in/forms/list.aspx?lid=267 Last accessed on 24/08/2016 Reproduced verbatim

- Decline in the glaciers and the snowfields in the Himalayas;
- Increased drought like situations due to overall decrease in the number of rainy days in many parts of the country;
- Increased flood events due to overall increase in the rainy day intensity;
- Effect on groundwater quality in alluvial aquifers due to increased flood and drought events;
- Influence on groundwater recharge due to changes in precipitation and evapotranspiration; and
- Increased saline intrusion of coastal and island aquifers due to rising sea levels.

From the above, it is apparent that in the context of likely impact of climate change on water resources, the most vulnerable areas in India would include (a) drought prone areas, (b) flood prone areas, (c) the coastal regions, (d) the region with deficient rainfall, (e) areas with over-exploited, critical and semi-critical stage of ground water development, (f) water quality affected areas, and (g) snow-fed river basins.

For achieving the objectives of the National Water Mission, long-term sustained efforts both in terms of time bound completion of identified activities and ensuring the implementation of identified policies and enactment of necessary legislation through persuasion at different levels with the State Governments have been envisaged. Some of the important activities which are planned to be completed in a time bound manner on priority areas under.

- **Comprehensive water data base in public domain and assessment of the impact of climate change on water resources**

- All data and entire information (except data of sensitive and classified nature) would be placed in public domain by 2012
- Review and establishment of network for collection of additional necessary data by March 2012
- Reassessment of basin wise water situation by March 2012

- The initial projections of the impact of climate change on water resources including the likely changes in the water availability in time and space are targeted by the year 2012

- **Promotion of citizen and state actions for water conservation, augmentation and preservation**

- Empowerment and involvement of Panchayati Raj Institutions, urban local bodies, Water Users' Associations and primary stake holders in management of water resources with focus on water conservation, augmentation and preservation
- Promote participatory irrigation management
- Encourage participation of NGOs in various activities related to water resources management, particularly in planning, capacity building and mass awareness
- Involve and encourage corporate sector / industries to take up support and promote water conservation, augmentation and preservation within the industry and as part of corporate social responsibility
- Sensitization of all Panchayat members and their functionaries in dark and grey blocks will be completed by 2011-12.

- **Focused attention to vulnerable areas including over-exploited areas**

- Comprehensive assessment of ground water in the country will be made by March 2011
- The revised master plan for artificial recharge to ground water would be in public domain by September 2011 for the entire country
- All over-exploited areas will be covered by recharge of ground water by the end of XII Five Year Plan.
- Expeditious implementation of water resources projects particularly the multipurpose projects with carry over storages benefitting drought prone and rain deficit areas
- Promotion of traditional system of water conservation
- Physical sustainability of groundwater resources
- Conservation and preservation of wetland
- Systematic approach for coping with floods – mapping of areas likely to experience floods, establishing hydraulic and hydrological models and

developing comprehensive schemes for flood management and reservoir sedimentation.

- **Increasing water use efficiency by 20%**

  - The timeline for action would be to increase water use efficiency by 20% by the year 2017
  - The gap of about 15% between the irrigation potential created and the irrigation potential utilized would also be reduced by half by the year 2017
  - Development of guidelines for incentivizing recycling of water including wastewater by March 2011.
  - Promotion of water efficient techniques and technologies including (a) promotion of micro irrigation techniques such as sprinkler and drip irrigation and (b) expansion of "Farmers' Participatory Action Research Programme"
  - Undertake Pilot projects for improvement in water use efficiency in collaboration with States by March 2012.
  - Promote Water Regulatory Authorities for ensuring equitable water distribution and rational charges for water facilities
  - Promote mandatory water audit including those for drinking water purposes
  - Adequate provision for operation & maintenance of water resources projects
  - Incentive through award for water conservation & efficient use of water
  - Incentivize use of efficient irrigation practices and fully utilize the created facilities

- **Promotion of basin level integrated water resources management**

  - Ministry of Water Resources will review the National Water Policy by 2011 to move towards basin development
  - Guidelines for different uses of water e.g., irrigation, drinking, industrial etc. particularly in context of basin wise situations by March 2012

The document also presents an outline for the operationalization of the "National Water Mission. A dedicated Mission Secretariat has also been proposed through creation of three posts i.e., one Mission Director and two Advisors and with

provision for either outsourcing or redeploying services of professional as per requirement.

Appendix C : List of sixty Union Government level institutions websites surveyed

Websites of the sixty Union Government level institutions – fifty under a Cabinet Minister or a Minister of State (with Independent Charge) and ten other constitutional bodies including the Supreme Court of India, Comptroller and Auditor General, etc., which were systematically analysed with key word searches using the '*Advanced Google*' search engine (http://www.google.co.in/advanced_search) are listed below. The keyword search was carried out during 13 to 23 May 2013. Some institutions have more than one website (as the websites of government institutions were on the transition to standardize the website domain name from nic.in to gov.in). In such cases the website which contained the most indexed pages (or documents uploaded online) was considered for this assessment. Some ministries are divided into two or more departments having different websites. For such institutions the total numbers of webpages detected were summed up. However, the autonomous institutions such as the Central Water Commission or Central Pollution Control Board that come under Ministry of Water Resources and Ministry of Environment and Forests, respectively, are not included within their respective ministries because they function separately with independent websites.

	Name of the institution	Website
1	Cabinet Secretariat	http://cabsec.nic.in/
2	Comptroller and Auditor General	http://www.cag.gov.in/
3	Department of Atomic Energy	http://www.dae.gov.in
4	Department of Space	http://www.isro.gov.in
5	Election Commission of India	http://eci.nic.in
6	Ministry of Agriculture	http://agricoop.nic.in/ http://dare.nic.in/
7	Ministry of Chemicals and Fertilizers	http://fert.nic.in/ http://chemicals.nic.in/
8	Ministry of Civil Aviation	http://www.civilaviation.gov.in
9	Ministry of Coal	http://coal.gov.in/
10	Ministry of Commerce and Industry	http://commerce.nic.in/ http://dipp.nic.in
11	Ministry of Communications and Information Tech.	www.deity.gov.in http://www.dot.gov.in
12	Ministry of Consumer Affairs, Food, and Public Distribution.	http://consumeraffairs.nic.in http://dfpd.nic.in/

13	Ministry of Corporate Affairs	http://www.mca.gov.in/
14	Ministry of Culture	indiaculture.gov.in
15	Ministry of Defence	http://mod.nic.in/
16	Ministry of Development of North Eastern Region	http://www.mdoner.gov.in
17	Ministry of Drinking Water and Sanitation	http://mdws.nic.in/
18	Ministry of Earth Sciences	http://dod.nic.in
19	Ministry of Environment and Forests	http://www.envfor.nic.in/
20	Ministry of External Affairs	http://mea.gov.in
21	Ministry of Finance	http://finmin.nic.in/
22	Ministry of Food Processing Industries	http://mofpi.nic.in/
23	Ministry of Health and Family Welfare	http://www.mohfw.nic.in/
24	Ministry of Heavy Industry and Public Enterprises	http://dhi.nic.in and http://dpe.nic.in
25	Ministry of Home Affairs	http://www.mha.nic.in/
26	Ministry of Housing and Urban Poverty Alleviation	http://mhupa.gov.in
27	Ministry of Human Resource Development*	http://www.mhrd.gov.in
28	Ministry of Information and Broadcasting	http://mib.nic.in/
29	Ministry of Labour and Employment	http://www.labour.nic.in
30	Ministry of Law and Justice	http://lawmin.nic.in/
31	Ministry of Micro, Small and Medium Enterprises	http://www.msme.gov.in
32	Ministry of Mines	http://mines.nic.in/
33	Ministry of Minority Affairs	http://www.minorityaffairs.gov.in
34	Ministry of New and Renewable Energy	http://www.mnre.gov.in/
35	Ministry of Overseas Indian Affairs	http://moia.gov.in/
36	Ministry of Panchayati Raj	http://panchayat.gov.in/
37	Ministry of Parliamentary Affairs	http://mpa.nic.in/
38	Ministry of Personnel, Public Grievances and Pensions	http://persmin.gov.in
39	Ministry of Petroleum and Natural Gas	http://www.petroleum.nic.in
40	Ministry of Power	http://powermin.nic.in
41	Ministry of Railways	http://www.indianrailways.gov.in
42	Ministry of Road Transport and Highways	http://morth.nic.in
43	Ministry of Rural Development	http://rural.nic.in/
44	Ministry of Science and Technology	http://dst.gov.in/
45	Ministry of Shipping	http://shipping.nic.in/
46	Ministry of Social Justice and Empowerment	http://socialjustice.nic.in
47	Ministry of Statistics and Programme Implementation	http://mospi.gov.in/
48	Ministry of Steel	http://steel.gov.in/
49	Ministry of Textiles	http://www.texmin.nic.in/
50	Ministry of Tourism	http://tourism.nic.in
51	Ministry of Tribal Affairs	http://tribal.nic.in/
52	Ministry of Urban Development	http://www.urbanindia.nic.in/
53	Ministry of Water Resources	http://mowr.gov.in

54	Ministry of Women and Child Development	http://wcd.nic.in/
55	Ministry of Youth Affairs and Sports	http://yas.nic.in
56	Planning Commission	http://planningcommission.nic.in
57	President of India	http://presidentofindia.nic.in/
58	Prime Minister's Office	http://pmindia.nic.in
59	Supreme Court	http://supremecourt.nic.in
60	Vice-President	http://vicepresidentofindia.nic.in

Appendix D : Sample letter to interviewees

Date: XX/XX/2014/5

Dear Shr/Dr…,

Subject: Data collection for research on climate change adaptation

I am a researcher of the India-UK Collaboration MICCI Project being funded by NERC (Natural Environment Research Council, UK) and Ministry of Earth Sciences, Govt. of India and writing to collect insights from key officials in important organizations/government institutions for climate change adaptation in water management in India. The project is being carried out in Cranfield University, UK in collaboration with IIT Roorkee with Prof Ian Holman and Prof C S P Ojha as principal investigators. India's National Water Mission identified collaboration across governments and agencies as a key strategy for adaptation and hence finding ways of improving inter-organizational network is one of the key aims of this project.

The aim of this project is to evaluate the role of networks in improving the adaptive capacity of Indian institutions to climate change and therefore requires collection of insights from key officials in important institutions. This project will therefore not only validate the adaptation strategies but also provide highly valued insights into improving collaborative networks for climate change adaptation in water management.

Since a key aim of the project is to include the insights of all key stakeholders; regulators, developers, academicians and practitioners, your inputs are very crucial for the success of the project. I am currently in India to collect data from all key stakeholders. Therefore I am keen to know whether it will be feasible for me to meet you in your office (for about half an hour) on Wednesday, February XX, 2014 (or any other time convenient to you). I look forward to meet you at your favourable time.

Yours sincerely

Azhoni Adani
Researcher,
Building 52, Cranfield University, Cranfield, Bedfordshire MK43 0AL
www.cranfield.ac.uk E: a.azhoni@cranfield.ac.uk
Phone: 91 7838 31 1979 (India)

Appendix E : Introduction, data protection and consent

E.1 : Introduction about the project

Thank you very much for agreeing to spare your time. As I mentioned in my letter I am working on the Ministry of Earth Sciences and UK Natural Environmental Research Council sponsored Mitigating Climate Change Impacts Project which is being carried out in Cranfield University, UK in collaboration with IIT Roorkee, NIT Kurukshetra and NIT Hamirpur. I am working as a PhD researcher since October 2012. Previous to that I worked with the Bureau of Indian Standards for six years after finishing my M Tech in Environmental Engineering and Management at IIT Delhi in 2006. Within the project my role is to evaluate the adaptive capacity of Indian Institutions to climate change impacts on water. Therefore a key aim of the project is to collect data from key officials/experts in influential institutions. Before sending out the request to you for this interview I have carried out a systematic analysis of all the sixty Union Government Institutions' websites and came to the conclusion that your Ministry/Department/Organization plays a key role in climate change adaptation for water management based on the documents uploaded in your website or the number of times other institutions mention your organization in their water and climate change adaptation discourse.

E.2 : Data protection, anonymity and ethics

As I mentioned in my letter the interview will be as short as possible keeping in mind your busy schedule. The interview questions are open ended and based on your day to day experiences and need not answer if it is not relevant to your activity. Although this research seeks to draw out the involvement, influences and interests of your organization in climate change adaptation the insights and experiences you share need not be the official position of your organization and shall be kept confidential and your comments will be anonymized. Also you are free to withdraw your insights and inputs anytime during the process in case you changed your mind. Cranfield University maintains a very high standard in maintaining the confidentiality of the respondents and fully complies with the UK Data Protection Act and hence only the researcher and Thesis Committee will have access to the information obtained through the interview. This research has been approved by the ethics committee. I am required to keep a proof of having obtained the consent from you before starting the interview. Therefore this form has been devised to show the ethics committee that I have intimated to you

the confidentiality arrangements.

Can I please record the conversation? This will help me in not missing the important insights you give and also enable me to recall them. As I already mentioned the recording will be used for this research purposes only and anonymity and confidentiality shall be strictly maintained. (Recording starts)

E.3 : Participant informed Consent Form

Date: _____

Participant No.:_____

Title of the Project: **Adapting water management in India to climate change**

Name of the Researcher: **A. Azhoni**

1. I confirm that I have been informed about the aim and objectives of this research project agreed to give my inputs.
2. I understand that all personal information that I provide will be treated with the strictest confidence and my name will not be used in any report, publication or presentation and I have been provided with a participant number to ensure that all raw data remains anonymous.
3. I understand that although the information I provide will be used by Cranfield University for research purposes, it will not be possible to identify any specific individual from the data reported as a result of this research.
4. I understand that the data collected will only be used for research purposes of the said project. The results will be written up as PhD thesis and/or published in scientific journals. I further understand that my raw data will be accessible only to the researcher and the supervising staff at Cranfield University.
5. I understand that I am free to withdraw from this project at any stage during the session simply by informing a member of the research team, for whom contact details have been provided. I also understand that I can also withdraw my data for a period of up to 7 days from today, as after this time it will not be possible to identify my individual data from the aggregated results.

Participant's signature: _____Date: _____

Participant's name: _____

Researcher's signature: _____Date: _____

Appendix F : Interview questions with institutions operating at national level

1. Can you tell me briefly about your organization and your role within the organization?
2. What is your view on climate change? Do you believe that climate change presents serious risks to India's water resources such that adaptation should be a priority? How serious is climate change to India's water resources management?
3. What adaptation strategies or activities your ministry/department/organization is involved in?
    a. Are you doing any work related to National Water Mission under National Action Plan on Climate change? What is your role in NWM?
    b. What are the challenges you see in NWM?
    c. What are the other adaptation strategies in water management that you know is initiated by other government or non-governmental institutions?
4. Which other organizations, governments, departments, ministries, consultants, NGOs, research organizations do you work with in connection to climate change adaptation?
    a. Why do you work with them? (information and data types, financial, natural or human resources)
    b. How difficult or easy it is to network with them? Why?
    c. How do you build informal networks? How do you identify who is important/expert?
    d. Which institution/organization/department/ministry is most important to your work in climate change adaptation? Which institution will affect your work the most?
    e. How frequently do you contact them? Do you get the desired reply or information/resources on time? If not how can we improve it?
5. What kind of resources does (or can) your organization provide to other institutions/organizations for climate change adaptation in water management?
    a. Who are these organizations?
    b. How do you disseminate information regarding climate change impacts, risks, and adaptation strategies to your stakeholders?

    c. What is the best way for other organizations to acquire information about climate change adaptation from your work (or organization)?

6. What are the main challenges for successful climate change adaptation for water management in India? If I am to ask you what is it that one thing that you need for adapting water management to climate change? Do you have that?
7. What factor influences the adaptive capacity the most? (Availability of natural resources, appropriate information on risks and opportunities, technology, law and policy, effective administration, collaboration and networks etc.)
    a. How can we enhance information network?
    b. How can we develop or acquire the technology required?
    c. How would policies from other sectors influence adaptive capacity for water management?
    d. How would you assess your capacity to adapt?
8. What kinds of resources do you think is required for climate change adaptation in water management and who provides them? (types of information/data, financial, natural, technical)
    a. How do you obtain information required for climate change impacts on water and adaptation strategies? (Through consultants, internet, IPCCC reports, scientific journals, etc.)
    b. Do you think internet is an effective way of communicating
    c. How often do you use the internet to obtain information needed for climate change adaptation and water management?
9. What are the main factors you consider for future planning? Should the plans and designs of irrigation infrastructure development incorporate climate change factor of safety?
    a. What kinds of guidelines and standards do we need to develop? Which organizations can/should develop such guidelines and standards?
    b. What are the main difficulties for incorporating climate change impacts into those designs?
10. What is the role of the state and local governments in the adaptation process and how do you involve them?
11. Do you feel there is any unproductive interference from other sectors/organizations etc. that hinders adaptation to climate change in water sector?

12. Should India's water policy have a priority and if so which sector should have the priority? (Domestic supply, industrial, agriculture, ecology etc.)
13. Do the projected climate changes present any opportunities for water resources development? What are they?
14. What should be India's practical preference in general for climate change adaptation in irrigation? (Rain water harvesting, reservoirs, interlinking of river basins) What adaptation strategies would you suggest the government or development agencies to adopt?
15. Do you think the government organizations are aware enough about the need for climate change adaptation or what are the needs to further raise awareness? To whom should we raise awareness? What groups of people need to be aware about climate change?
16. Have you observed any noticeable change in the way the government functions to manage water in the recent past?
    a. What are the changes? What drives this change? Or why there is no change?
17. Which organizations/department/ or person do you suggest that I should approach in order to gain more insights into these questions?
18. Is there anything that I need to know but I did not ask or anything you want to add to the conversation we just had?
19. What are the channels through which farmers can be involved in the decision making process as an important stakeholder?

Appendix G : Number of references made by each respondent

		Respondents* →	AI06	AI25	GA01	GA12	GA22	GA24	GA5	NG03	NG10	NG14	NG15	NG21	RI07	RI11	RI14	RI17	RI19	RI23	UM02	UM03	UM08	UM13	UM16	UM18	UM20	UM26	
Involvement		advocacy	0	0	0	0	0	0	0	1	0	1	1	1	0	0	2	0	0	0	0	0	1	0	0	0	0	0	6
		capacity building	1	1	1	1	0	0	0	2	2	3	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	10
	Specific project	disaster reductions	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
		groundwater	0	0	0	0	0	2	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
		pilot projects	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
		sustainability	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
		water quality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	3
		water use efficiency	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	3
		building networks	0	0	0	0	0	0	0	0	1	2	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
		policy	0	0	2	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	1	0	2	0	0	1	1	0	7
		research	1	1	0	0	0	3	0	0	0	0	0	0	0	2	1	5	1	0	0	0	0	0	0	3	0	0	8
Barriers		bureaucratic and systemic	1	1	2	0	0	0	0	0	0	3	0	2	1	1	4	3	2	0	0	0	0	2	0	0	0	0	11
		other concerns	0	0	0	0	0	0	0	1	0	0	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
		information & data inaccessibility	1	3	0	0	0	0	0	0	0	1	0	0	0	0	2	7	0	0	1	0	0	0	0	0	0	0	6
		conflicts of interests	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	4
		institutional barriers	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	3
		inadequate policies	1	0	0	0	0	0	0	0	0	0	2	0	0	2	1	4	0	0	0	0	0	1	0	0	0	0	6
	Lack of	financial reources	0	0	3	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	5
		human resources	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
		infrastructure	1	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		knowledge capacity	0	0	0	0	0	0	0	0	1	1	1	1	1	3	0	1	0	0	0	0	0	0	0	0	0	0	7
		resources	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
		involvement of users	1	0	0	0	0	1	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5
		technology	0	0	2	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Poor	awareness and communication	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	5
		coordination	0	0	0	0	0	0	0	0	0	0	1	0	0	3	2	0	0	0	2	0	0	0	1	3	0	0	6
		implementation & enforcement	0	0	0	0	0	0	0	0	1	2	0	1	0	2	1	2	0	0	0	0	0	0	0	1	0	0	7
		Socialogical outlook	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Aspirational strategies		Build knowledge	0	0	1	0	0	0	0	0	1	1	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	6
		Dedicated hydrologists	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
		Climate resilient infrastructures	0	0	3	0	0	1	0	0	0	0	0	1	0	2	0	0	0	0	1	0	0	0	0	0	3	0	6
		increase storage capacity	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3	0	4
		technologies	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		develop guidelines and standards	0	0	1	1	0	0	0	0	0	0	0	0	1	3	0	1	0	0	0	0	0	0	0	2	0	0	6
		provide data accessibility	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2
		improve coordination	1	0	0	1	0	0	0	2	0	2	0	1	0	3	0	1	0	0	0	0	0	0	1	0	0	0	8
		involve user communities	1	0	0	0	0	0	0	2	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4
		Increase efficiency and reuse	0	0	2	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	3	0	0	0	0	0	2	0	7
		integrated water management	0	0	1	0	0	1	0	0	0	0	1	1	0	4	1	1	1	0	2	0	0	0	1	0	1	0	11
			11	5	15	7	0	5	0	11	5	14	13	15	8	19	11	15	4	2	12	1	2	6	6	5	5	0	

* The respondents in the header row are coded alpha-numerically. The numbers represent the serial number and the alphabets indicate the type of institutions:

AI: Academic Institutions, GA: Government Agencies

NG: Non-governmental Organisations RI: Research institutions

UM: Union Government Ministries/institutions headed by a Union Minister.

Appendix H : Interview questions with State level institutions

Question	Objective
1) Can you tell me briefly about your organization and your role within the organization? What are the main activities of your Centre/Department/Institution?	• To understand the relevance of the respondent's work to water management.
2) What is your view on climate change? Do you think that climate change presents serious risks to Himachal Pradesh specifically? What are the likely impacts of climate change for water management in Himachal Pradesh?	• To draw out personal opinions and understandings of the respondents about climate change and its impact for water management.
3) Can you highlight some of the signals that you have experienced that could be attributed to climate change? How did you address those challenges?	• To draw out specific examples of practical experiences faced by the respondent. • Specific reactions prompted by experiences. Reactive adaptive
4) What adaptation strategies or actions your department/institution is involved in to address climate change impacts for water management? Why did your institution initiate these actions? Is it because you got some specific directive/instructions about the need to initiate these actions by the state or central government?	• The question focuses on planned adaptation or the initiative taken by the respondents' institutions. Proactive and/or contemplative adaptation.
5) How your department is involved in the State Strategy and Action Plan on Climate Change? Policy and planning, information and data, monitoring and implementation, funding, raising awareness and developing knowledge capacity, etc.	• To understand their involvement and contribution towards the state's planned adaptation.

6) Are you being informed of the strategies/action being planned and initiated at the state level? How were you informed and at what stage?	• To understand how the adaptation policies, strategies and plans trickle down to sub-state level.
7) What specific inputs were sought from your department regarding this? At the stage of framing the strategy For implementation and monitoring	• To understand the involvement, coordination and bottom-up adaptation planning.
8) Have you received any specific guidelines to incorporate climate change factors into your planning and designing of water infrastructures from the State or Union Government?	• To understand how the stated objectives in SAPCC translates into adaptation action.
9) How do you and to which ministry/department do you report about the implementation of these adaptation strategies?	• To understand the effectiveness of coordination and monitoring the implementation.
10) Which other organisations, departments, ministries, consultants, NGOs, research institutions do you work with in connection to climate change adaptation for water management?	• To identify the key partners: vertically and horizontally
11) Why do you work with them? What are the kinds of support you get from your key-partners listed your website? What kind of support do you give them?	• To understand the level of cooperation and coordination.
12) What are the challenges of working with other departments, institutions?	• To identify barriers
13) What do you think is the role of the Union Government in the adaptation process and how do you liaise with them?	• To understand the expectations and coordination.
14) Who is revising the State water policy and have your department contributed any inputs? What prompted the need to revise it?	• To identify the influential institutions and the respondents' involvement and

How is the new revised water policy likely the affect the different stakeholders and their capacity to adapt to Climate change?	interests in the state water policy.
15) What is the role of the local governments in the adaptation process and how do you involve them?	• To draw out the perspectives regarding responsibilities at different levels
16) How do you involve the water users individually or as a community or through the Water Users Association?	• To understand the respondents' engagement with the water users.
17) What are the steps that your department/Centre is developing to strengthen the community based institutional arrangements for adaptation?	• To understand the respondents' engagement with the water users.
18) What are the main challenges for successful climate change adaptation for water management in Himachal (or your zone or district)?	• To understand the barriers
19) What kinds of resources do you think is required for climate change adaptation in water management and who provides them? What kind of knowledge, information, data, technology, human resources, etc.	• To identify resources for enhancing the adaptive capacity
20) How can the coordination between various departments, institutions, and different stakeholders be improved?	• To identify ways to improve coordination through which to improve adaptive capacity.
21) Do you feel there is any unproductive interference from other sectors/ organizations, persons etc. that hinders adaptation to climate change in water management?	• To identify barriers from specific sectors or institutions
22) How do you obtain information required for climate change impacts on water and adaptation strategies?	• To understand the effective sources of information
23) Do the projected climate changes present any	• To understand the perceptions

opportunities for water resources development?	and also identify the opportunities.
24) What should be India's practical preference in general for climate change adaptation in irrigation?	• To understand the perceptions of practical solutions
25) Do you think the government organizations are aware enough about the need for climate change adaptation or what are the needs to further raise awareness? To whom should we raise awareness? What groups of people need to be aware about climate change?	• To understand the need for raising awareness.
26) Have you observed any noticeable change in the way the government functions to manage water in the recent past? What are those changes? What drives these changes? Or why there is no change?	• To understand the perceptible changes in the government systems due to the recent changes in policies or awareness and explore the drivers of change.
27) What policies, plans and schemes would you suggest the State or Central Government should adopt that will enable adaptation for water management at the local level?	• To identify opportunities for bottom-up adaptation.
28) What are some of the practical steps water users in your area/region can take for water management to climate change adaptation in irrigation with or without government's intervention?	• To explore the expectations of the respondents from the water users.
29) Which organizations/department/ or person do you suggest that I should approach in order to gain more insights into these questions?	• To further identify key stakeholders.
30) Is there anything that I need to know but I did not ask or anything you want to add to the conversation we just had?	• To provide an opportunity for the respondent to add up any input.

--Thesis ended--