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Climate Change and Urban Water Supply: Adaptive Capacity ofLocal Government in Kathmandu City, Nepal

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Abstract: Climate change poses significant challenges to water resources in cities in the form of high variability and seasonal scarcity, given the weak institutional capacity of the concerned agencies. Given the massive speed and scale of urbanization in developing countries like Nepal, the gaps in current knowledge of the role of city government in adapting to the impacts of climate change on water are considerably large. Hence, this research aims to investigate the capacity of the local government to adapt to the impacts of climate change on drinking water supply, with a case study of Kathmandu Metropolitan City. The research is based on a critical literature review, policy analysis, observations and reflections. Results indicate that drinking water supply in Kathmandu is under severe stress because of a sharp reduction in precipitation, rapid increase in urban population and poor urban water governance. There is a high degree of uncertainty in predicting the impacts of climate change on precipitation, which demands a variety of solutions engaging various actors, piloting different options, learning from piloting and adapting new institutions based on the learning. Besides, strong leadership and resources are required to deal with the insurmountable challenges of climate change. City governments involved in water supply do not have adequate capacity or resources to cope with the current and future climate change impacts on urban water. Existing efforts are focused on supply of water from inter-basin water transfers with no detailed analysis of options. The paper concludes by highlighting the need to reframe the relationship between citizens, policy-makers and scientists to bring about effective solutions to the problem of urban water supply in a changing climate.

Key words: Climate change, adaptive capacity, water supply, urbanization, Kathmandu

INTRODUCTION

Climate change is recognized as one of the most significant environmental, social and economic challenges of the twenty-first century. The question of how, and to what extent, the local governments respond to the effects of climate change on water is likely to determine prospects for population health, development and sustainability. A growing body of literature shows that climate change results in melting of glaciers and snow covers, change in weather pattern, irregular rainfall and increase in frequency and severity of extreme event, including drought, flooding, cyclone and heat waves (IPCC 2007). Two main approaches, *viz.* 'mitigation' (i.e. reducing emission of green house gases - GHGs) and 'adaptation' (i.e. coping with the impacts and living with changing climatic conditions) are adopted to address the issues of climate change throughout the world. However, due to significant volume of GHGs already present in the atmosphere as a result of past activities that will change the environment in the century and beyond (Adger and Barnett 2009), adaptation to impacts of climate change is critical.

Adger (2003) defines adaptation as a dynamic social process. He argues that societies have inherent capacities to adapt to climate change and that they have adapted to a changing

climate in the past and this process will continue in the future. He also recognizes that adaptation takes place at various scales with the involvement of various actors. Adaptation is particularly important at the local level where the impacts are most visible and uncertainties remain the highest. Vulnerability and its causes are also location specific (Næss *et al.* 2006). Adaptation actions are therefore, inevitably local and the local institutions are crucial for planning and implementation of adaptation policies and programmes (Agrawal 2008). However, the issue of how, and to what extent, local institutions facilitate effective climate change adaptation policy and practices is not clear.

Climate change literature suggests that city government institutions (and also other formal and informal institutions) are crucial for effective adaptation actions (both anticipatory and reactive) to occur (e.g. Adger 2000; Agrawal 2008; Koch *et al.* 2007). The laws, rules, regulations, services and policies of institutions, including the state, private and civil sectors from local to national and ultimately to international levels, determine the strategy and ultimately the adaptive capacity (Dulal *et al.* 2010). Success of the adaptation initiatives depends upon whether the institutions are able to, or they want to, make adjustments in their roles, or their willingness to support the innovations (Tompkin *et al.* 2002). In the meantime, adaptation in urban areas is neglected (Sanchez-Rodriguez 2009; Lwasa 2010; Zimmerman and Faris 2010). Hallegatte and Corfee-Morlot (2011), for instance, argues that the climate change initiatives at the city scale are often mitigation-oriented. The topics of climate impacts, vulnerability and adaptation are less researched. Clearly, the existing literature focuses on climate change mitigation and climate modelling, and they ignore local impacts and the capacity of the city governments to adapt to these changes.

Adaptation to climate change impacts on water is crucial to many rapidly urbanizing countries and cities around the world today. More than half of the global population lives in the cities (C40 Cities 2010) and economic activities are also concentrated in urban areas (Hallegatte and Corfee-Morlot 2011). Urban areas are also the major source of GHGs (Lindseth 2004; Rosenzweig *et al.* 2010). Developed countries with high adaptive capacities are less vulnerable, but the poor people from least developed countries (LDCs) are highly vulnerable to the impacts of climate change due mainly to their low adaptive capacity (IPCC 2007). Institutions of urban governments, Non Governmental Organisation (NGOs) and community groups play a mediating role in adapting to the changing climate. However, their roles as a mediator between actors to bring about effective climate adaptation plans, strategies and actions at the local urban level is not well understood. There is a knowledge gap in how local governments can act for more effective climate change adaptation.

Nepal is one of the LDCs, as defined by the United Nations in terms of its low national income, less developed human capacity and a high degree of economic vulnerability (UN-OHRLLS 2011). The impact of climate change has already been observed in Nepal in the form of increase in the average annual temperature at a rate of 0.04^0C – 0.06^oC and high rate of glacier melting and retreat (Marahatta *et al.* 2009). However, there is no established prediction on the impacts of climate change on precipitation. Some authors such as Agrawal *et al.* (2003) projected an increase in precipitation in the range of 5-20 percent. Nepal Climate Vulnerability Study Team (NCVST), on the other hand, projected both an increase and a decrease in precipitation, in the range of -36 to 67 percent by 2050 (NCVST 2009). While there is now a consensus that climate change is one of

the most critical challenges in Nepal, climate variability and climate change trend remains highly uncertain.

Nepal is one of the fastest urbanizing countries in South Asia, and its cities such as Kathmandu face massive problems to meet the increasing water demand for the growing urban population. The situation is expected to worsen worldwide due to the impact of climate change, which will reduce the water supply and increase water demand (IPCC 2007). Under the changed climatic conditions, water supply is expected to decrease due to the increase in variability of precipitation, decrease in snowfall, rapid melting of glaciers in the long run and reduced groundwater recharge (IPCC 2007). On the other hand, water demand is expected to increase due to increase in temperature (IPCC 2001). A study in New York City has shown that the daily per capita water use increases by 19 litres for every 1^0 C increase in temperature (Protopapas *et al.* 2000). It is not yet clearly known what city governments are doing and what capacity they have to respond to the impacts of climate change on water.

The aim of the paper is to investigate the adaptive capacity of urban local government to respond to the impacts of climate change on water. With a case analysis of Kathmandu Metropolitan City, four specific questions are investigated:

1) What are the impacts (or likely impacts) of climate change on urban water availability?
2) Whether or not government policies at different levels articulate the issue of water supply in Kathmandu valley and, if they do, how do they do it?
3) What are the institutional factors that constraint or enhance water adaptation practices of Kathmandu?
4) What are the potential options for enhancing adaptive capacity of Kathmandu?

In the next section, the paper provides a brief outline of the conceptual framework on adaptive capacity. In Section 3, methodological strategy, case study and data collection has been outlined. Section 4 presents results from the analysis of adaptive capacity of Kathmandu Municipality to the impacts of climate change on water supply to the residents. In Section 5, we discuss the reasons and implications of the findings. Finally, the paper concludes by highlighting the need to reframe the relationship between different institutions at the local level to enhance adaptive capacity of the city government.

CONCEPTUAL FRAMEWORK

Adaptive capacity in an institutional context

Effective climate change adaptation requires institutions to promote the adaptive capacity of individuals and groups. Gupta *et al.* (2010) provide an innovative framework to analyse the adaptive capacity in an institutional context for climate change adaptation. It explains adaptive capacity as:

> The inherent characteristics of institutions that empower social actors to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative response from society both *ex ante* and *ex post.*

Gupta *et al.* (2010) suggests that, to promote adaptive capacity, the institutions should possess six dimensions. These dimensions can be used to assess the institutions (in this case, urban local government), which are:

1. *Variety* - encourage the involvement of a variety of perspectives, actors and solutions
2. *Learning* - enable social actors to continuously learn and improve their institutions
3. *Managing change* - allow and motivate social actors to adjust their behaviour

4. *Leadership* - mobilize leadership qualities
5. *Resources* - mobilize resources for implementing adaptation measures
6. *Governance* - support principles of fair governance.

In order to assess the local governments in their ability to catalyse adaptive capacity based on the above six dimensions, the authors have developed an adaptive capacity wheel (Figure 1). The wheel consists of adaptive capacity as a central element and the six variables mentioned above situated in the middle ring and twenty-two criteria in the outermost ring.

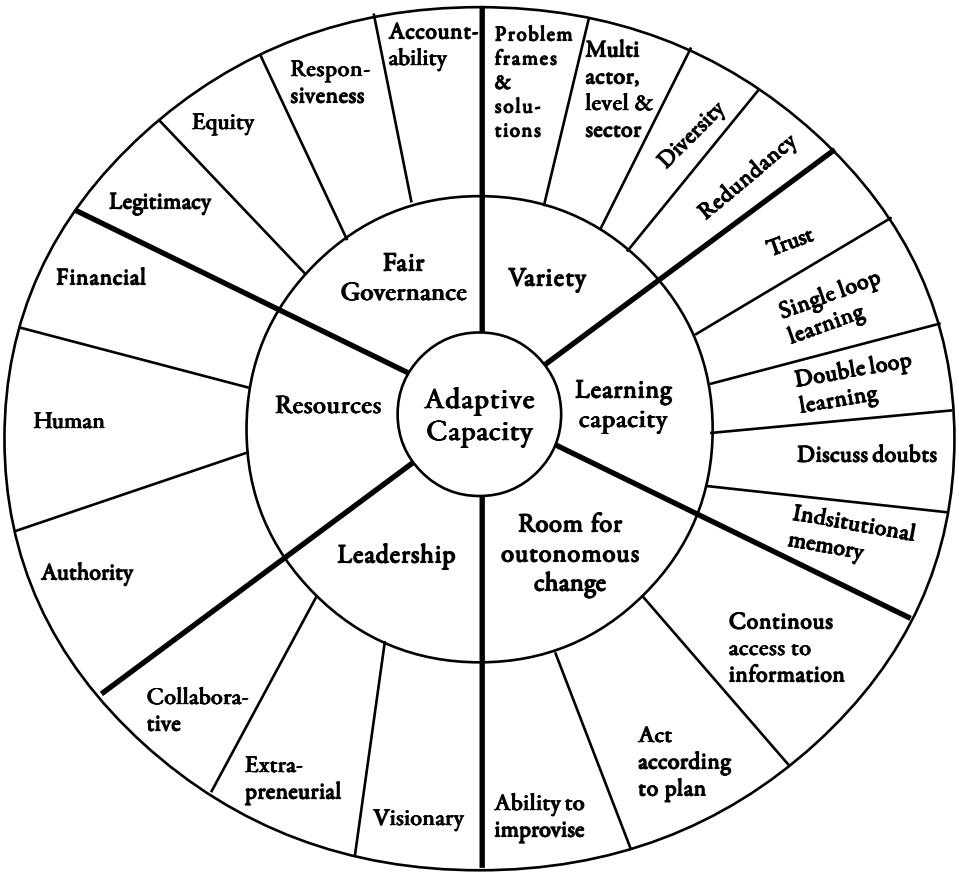


Figure 1: Adaptive Capacity Wheel (Gupta *et al.* 2010: p. 464)

Twenty-two criteria are seen to influence the adaptive capacity of an institution. The authors highlight that this wheel may be used to both assess and inform the social actors about how institutions affect different aspects of adaptive capacity and where improvement is needed. The Adaptive Capacity Wheel can be applied in both qualitative and semi-quantitative studies with specific implications for measuring adaptive capacity. The qualitative approach includes 'case study' where data is collected through interviews. In case studies, the wheel provides information on institutional performance in a specific context. The wheel also allows

identification of areas in which institutions do not support adaptive capacity and hence, with proper explanation, can help understand the reasons behind the lack of functioning in particular areas and make suggestions for improvements. Semi-quantitative analysis includes content analysis of policy documents where quantitative scores are assigned to different criteria.

RESEARCH METHODS

This study employs critical case study as a methodological strategy. Creswell (2009) defines case studies as a strategy of inquiry in which researcher explores a programme, event, activity and process or individuals in depth. Case study method has been widely used in understanding the efforts being taken at local governments, communities and local services in different fields of social sciences (Yin 2003). This study analyses water supply of Kathmandu Metropolitan City as a case study. This is an important case as Kathmandu is the capital and biggest city of Nepal with acute water supply problems. With a number of projects such as Melamchi Drinking Water Supply Project (MWSP) being constructed for many years, urban populace is relying heavily on water supply through water tankers and bottled water, which come from groundwater and water sources away from the city. Climate change impacts are likely to affect both the sources of piped water and bottled water. Groundwater in Kathmandu is seen to be both shallow and heavily polluted.

The study is based on a critical literature review, observation, informal discussions and authors' reflections. The policy and institutional preparedness related to adaptation are investigated through a content analysis of government policy documents, published and unpublished reports of the developmental and research organisations and government agencies. The study is focused on assessing the capacity and preparedness of local agencies, their capacities to adapt and areas for improvement.

For predicting the biophysical impact, the study draws on Jha (2012), which used precipitation data from four stations, *viz*. Thankot, Chapagaun, Changu and Kathmandu airport, of Kathmandu Valley for the duration of 1980 and 2009 to analyse the precipitation trend. SIMClim software was used to project future precipitation under different scenarios. The impact of climate change was identified for the worst-case scenario and the average case scenario. The worst-case scenario of climate change was projected using the SRES A1FI emissions scenario, a high level of climate sensitivity and IPSL-CM40 GCM, which shows the largest reduction in precipitation. Similarly, the average case scenario was generated by an ensemble from the 21 GCMs available in SimCLIM, SRES A1B emissions scenario and a mid level of climate sensitivity.

Case background

Kathmandu Valley is situated in the middle mountain region of Nepal (LRMP 1986). It is the largest economic and population centre of Nepal, as it contributes to 30 percent of the country's gross domestic product (GDP) and is home to 50 percent of the total urban population (GHD Pty. Ltd. 2010). Rapid population growth and unplanned urbanization have threatened the future socio-economic contribution due to the impact of such unplanned growth on sufficiency of the water supply system (*ibid*).

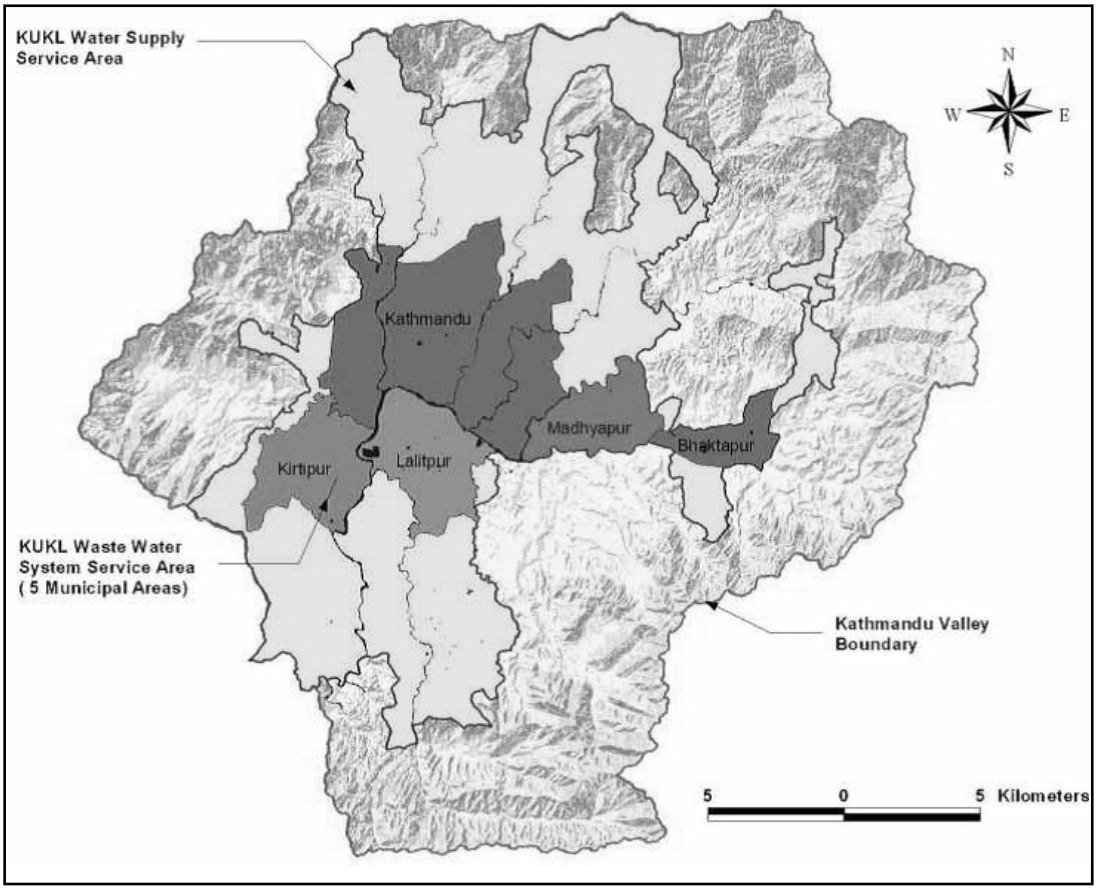


Figure 2: Kathmandu Valley and KUKL service areas (GHD Pty. Ltd. 2010).

The total population of Kathmandu Valley was 1.58 million in 2001, which is projected to increase to 5.76 million in 2025 (GHD Pty. Ltd. 2010). The Valley's current water demand is about 280 million litres per day (MLD) but the supply remains at around 86 MLD during the dry season and 105 MLD during the wet season (Shrestha 2009). Moreover, a high degree of leakage, lack of treatment of waste water and poor water quality has made the system unreliable and unsafe (GHD Pty. Ltd. 2010).

Drinking water supply in Kathmandu

Main sources of drinking water for Kathmandu Valley are Bagmati River and its tributaries, groundwater obtained through stone tap, from dug wells, borings and springs located in mountain ranges surrounding the valley (Shrestha 2009; Dixit and Upadhya 2005). Water from Bagmati River is collected by means of a dam and reservoir at Sundarijal and is distributed through piped networks (Shrestha 2009). Groundwater is extracted at a rate of 57 MLD, which is six times higher than its natural recharge capacity (*ibid*.). Shrestha (2009) argues that this causes the lowering of the groundwater table by approximately 2.5 metres per year and is threatening its future potential. He further asserts that rainwater harvesting is practised only on an experimental scale. The average annual rainfall of Kathmandu Valley is 1,900 mm; however, 90 percent of the rainfall takes

place during June–September, leaving other months dry (Shrestha 2009).

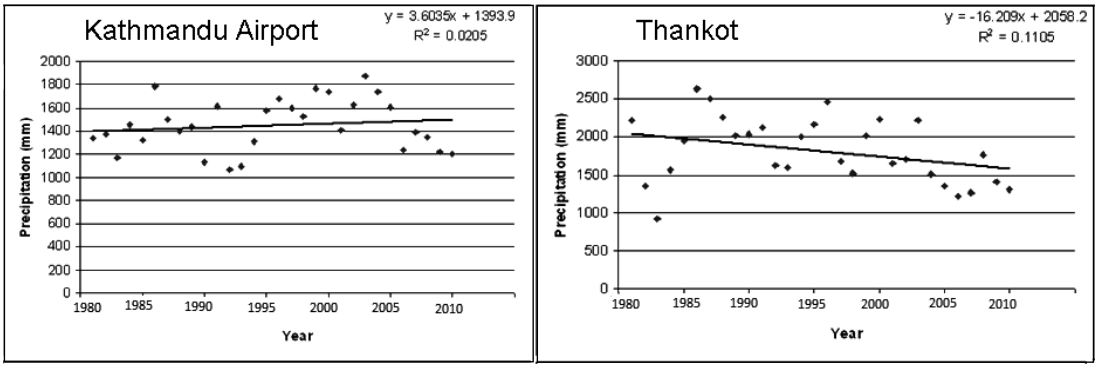
The water quality is very poor due to lack of treatment of wastewater, unreliable solid waste collection system, the combined system of sewerage and storm water drains, lack of water for self-cleansing of sewers, inadequate sewer cleaning equipment and less optimal design standards (GHD Pty. Ltd. 2010). As a result, every year thousands of people suffer from water-borne diseases during the wet season (*ibid*).

Kathmandu Valley had self-sufficient water supply systems before the introduction of the centralized piped water supply system in the 1980s (Shrestha 2009). This was in the form of rain-fed ponds and springs, which were later modified to stone spouts and dug wells, and networks of canals and ponds. This decentralized system, however, was ignored by the government after the introduction of the piped water system (Shrestha 2009). Moreover, the high rate of urbanization resulted in increased pressure on groundwater harvesting through locally dug wells/bores with little opportunity for recharge. This caused drying of stone spouts, the most common decentralized water supply system (Shrestha 2009). The average growth rate in the urban area of the Kathmandu Valley between 1991 and 2001 was 5.1 percent, while in some areas near ring road the growth rate was as high as 20 percent (GHD Pty. Ltd. 2010).

As a result, people do not have sufficient water for meeting their minimum requirements such as toilet flushing, bathing and other sanitation activities. In urgent situations, people rely on tankers, bottled water, private wells and other traditional supplies as a part of the coping strategy (GHD Pty. Ltd. 2010). The price of water from public sector tanker is US$2-2.4 per kilolitre of water, while it is 20-30 percent higher for private tankers (Bhattarai *et al.* 2002b).

IMPACT OF CLIMATE CHANGE ON URBAN WATER

The average annual precipitation of Kathmandu Valley was recorded to be from 1,365 mm to 1,872 mm based on the data from 1980 to 2009 in four stations, namely Kathmandu Airport, Thankot, Chapagaun and Changu. There were no systematic records and trend for precipitation with inter-annual and periodic fluctuations (Figure 3) (Jha 2012).



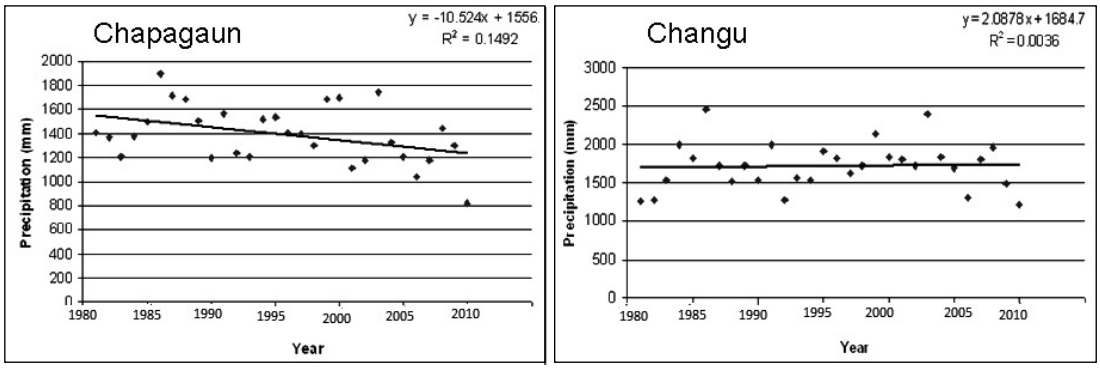
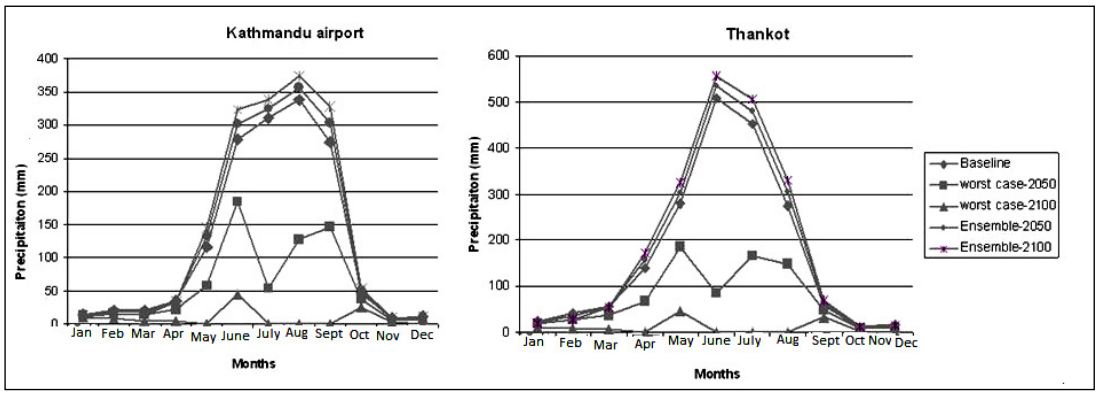


Figure 3: Annual precipitation trend for four stations in Kathmandu Valley during 1980–2009 (Jha 2012).

There is no agreement among General Circulation Models (GCMs) to project future precipitation records for Kathmandu Valley; the projected change in precipitation is -20 to +37 percent per ^{0}C of global warming (Jha 2012). However, looking at the worst-case scenario, precipitation could decrease to 634 mm by 2050 and 120 mm by 2100 (Jha 2012). The months receiving high amount of precipitation is expected to decrease to three months by 2050, to two months by 2100 (Fig. 4). Similarly, rainy days would be limited to 7-10 days per year by 2100 (Table 1). Precipitation is expected to decrease significantly however, the rate of decrease is not uniform across all months. By 2050 the months receiving highest precipitation would shift one month earlier to May, followed by a sharp decrease in July and then a moderate increase in August and September, based on the data from Airport, Changu and Chapagaun stations (Fig. 3) (Jha 2012). On the other hand, temperature is projected to increase up to 3.8^{0}C by 2050 and by 9.7 ^{0}C by 2100 under the worst-case scenario (Jha 2012).

Although precipitation is not expected to change much under average scenario, the above data shows that precipitation could decrease very sharply under the worst-case scenario.



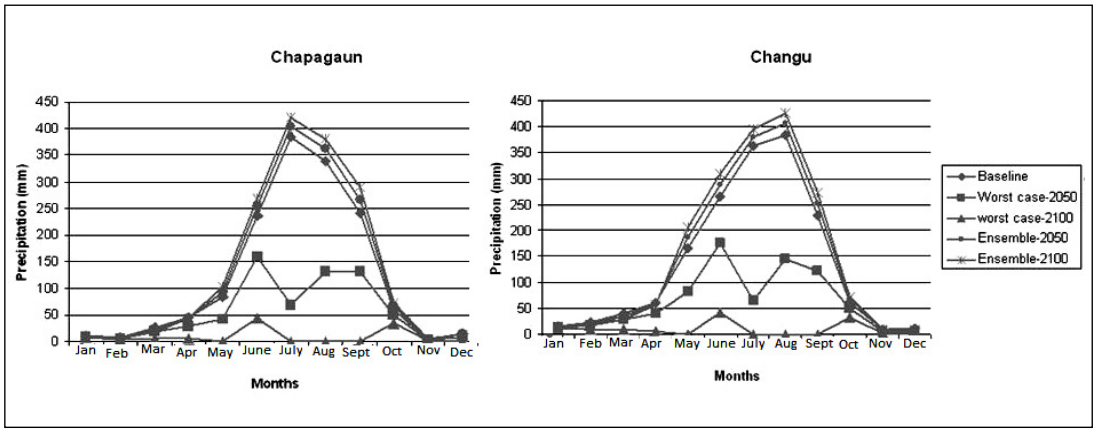


Figure 4: Monthly precipitation projection for four stations in the Kathmandu Valley under worst case and average case scenarios of climate change for different time periods.

Table 1: Projected change in total number of rainy days per year for the worst case scenario and average case (Jha 2012)

	Worst case scenario				Average case scanario				
Stations	**Baseline**	**2015**	**2030**	**2050**	**2100**	**2015**	**2030**	**2050**	**2100**
Kathmandu airport	187	182	178	143	10	188	190	190	189
Thankot	187	185	180	161	11	187	190	189	187
Chapagaun	177	171	162	125	9	177	177	177	177
Changu	189	184	178	159	7	188	189	189	187

POLICY CONTEXT

Adaptation discourse for policy development in Nepal was catalysed after the Marrakech Accords resulting from the 7th Conference of the Parties (COP 7) to the United Nations Framework Convention on Climate Change (UNFCCC), held in 2001. As a response to recognising the vulnerability of 49 LDCs to climate change, COP 7 proposed the LDCs to develop and submit the National Adaptation Programme of Action (NAPA). NAPA was reinforced by the UNFCCC to take urgent and immediate adaptation actions against climate change by the LDCs (UNFCCC 2012). 'Urgent and immediate needs' referred to recognizing those needs that could lead to increased vulnerability or increased adaptation if implementation is further delayed. The main aim of submitting NAPAs is to become eligible to submit projects to apply for the adaptation funds for LDCs provided by the Global Environmental Funds.

NAPAs needed to be prepared according to the annotated guidance developed by the LDCs Expert Group. Instead of focusing on scenario-based future vulnerability assessment and long-term national policies, NAPA identifies and uses existing information and local knowledge of coping strategies to identify the priority areas

and thus identify grass roots communities as the main stakeholders to respond to urgent and immediate needs.

As a requirement set by international mandate, the Government of Nepal (GoN), under the Ministry of Environment, initiated the preparation of NAPA. However, the process was immensely delayed. The NAPA preparation started only in late 2008, after almost seven years of COP 7. Nepal submitted NAPA to the UNFCCC in November 2010 and is one of the last countries to submit it (the last two submissions were Timor-Leste in September and Angola in December 2011). However, this delay was seen as an opportunity to learn from various best practices and cautionary lessons from other NAPAs (MoE 2010).

Through NAPA Nepal intends to contribute to the national goal of poverty reduction, livelihood diversification and building community resilience by mainstreaming climate change into the national development agendas (MoE 2010). It is reported that the NAPA process involved intensive community consultations and workshops, including consultations with the indigenous communities, which gives a sense that the process was somewhat inclusive. However, it is not explicit on how feedback from community consultations is reflected in the identified priority adaptation activities and how inclusiveness will be addressed further during project development and implementation. Furthermore, the document mentions that the stakeholders from different sectors will be involved in the implementation phase of climate change project. The term stakeholder is used frequently but loosely. Moreover, the document does not explicitly define who these stakeholders are and their level of involvement throughout the process, apart from implementation.

To facilitate NAPA implementation, the Local Adaptation Programme of Action (LAPA) has also been established. This is intended to facilitate need-based actions according to the local conditions. NAPA has been criticised for the missing link between the national and local initiatives in adaptation planning (see Agrawal and Perrin 2008). Nepal's intervention to establish LAPA is noteworthy and commendable, as it has recognised the importance of local level in adaptation. However, it fails to specify what 'local' means and ignores local institutions, even though the priority projects focuses on local interventions like agriculture, forestry and capacity building at the local level. In fact, the priority activities that are identified are very broad and sector-focused. Even though claims were made that delaying NAPA process provided an opportunity to learn from other NAPAs, Nepal seems to have missed critical institutional dimensions, which is quite well focused by some of those submitted earlier, for instance that of Sudan. The document largely remains a technical one with least recognition of social aspects of climate change adaptation. This is also reflected in the exclusion of social scientists in the preparation phase.

Similarly, the national Climate Change Policy was formulated in Nepal in 2011. However, as in the case of NAPA, the scope of Climate Change Policy is limited to technical aspects and the social aspect is largely neglected. The main problem identified behind the need to develop were the lack of scientific data related to climate change impacts, risks and lack of technologies and resources to adapt, including disaster preparedness and risk reduction. Not having a proper framework and institutions to deal with climate change in terms of 'science and technology' was argued to be a problem leading to the development of Climate Change Policy in Nepal. Much focus was on bureaucratic and technical institutions in most of its objectives. Other objectives of the policy document include reducing GHGs through green technologies, implementing adaptation

programmes and enhancing adaptation capacity of communities and so on. However, none of the objectives address the deeper social issues such as justice related to climate change.

The climate change policies are listed within eight broad policy areas, including adaptation and disaster risk reduction, reducing carbon emission, increasing access to fund, capacity building and empowering communities, increasing research activities, technology development and transfer and climate-friendly natural resource management. In terms of institutional aspect, which is relevant to this research, the Climate Change Policy addresses the need for institutional development quite frequently. For instance, it highlights the need to enhance capacity of public institutions, private sectors, NGOs and civil societies and to strengthen existing institutions and enhance capacity of local institutions for implementing programmes. In fact, there is a separate section devoted to 'institutional structure'. This section includes activities, including strengthening the existing institutions working on climate change issues and expanding their functions, conducting climate change programmes under the climate change council and forming a climate change center. This gives a sense that institutions are considered in the policy document as an organization rather than the underlying rules and norms within it. This can be further verified by the existence of legal aspect, which briefly talks about formulation of new laws and revising the existing ones for effective implementation.

Community engagement is also mentioned in the policy. The policy is explicit over the participation of women, *Dalits*, marginalised indigenous communities, children and the youth in the 'implementation' of adaptation and climate-related programmes. As such, there is very small scope of participation in the policy development and it was rather limited to implementation. Participation in planning and decision-making is neglected by the policy, with implications for procedural and distributional injustice. Even when the document mentions stakeholders, it is not clear who are the primary, secondary and tertiary stakeholders. The document further mentions that local institutions will be responsible for implementation, monitoring and evaluation of programmes and for information dissemination and capacity building. However, the mechanism is not quite explicit about what 'local' is and why 'local institutions' are limited to implementation, but not in policy development. Furthermore, the document addresses the importance of local knowledge, skills, practices and technologies and hence mentions that such existing information on adaptation and mitigation will be collected, published, disseminated and utilised. There needs to be much more emphasis on how this will be ensured.

The GoN has formulated and implemented various policies to ensure access of citizens to safe and adequate drinking water, which are reflected in the five-year development plan, sectoral acts, regulations, guidelines and annual activities. For example, the current five-year development plan (2010-13) has set the target of 85 percent of the population having access to drinking water and 60 percent receiving toilet facilities (NPC 2010). The Kathmandu Valley Water Supply and Sanitation Programme (KVWSSP) of the GoN aims to increase access of an additional 1.5 million people by 2012 and 3 million people after 2017 (WECS 2005).

The government policies related to water supply also emphasise, among others, water quality standards, access to water supply for the poor and disadvantaged groups, and involvement and empowerment of community and private sector. For example, the National Drinking Water Quality Standards (2006) has prescribed a detailed water quality standard to be fulfilled by service providers for all major urban areas

(MPPW 2006). Similarly, the National Urban Policy (2007) aims to empower municipalities to plan and implement water supply-related activities by seeking participation of local communities and private sectors (MPPW 2007). Another important policy is the National Urban Water Supply and Sanitation Sector policy (NUWSSSP), which focuses on increasing access of poor and disadvantaged groups to water supply through provision of subsidies (MPPW 2009). It also focuses on reducing demand, promoting involvement of private sectors and communities, recovering costs as an integral part of water supply projects (MPPW 2009). Thus, many institutions have been developed at the national level, whereas very little consideration has been given at the implementation level or local level, thus increasing ambiguity regarding the implementation of climate change programmes.

INSTITUTIONS FOR CLIMATE CHANGE ADAPTATION IN NEPAL

Since the climate change discourse gained momentum in Nepal during the mid 2000, many institutional arrangements have emerged at the state level. The Government constituted the Climate Change Network (CCN) in 2007 under the chairpersonship of the Secretary of the Ministry of Environment for stakeholders' coordination. Climate Change Council (CCC), which was constituted under the chairpersonship of the Prime Minister in 2009, is the apex body responsible for policy coordination in climate change. Realising the need for involvement of multi-stakeholders, the Government constituted the Multi-sectoral Climate Change Initiatives Coordination Committee (MCCICC) as the key national platform for ensuring regular dialogue and consultations on climate change-related policies, plans, finance, programmes/projects and activities.

At its fourth meeting, the Council evaluated its activities and achievements of the COP 15 and decided to launch the Mountain Alliance Initiatives (MAI) as a platform to ensure that mountain issues and concerns get due attention in international deliberations, in particular climate negotiations. The Ministry of Environment functions as the secretariat of the Council. The Ministry has the Council Secretariat Section under the Climate Change Management Division to implement activities related to climate change.

For the implementation of LAPA, formation of District Coordination Committee is proposed within the District Development Committee which will be represented by the existing district-level offices of the line ministries, including Ministry of Agriculture, Ministry of Forest and Soil Conservation, NGOs, Community-based Organisation (CBOs), local service delivery organizations, including community forest user groups, farmers' group, water users group, mothers group and private sectors. Adaptation initiatives are planned to be incorporated within the local development plans of Village Development Committees (VDCs) and municipalities. The Local Self-governance Act, formulated in 1999, provides local governments with a mandate to carry out environment and development-related activities.

The government has recently initiated the National Climate Change Support Programme (NCCSP) in 14 districts to help implement the LAPA. However, LAPA is yet to be prepared for the water supply of Kathmandu Valley (MoE 2013). One of the important reasons for this is water supply of Kathmandu Valley is treated as a more technical and engineering matter, while LAPA is treated as an environmental matter. This is further supported by the mindset among ordinary citizens and politicians which holds

that water supply is an engineering problem. They take climate change as a foreign agenda and do not consider climate change adaptation as a priority for the water supply of Kathmandu Valley.

ADAPTIVE CAPACITY OF KATHMANDU VALLEY

The GoN has been giving special focus to the management of drinking water supply for the Kathmandu Valley. The government, with support of donors, has been implementing a mega inter-basin water transfer project called the Melamchi Water Supply Project (MWSP) since 2001. The Melamchi scheme includes transfer of 170 MLD (1.97 m^3/s) of water from the Melamchi River, a glacial-fed river, through a 27 km-long tunnel entering Kathmandu Valley near Sundarijal (Bhattarai *et al.* 2002a). It also includes transfer of an additional 170 MLD (1.97 m^3/s) of water from the Yangri and Larke tributaries of the Indrawati catchment, which is expected to meet the water supply need of Kathmandu Valley for the next 30 years (Bhattarai *et al*. 2002a).

The government established Kathmandu Uptakyaka Khanepani Limited (KUKL) as a separate entity for the management of water supply in Kathmandu Valley in 2003. Outside Kathmandu Valley, the Nepal Water Supply Corporation (NWSC), a government institution, is responsible for drinking water supply-related activities.

The GoN restructured the NWSC in 2003 into three different entities: Kathmandu Valley Water Supply Management Board (KVWSMB), for asset ownership and providing policy direction; Kathmandu Upatyaka Khanepani Limited (KUKL) for the operation and management of services; and Water Supply Tariff Fixation Commission (WSTFC) for financial regulation (GHD Pty. Ltd. 2010).

Thus, a separate public–private entity called KUKL has been responsible for the management of water supply and wastewater-related services in the Kathmandu Valley since 2008 (KUKL 2011). KVWSMB authorizes KUKL to manage the assets and services related to water supply through a 30-year lease agreement between them (KUKL 2011). The KUKL needs to comply with all the government policies, including the provision of safe and sustained drinking water for most of the people of Kathmandu Valley (KUKL 2011). The shareholders of the company, with their respective shares, are: GoN (35%), municipalities in the Valley (50%) and the private sector (15%) (KUKL 2011).

The GoN established a Low Income Consumer Support Unit (LICSU) in 2008 and formulated policies, strategies and plans to increase involvement of poor people. These also include the construction and rehabilitation of public tap stands and storage tanks, and procurement of tankers to carry water from distant sources (ADB 2008). At the local level, the new tap points are being managed by local-level citizen committees whose recommendation is necessary to get connected with a new tap from the KUKL. Similarly, various NGOs have been carrying out activities such as renovation of stone spouts, rainwater harvesting for artificial groundwater recharge, constructing water treatment and distribution systems, bottled water distribution, improved toilets and awareness related to sanitation (UN-HABITAT 2009).

Besides, there are national-level government institutions that are directly responsible for formulating policies, strategies and plans for ensuring the supply of safe and adequate water supply in Kathmandu Valley. These include the National Planning Commission (NPC) and Ministry of Physical Planning and Works (MPPW) for policy at the national level (GHD Pty. Ltd. 2010).

ISSUES AND WAY FORWARD

What are the impacts of climate change on urban water availability and quantity?

There is a high degree of uncertainty in predicting the impact of climate change on precipitation. The uncertainty is due to various limitations of GCMs, including their coarse resolution (1-4 degree equivalent to 100-400 Km), uncertainty in climate feedback and climate sensitivities and uncertainty in future SRES.

The high degree of uncertainty necessitates the need for a variety of water management strategies and need for adaptive management. The existing efforts are less diversified and solely rely on the Inter-Basin Water Transfer (IBWT). The expected sharp reduction in quantity of precipitation and number of rainy days under the worst case scenario of climate change would also decrease the potential of precipitation-dependent water supply options such as river flow, rainwater tanks and artificial groundwater recharge drastically after 2050 (Pitre 2005; Jha 2012). This further necessitates the need to diversify the water supply options.

The uncertainty also shows need to increase the learning capacity and need for adaptation based on the information from learning. For this there is a need for more piloting on various options to increase water supply and reduce water demands. The institutions need to be open and flexible to learn from these trials. This requires strong management information and monitoring systems to link the results from these trials to inform users and change institutions. In this process, trust is needed between users, researchers and managers.

The abrupt reduction in precipitation, coupled with the high rate of temperature increase under the worst-case scenario, would further deepen the gap between the demand and supply of water (Protopapas *et al.* 2000). People without having the minimal needed water would rise to 5.21 million by 2050 and 14.67 million by 2100 based on the population projection of the Asian Development Bank (ADB) and World Health Organisation (WHO) standards of minimum needed water even after the operation of the MWSP (Jha 2012). For this, political consensus, strong leadership and policies are needed. Moreover, demand management strategies such as pricing based on marginal use principle, introduction of water efficiency labelling, regulatory compliance and motivating people not to waste water can help prevent increase in the water demand in the future (Cheng and Hu 2011).

The expected increase in frequency of extreme rainfall events could further degrade the water quality through inflow of debris in the water supply system and increase unexpected costs in maintenance and designs and blockages.

The significant reduction in low flow and increase in temperature could degrade the water quality (Environment Canada 2001; DFID 2004). Thus, additional resources are necessary to tackle these unexpected challenges, along with improved capacity to design infrastructure, by considering the changed climatic conditions.

Whether and how do government policies articulate the issues of water supply?

The existing efforts to tackle the problem are not sufficient, as indicated by the fact that none of the aforementioned policies include any actions to deal with the impact of climate change. The current three-year development plan of the GoN (2010-12) mentions that the government is aware of the impact of climate change and includes some strategies but no concrete actions to deal with them (NPC 2010). Similarly, Kathmandu Valley Water Supply Management Project (KVWSMP) has

mentioned climate change as a risk, but does not suggest actions to deal with it, except for monitoring and development of other water sources as a mitigation action (GHD Pty. Ltd. 2010).

The GoN prepared NAPA in 2010 (MoE 2010). To deal with water scarcity, NAPA has prioritised several activities such as rainwater harvesting, groundwater recharge and promotion and rehabilitation of traditional water sources, and recycling and treatment of waste water (MoE 2010). However, there is a lack of detailed analysis of these options to meet the need of safe and adequate drinking water under the worst possible case of climate change. Similarly, the Climate Change Policy endorsed by the GoN in 2011 is not explicit on dealing with the water scarcity to meet the increasing water demand and decreasing water supply of Kathmandu Valley.

None of these instruments have a clear-cut plan to deal with the expected abrupt reduction of water sources such as river flow. There is a lack of scientific assessment of the impact of climate change on the potential of water supply sources for Kathmandu Valley such as rainwater harvesting, rain-fed river and glacial-fed river. The large-scale uncertainty in precipitation projection needs to be reduced. This is possible by capacitating the Department of Hydrology and Meteorology (DHM) to develop high resolution RCMs, increase coverage of meteorological stations to have good quality long-term observed precipitation data and validating precipitation projection by other methods such as paleo-climatic studies.

The existing water supply policies are hardly prepared to deal with the worst case of climate change. They are highly focused on IBWT projects, particularly on the MWSP. The MWSP has been taken as a panacea to solve all water supply-related problems. The MWSPs, however, even after operating at its full capacity of 340 MLD, would not be able to fulfil the minimum needed water of 100 litres per capita per day (LPCD) by 2030, considering the existing rate of population growth. The potential of the ongoing MWSP to meet the growing demand for water is questioned even under the existing conditions. This is due to the unexpected increase in population of Kathmandu Valley after the project was started and also due to the debate on the adequacy of the water left to meet the need for minimum environmental flow. The situation could become worse due to the projected large-scale decrease in the precipitation and decrease in glacial melt portion of the river flow after 2050.

What are the institutional factors that constrain or enhance water adaptation practices?

The KUKL has been blamed for bad governance. In December 2012, Baburam Bhattarai-led government was criticised for appointing his sister-in-law Timila Yami as the chairperson of the KUKL without following proper process (Poudel 2012). The water supply from the KUKL is very irregular and unreliable. In the Satdobato Bodhigram area, Lalitpur ward number 17, the author used to get water from KUKL tap two or three times a week for few hours since 2008, but from 2012 onwards the tap has been dry. The KUKL management is hardly responsive to complaints and takes such issues lightly. Without the political and bureaucratic pressures an average customer cannot hope to get his complaints solved.

The Bagmati River and groundwater are sources of water for KUKL and in future, water is expected to be added from the MWSP. Everyone hopes that the completion of the MWSP will solve the problem of drinking water supply in the Kathmandu Valley. However, with the delay in its implementation, people are losing their patience. The MWSP, which was previously supposed to be completed in 2006, has completed

just 6.5 km out of the 26 km tunnel by the end of 2012 (Bhusal 2012). In 2012, the MWSP terminated the contract and is in the process of recruiting a new contractor; the project is expected to be completed by 2017.

The reliance on the MWSP shows government's preference to a single solution and lack of involvement of multiple actors on the water supply in Kathmandu Valley. The MWSP is an authorized project of the government; the total project budget in 2000 was US$464 million and it has highly skilled human resource and technologies. However, the progress of MWSP shows its inability to act according to the plan and lack of strong leadership. The project document also fails to mention any measures to deal with the worst case of climate change.

The private tanker operators are the most reliable source of drinking water, but they are ten times more expensive than the rates charged by KUKL. Even residents with KUKL's taps rely on water tankers during dry season to supplement water; however, water from all tankers is not safe for drinking. Also, they need to be informed at least a few days ahead in dry season as they have to bring water from distant sources by waiting in queue. These tankers used to bring water from various springs, rivers and groundwater boring from the outskirts of Kathmandu Valley. However, with the increase in number of tankers collecting water from these areas, conflicts have started between the local people of these areas and private tanker operators. Despite their large contribution in supplying water, the government seems less responsive to regulate these tanker operators to provide safe water and minimize the tensions between tanker operators and local people of the water collection area.

What are the potential options for enhancing adaptation capacity of Kathmandu?

The vulnerability can be minimised by diversifying the water supply sources, improving governance of the institutions, having visionary leadership and adopting the principles of adaptive management. The existing practice of depending on a single solution such as the MWSP and the government only, need to be replaced by multiple solutions and multiple actors.

Various possible water supply options, both centralised and decentralised, along with the involvement of multiple actors, including the government, private sectors and citizens need to be explored. Only listing potential options in NAPA is not sufficient. These options have not been reflected in the water supply policies, strategies and plan of the GoN. Detailed analysis of these options is needed which can be answered through the following questions; what percentage of the household water requirements can be fulfilled from rainwater harvesting, especially in dry season and what percentage of the total households in Kathmandu Valley have the potential to fulfil water requirement from rainwater harvesting? Can every household afford rainwater harvesting in terms of capital, operation and maintenance costs? What is the role of different actors in rainwater harvesting? What is the social acceptability and suitability of rainwater from health perspective?

Reusing water after treatment is the most reliable adaptation strategy in a situation when the precipitation-dependent water supply options are not reliable. However, public acceptance of using recycled water varies (Allen *et al.* 2010). We need to assess the acceptability and potential of the change. To what extent can recycled water contribute to the per capita water need? What is the social acceptability of recycled water? How costly it is to make recycled water safe for drinking? What is the minimum number of households to be connected to make recycling affordable to people? What is the compatibility

of mixed system? What are the infrastructure requirements of the recycling and potential for its integration with the existing expansion of the MWSP? Considering the resistance of people to change, an easy start could be to recycle grey water and use it for non-potable purposes such as bathroom, toilet, washing and garden, although full recycling needs to be promoted gradually. Timely integration of these could minimise the complete replacement of the existing water supply network in the future.

The average population density in most of the city areas is 40,000 to 45,000 per km^2 and approximately 80,000 per km^2 in the core city areas, which could be even more when temporary populations are included (GHD Pty. Ltd. 2010). Every year, thousands of residential buildings are constructed in Kathmandu Valley and the average land area occupied by these houses is 100 m^2. Such small areas of land are not suitable for rainwater harvesting or artificial groundwater recharge. For this, a policy needs to be formulated and strictly implemented to have minimum divisible land size and provisions of rainwater tanks in all new buildings.

CONCLUSION

The shift of government policies in Nepal shows that climate change has become one of the critical issues for the government. With rapid urbanization in the country, the paper has focused on the analysis of adaptive capacity of Kathmandu city government to cope with the impacts of climate change on drinking water supply. The paper explains that the existing efforts of Kathmandu Municipality are limited, focusing on IBWT and due to the projected sharp decrease in precipitation, the IBWT projects cannot meet the increasing demand for drinking water of the city residents. Meanwhile, the existing climate change adaptation policy only lists some broad options. Detailed analysis of these options is lacking. Most institutions and their decisions seem to be informed by the knowledge produced by professionals and scientists. Institutions and knowledge with local communities is ignored. While the current policy attempts to provide some efforts to address water supply issue in a changing climate, the actual practice fails to do so. This failure highlights the need to look at the issues of institutions and their capacity as central to decision making about climate and water policy and development issues. Clearly, the restricted thinking embedded within the bureaucratic culture and scientific tradition continues to inform policies about urban water issues. The restricted thinking is linked to the hegemony of 'science', which provides knowledge and skills to facilitate narrow understanding of urban planning and development problems and solutions. The policy-makers have failed to appreciate wider social, economic and political relevance of community institutions, knowledge, problems and solutions. The conventional institutions and power relations remain unchanged, as the traditional bureaucratic policy-making style maintains status quo. Therefore, there is an urgent need for reframing the relationship between citizens, scientists and policy-makers to promote knowledge-based urban planning practices.

While we do not assert that improved institutions and policies may be devised and urban water supply problem is addressed, improving institutions, policy and development outcomes necessitates realising that community institutions and knowledge are important to complement bureaucratic institutions and scientific knowledge. The reframing should aim at improving the institutions, policy and development practices by providing a suitable and sufficient opportunity for urban local community participation to occur. The restricted thinking of a narrow focus on the bureaucracy, scientists and professionals should be modified so that social goals such as justice and participation are paramount and that

institutions from the orthodox science are used to promote such social goals. This may, however, be controversial because it challenges the structures of power and privilege of scientists, experts and planning professionals. Furthermore, it may be upsetting for traditional planning and development agencies as it challenges long-held bureaucratic practices and processes. Nevertheless, an analysis of institutional history and current development practices suggests that it is overdue to question institutional assumptions and to set agendas, with which the Kathmandu Metropolitan planning policy and development practice can be advanced.

We offer following specific recommendations based on this study:

- Planning policies about urban development not only need to clearly reflect the intent of the overarching policies, but they also need to provide (with resources) specific institutional guidelines to implement them in practice;
- There is a need for a broad range of opportunities to be created/implemented and to bring about community institutions and knowledge, a targeted social science approach needs to be employed to analyse climate change issues;
- Local communities and professionals need to be re-educated so that their attitude, capacity and interests for climate change adaptation are increased; and
- Detailed analysis of options and translation of suitable options into socially desired plans and activities.

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