Water Security in Peri-Urban South Asia

Adapting to Climate Change & Urbanization

WATER SECURITY IN PERI-URBAN SOUTH ASIA
ADAPTING TO CLIMATE CHANGE AND URBANIZATION

Scoping Study Report: Nepal

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Working primarily on water security issues in Peri-Urban South Asia, across India, Bangladesh and Nepal, the project's main concerns are the rapidly changing peri-urban landscapes due to urbanisation and implications for water security in specific locations in the larger context of climate change. As an action research project, working across four locations in South Asia, it will serve as a basis for capacity-building at the grass roots level to address concerns of the poor, marginalised and other vulnerable communities to water security and seek to understand the dynamics of adaptation in the specific locations, for action and policy agenda at the regional level. It will build their capacities to cope with climate change induced water in-security.

The project is being coordinated by SaciWATERs, Hyderabad, India and executed in association with Bangladesh University of Engineering and Technology (BUET), Dhaka in Bangladesh and Nepal Engineering College (nec), Kathmandu in Nepal. This project is supported by Canada's International Development Research Centre (IDRC).

A scoping study was carried out for a period of six months from August 2010 – January 2011. It was an exploratory phase that investigated the key peri-urban and climate-change related issues in the research sites. The process of changing peri-urban landscape and its impact on water security and vulnerability was probed by literature review, field visits, discussions with various stakeholders, and use of other qualitative techniques. Specific sites were identified in Kathmandu (Nepal), Gurgaon, Hyderabad (India), and Khulna (Bangladesh) where the research would be carried out.

Four scoping study reports consolidate the outcome of this study. This is the Nepal Scoping Study Report.

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1. INTRODUCTION

Urbanization has become a major trend worldwide. In 1920, the urban population made up 14% of the world population that reached to 25% in 1950 (Weber and Puissant, 2003). At present, nearly 50% of the global population, which estimates roughly 3.3 billion people, live in the urban areas (UN, 2008). Rapid urbanization is an ongoing and dynamic phenomenon worldwide. The growth in the urban population is expected to be large in the developing countries and that too in small and medium towns and cities in the South Asia, Africa and Latin America. This trend in the urban population growth has also been visible in Nepal, especially after 1980s (Thapa et al., 2008). The number of urban centers in the country have increased from 10 to 58 between 1952 and 2008 and the size of urban population has increased from 0.4 million to 4.09 million during 1971 to 2008 (Portnov et al., 2007; Thapa et al., 2008).

Kathmandu valley has been the most urbanized area in the country. The pace of urbanization has been rapid after 1970s with the increased connectivity of Kathmandu to other parts of the country and to the Indian border in the south. The average growth of population in the valley has been consistently above 3% during 1951-2001 (Dhakal, 2009) that has brought dramatic changes in the land use pattern in Kathmandu valley. While the built-up area in the valley expanded fivefold, from 3,330 ha in 1955 to 16,472 ha in 2000 (Pradhan and Perera, 2005), the agricultural land has been declining on an average of 2.04% per annum. The process of urbanization and subsequent expansion of the built-up area to the peripheral rural landscape has resulted to emergence of rural-urban intermediary, differentiated by a mixed rural-urban economy and livelihood, differently called, as rural-urban fringe, peri-urban interface and Desakota by different researchers (Allen, 2003; Brook et al., 2003; Narain and Nischal, 2007). These areas have traditionally been supplier of food and much needed natural resources-land, water, soil and clean air, to sustain urban livelihood and maintain urban ecology. The obvious consequences of urbanization, and the resulting stresses on the peripheral rural areas, have been changes brought in the use and management of land and water resources, thus raising concerns for water security. Since these peripheral areas are generally inhabited by poor and marginalized people and the governance structure in these areas are generally weak, these are vulnerable to exploitation of resources by the forces of market and also by the government led development initiatives which often tend to be in the favor of the urban areas. The uncertainties and variability resulting from climate change are expected to further worsen the water security in these areas, in terms of availability in quantity and quality of water, likely to be stressing further the livelihood and wellbeing of the people living in these areas. The rural poor and those weak in the power structure are expected to face much larger consequences of the water insecurity resulting from urbanization and climate induced changes in the water availability. Developing understanding on the processes and changes brought in the rural landscape as a result of urbanization and its consequences to the use and management of land and water resources in the realm of climate induced uncertainties, would be the entry point to addressing the established and emerging water security concerns in the peripheral areas. It is in these realities that a three years long action research is underway to look into the issues of water security in the peri-urban areas in four South Asian Cities in India (Gurgaon and Hyderabad), Nepal (Kathmandu) and Bangladesh (Khulna), beginning July, 2010, under financial support of IDRC and coordinated by South Asia Consortium for Interdisciplinary Water Resources Studies (SaciWATERs) based in Hyderabad, India. Nepal Engineering College (nec) is one of the recipients of the IDRC's support and entrusted to undertake the part of the action research in Kathmandu.

This report is outcome of the six months long scoping study under the stated action research, from July-December, 2010, which aimed at: i) reviewing relevant literatures, and in doing so, focusing on water issues in rural and urban areas, ecological footprints of urbanization, climate induced uncertainties to water availability and emerging quantity and quality concerns, effects on ecosystem services resulting from urbanization induced stresses to watershed and watershed based natural resources, people's response and adaptive strategies; ii) identifying researchable issues/problems relevant to Kathmandu and also inferential to the regional context of South Asia; iii) defining the dimensions of the issues by analyzing the direct and indirect linkages to urbanization induced anthropogenic factors, climate related uncertainties,

development policies and other exogenic forces, iv) identifying research sites that provide opportunity to carry out investigations (qualitative and quantitative) on one or more of the identified issues, and v) designing the research for the remainder period of two and a half years, identifying the project milestones, activities to the undertaken and methodological approaches to the activities.

2. THE RESEARCH PROBLEM

2.1 The Context of Kathmandu and Water Security Concerns

Kathmandu Valley lies at latitudes 27°32'13" and 27°49'10" north and longitudes 85°11'31" and 85°31'38" east at an altitude of 1,300 m above mean sea level. Administratively the valley encloses three districts- Kathmandu, Lalitpur, and Bhaktapur that together cover an area of 899 km2, whereas the area of the valley as a whole is 665 km2 (Figure 1). The three districts of the valley consist of five municipalities and 114 Village Development Committees (VDCs). As per the criteria for the classification of urban and rural areas set by Local Self Governance Act of 1999, there are three municipalities (Bhaktapur, Madhyapur-Thimi, and Kirtipur), one sub-metropolitan city (Lalitpur) and one metropolitan city (Kathmandu). The valley is bowl shaped and surrounded by the Mahabharat range of mountains on all sides. The whole population of the valley shares the same natural resources- waterways and drainage channels, forests, soil, and air. The surface runoff of the entire area the valley drains through Bagmati River with the outlet at Katuwaldaha, located on the southern tip. The physiography and drainage system of the valley create possibilities for air and water pollution occurring at any one location easily getting spread to the entire area.

Historically Kathmandu has been an important trade route, through Indo-Nepal-Tibetan trade links. The valley has also been important cultural and religious center. With the unification of Nepal after Gorkha Conquest in 1769, Kathmandu was made the capital of Nepal and since this time Kathmandu continues to remain the center of power and politics in the country. Nepal was largely isolated until 1950 owing to its geopolitical settings, inaccessibility and difficult transport and communication. During 18th, 19th and first half of 20th century, Nepal was ruled by families who deliberately kept the country in isolation so that their rules could be prolonged (Lama, 2001; Luitel, undated; Manas Reprint, 1951; Amatya, 1983). Nepal started getting known to rest of the world only after abolition of Rana Regime in 1951. Construction of Tribhuvan Highway linking Kathmandu to Hetauda in 1956 was the first transport corridor in the country that linked Kathmandu to Terai and to the Indian border in the south. People from other parts of the country started migrating to Kathmandu valley after 1950 with the development of transport and communication infrastructures.

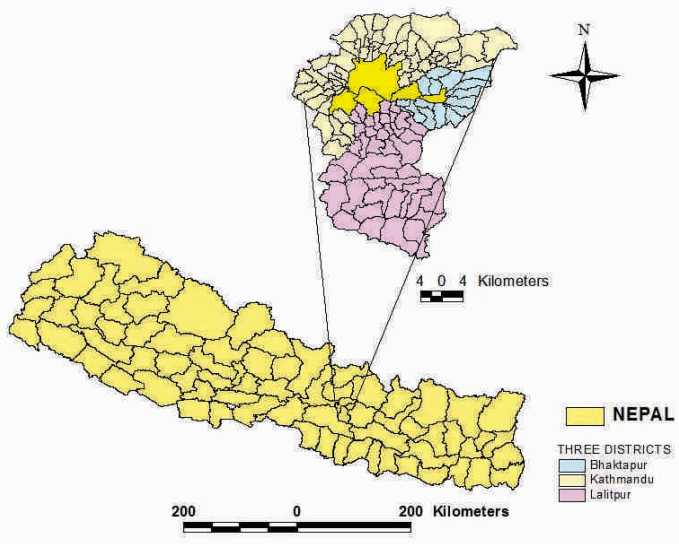

Figure 1 : Location of Kathmandu Valley

This trend of urbanization has led to serious environmental degradation, especially those resulting from the degradation in the river water quality and the river environment (Thapa et. al., 2008). The degradation of the river environment can be attributed mainly to disposal of household sewerage, effluent discharges from factories, solid waste disposal on the riverbanks, upstream water extraction, encroachment of river banks for illegal settlements and unplanned physical infrastructures along the river course without considering the possible consequences to the river environment (Sada, 2010).

Early settlement in Kathmandu and adjoining cities were limited to the historical city core, which were generally located to elevated areas that had low agricultural potential. The migration of the people that started after 1950s, and more rapidly after 1980s, led to expansion of the urban areas beyond the traditional city core. Construction of ring road in Kathmandu during mid 1970s further accelerated the pace of urbanization that started reaching the adjoining rural areas in the post 1990s (Thapa et. al., 2008). This trend of urbanization has resulted to unprecedented land subdivision in the rural areas with the construction of houses and commercial buildings and other infrastructure facilities and services. The influx of internally displaced people who started coming to settle in the valley after the start of Maoists' armed struggle in 1992 suddenly created demand for housing plots and other services. Those who could not afford buying land in the municipal areas preferred buying in the fringe areas of the city and in the adjoining rural areas. Huge demand for housing plots in the land market motivated rural landowners to sell the agricultural land for the development of houses at lucrative prices. Difficulties in cultivation of land due to shortage of manpower and increasing opportunity for non-agricultural employment opportunities encouraged rural people to sale their land and search for alternative employment. Besides getting cheaper housing plots, another motivating factor for new migrants to settle in rural areas was that there were no needs to get permits for the construction of houses from the local authorities. People could build anywhere and build anything they like, in the absence of the regulatory mechanisms in these areas.

This trend of rapid urbanization that started in 1990s continues to expand due to continued migration of people even after the signing of peace accord with the Moists' in 2006 and initiative underway to write the new democratic constitution of the country by the elected parliament. The push factors that have been responsible for migration of people from other parts of the country into Kathmandu valley, are, continued insecurity and lack of employment and livelihood opportunities. Increased flow of remittance sent by the family members in the foreign employment and growing aspiration to live in the urban areas has been yet another factor for rural-urban migration.

In the absence of government led land development, private land developers and land entrepreneurs are involved in land related businesses. Buying of tracts of low priced land, partially developing it and reselling for a profit has been a characteristic of urban development in Kathmandu and in other urban areas in the country. Land speculation is prevalent at both individual and institutional levels. Land brokers and housing development companies hold huge parcels of land in urban fringe areas for speculative purposes.

The growths of the settlements and the resulting land use and land cover changes in Kathmandu have been largely spontaneous without any government intervention. This informal process of urbanization that has been occurring over the last 30 years has created several physical, social, and environmental problems in Kathmandu. The ecosystem of the valley is affected severely by ever-expanding built-up areas and incompatible economic activities. The most visible changes have been loss of agricultural land, increasing air and water pollution, rapid decline in the vegetation cover, deficiency in the basic amenities and services for the urban and rural water supply and sanitation and drainage of wastewater. The quality of the river water has degraded to the extent that most of the rivers, especially those passing through the city core in Kathmandu, Bhaktapur and Lalitpur have become biologically dead. The degradation of the Bagmati River and its tributaries follows clearly the pattern of population growth in Kathmandu Valley. Continued degradation of river environment has led to rapid erosion of rich cultural heritage along the river courses, such as, temples, religious and cultural monuments and ghats. The river waterways and public lands along the river course have been encroached by the people. As a result of this encroachment, the greenbelt that existed along the river course until few years back has completely vanished (NTNC, 2008).

The most visible and direct impact of urbanization has been significant increase in the competing water uses and diminishing water supply. Water in Kathmandu valley is derived from surface and groundwater sources.Over time, requirements of water for drinking and personal hygiene, agriculture, industrial production and religious and recreational activities have increased in the valley.

The rivers are also the main repository for the valley's untreated sewage, solid waste and industrial effluents. The pressure on the water resources is large due to limited supply compared to the demand.

In 1988, the water demand of Kathmandu valley was estimated to be 35.1 MLD (million liters per day) which was estimated to have reached 155 MLD in 2000 (Gyawali, 1988; Moench and Janakrajan, 2006) that further increased to 320 MLD in 2009 (KUKL, 2009). In contrast to this, Kathmandu Upatyaka Khanepani Limited (KUKL), the water service providing agency in the valley, has been supplying only 155 MLD during the wet season and 105 MLD during the dry season, serving population of 3,200,000 (KUKL, 2009). The deficit in the water demand is met from rampant groundwater pumping, traditional water spouts, wells and supplies of private water vendors and water bottling industries. Water market has been constantly evolving in the valley since 1990s in response to ever increasing deficit in the water supplies and failure of water service providing agencies to meet the demand. Shrestha and Shukla (2010) estimated more than 450 tanker trucks operating in Kathmandu valley as in 2009, transporting water from different locations to meet the domestic, institutional and commercial water demands in different parts of Kathmandu and Patan, which are the most urbanized areas in the valley. The tanker based water supply has been estimated to command nearly 9.1% of the water demand in the valley. These tankers are essentially transferring water from the urban fringe and surrounding rural areas, tapping both surface and groundwater sources. The water market in the valley includes spectrum of water entrepreneurs, from small scale water vendors to people who have invested in developing deep tubewells for groundwater pumping, tanker water entrepreneurs and water bottling industries of industrial scale. This market is essentially unregulated, except the water bottling industries which need to abide by the quality regulations.

The annual groundwater use in the valley for domestic and industrial purposes is two times in excess of the annual recharge. A recent estimate of Groundwater Resources Development Project shows that half of the domestic water needs in the valley, at present, is met from groundwater. The daily pumping of groundwater in the valley, that also includes water pumping in the industries and hotels, is estimated to be 300-450 MLD (The Kantipur, 2009). While the rates of groundwater pumping has been constantly increasing, the groundwater recharge zones have been shrinking due to land use and land cover changes and changes brought in the landscape as a result of sand mining and large scale land development activities carried out by the land developers. The rivers in the valley have been traditionally mined for sand. With the decreasing sand availability from the river bed and enforcement of restrictions on river bed sand mining, the mining of sand has now shifted to pit mining along the river terraces. A very important feature of the river terrace sand mining in Kathmandu valley is that these fall within the recharge zone of groundwater. The loss of this recharge zone is likely to produce serious consequences to groundwater supply in the valley, thus further limiting the water security in the urban and rural areas.

In many parts of the valley, inter-sectoral water conflicts, mainly between agriculture and domestic uses, have started emerging. These are particularly apparent in the dry season and during the periods of peak of agricultural water demand. In some areas, these conflicts have become serious to the extent of stressing the livelihood of the people and translating into violence. Further, increasing trend of water allocation shift, from agriculture to municipal and industrial uses, have important implications to ecology, food security and livelihood of the poor and marginalized communities.

The failure in the conventional governance arrangements and absence of devising newer arrangements for governance and regulations result to haphazard mixture of planned and unplanned operations and a tendency to flout regulations. This results to a situation of confusion in the understanding and assessing the problems in rapidly transforming rural and urban landscape in Kathmandu. The uncertainties of climate further complicate the water availability and demand management and pose additional challenges to ensuring future water scarcity in the valley. With multiple claimants over existing water resources, the access to and control over water and its distribution has already become problematic in Kathmandu and sure to become even more complicated and problematic in the days to come.

2.2 The Research Questions

The preceding section presented the current and possible future scenario of growing water scarcity in Kathmandu and the emerging stresses thereto. This section also established the ecological implications of urbanization in Kathmandu to the urban fringe and in the rural areas in the periphery. The consequences to water availability produced in these areas are result of the changes brought in the landscape, conversion of agricultural land into settlements and increasing transfer of surface and groundwater to more urbanized location through water transfer infrastructure and services by formal water service providing agencies and involvement of water entrepreneurs and vendors in the surface and groundwater extraction and rural-urban water transfer. This situation is expected to further aggravate in the days to come due to continued political uncertainty and weak governance at the center as well as at the village levels. The changes brought in the land and water use and management in the urban fringe and rural areas have started posing livelihood insecurity which is expected to magnify in the days to come due to continued unplanned urbanization. This situation is expected to become more complicated with the growing uncertainties in water availability as a result of climate change.

The mechanics of response to growing water insecurity in the urban and rural areas in Kathmandu must be based on comprehensive understanding of the factors and processes responsible for water insecurity, stresses posed to existing water security by climate induced uncertainties and the adaptive strategies and the responses of the people and their institutions. An equally important element would be to look into the policy and response of the formal government institutions to the emerging water insecurity in these areas. These then become the bases to propose alternative responses to existing and possible future water insecurity through policy changes and development of newer institutional arrangements for water governance and management.
In these premises following research questions and sub-questions have been identified to be looked into in attempt to understanding issues of water security in the peri-urban areas of Kathmandu:

1. How have the urbanization and variability in climate been inducing changes in the land use, natural resources and hydrology that are likely to influence the availability of water in terms of quantity and quality?

i. How have the processes of urbanization been proceeding in the study area, in time and space?
ii. How have the processes of urbanization been responsible for land use and land cover changes, likely to influence the surface and groundwater hydrology?
iii. How are climatic variability understood in the context of the study area, both in terms of observed anomalies and uncertainties and also those perceived by the people?
iv. How have the urbanization induced land use and land cover changes and the climate variability been responsible for influencing the water availability and quality?

1. How have the processes of urbanization been responsible for demographic and livelihood changes in the context of the study area, what have been the drivers for the demographic changes and what are the implications to the changing water demand and management at the local level?

i. How have the demographic profile of the study locations been changing over time and what have been the drivers for the demographic changes?
ii. How have the occupation, income opportunities and access to education and health services been changing over time?
iii. How have the infrastructure and services in the area, including the growth in the industries, been occurring over time as a result of urbanization?
iv. How have the changing demographic profile, occupation and income opportunities and growth in the infrastructure and services, including industrial growth, been responsible for the changes in the water demand?
v. What are the competing water uses in the study area and how have they emerged and been changing over time?
vi. What are the management challenges emerging from the changes in the water demand and uses and how are these challenges addressed by the people and their institutions?

3. How the processes of urbanization and climate induced water scarcities and uncertainties stressing the livelihood of the people at the local level?

i. How have the water stresses been appearing and manifesting in the context of the study location?
ii. Are their differential stresses to different groups of people (class, caste and power structure) and what are the reasons for the differential stresses?
iii. What are the levels of vulnerability of different groups of people to the water stresses?
iv. Are their intra-household differentials in terms of water stresses what does it mean to different members within the household?

4. What are the formal and informal institutions relating to and involved with the water issues and their roles in water management in the context of the study area?

i. What are the formal and informal institutions that have direct and indirect roles and involvement with the water issues and water management in the study area?
ii. What changes have been brought to the configuration of traditional institutions and their roles in water management as a result of urbanization?
iii. What new institutions and governance structure have emerged as a result of urbanization and how have they been influencing and responding to the emerging water issues in the context of the study area?

5. How are the people responding to the water stresses resulting from urbanization and climate induced uncertainties?

i. How are different groups of people responding to the water stresses that they have been facing?
ii. What are the coping strategies of different groups of the people?
iii. What are the adaptive strategies of the people to water stresses and what are the roles of technology interventions to the adaptive strategies?

6. What policy changes and responses and institutional arrangements would be essential, and also effective, to addressing the existing and possible future water security in the peri-urban areas of Kathmandu.

i. How are established and emerging water issues in the peri-urban areas, addressed in the existing urban development policies and how effective have been the existing policies and development strategies in addressing the emerging water issues?
ii. What are the strengths and weaknesses of existing policies and institutions in terms of governance and management of water in the peri-urban areas?
iii. What alternative institutional arrangements and governance would be effective in addressing the existing and possible future water insecurity in the area?

3.REVIEW OF LITERTURES

3.1 Urbanization

Urbanization refers to increasingly large number of people living in small places, with concentrated and more intensified infrastructure and services, with their livelihood derived essentially from non-agricultural activities. Urbanization is often considered as an index of modernization due to high level of access to infrastructures, information and communication and income opportunities, especially in the context of developing countries (Roy 1986; Singh 1987; Sharma and Maithani 1998). The economic differentials in the rural and urban areas and the migration of people from rural to urban areas as result of this differential have been the major input to urbanization and urban growth in most developing countries (Basyal and Khanal, undated).
Urbanization is the predominant phenomenon all over the world. In the developing countries, the percentage of the population living in the cities and towns rose from 18% to 40% and this percentage is expected to rise to 56% by 2030 (COHRE, 2008). In Nepal, rapid growth in the urban population has been observed beginning 1970s (Table 1). The rate of urban population growth in Nepal has been one of the highest in the Asia and the Pacific (ADB/ICIMOD, 2006). The Central Bureau of Statistics projects the urban population in Nepal to reach 20% in 2011, 23% by 2016 and 27% by 2021 (CBS, 2003).

Parameters	1941	1952/54	1961	1971	1981	1991	2001	2008
Urban Population ('000)			336	462	957	1696	3228	4089*
Number of Urban Areas	10		16	16	23	33	58	58*
Urban Population (%)		2.9	3.6	4.0	6.4	9.2	13.9	17.0**
Urban Growth Rate (%)			4.40	3.23	7.55	5.89	6.65	4.90**
National population Growth Rate (%)			1.65	2.07	2.66	2.10	2.27	1.28**

(Source: Pokharel, 2006 as cited in MoPE, 2004; Pradhan and Choe, 2010 as cited in *NUDI, 2008; **CIA, 2009; CBS, 2003)

3.2 Urban Development in Kathmandu

Though small townships had emerged in Kathmandu, Patan and Bhaktapur as early as in the 11th century, the process of urbanization in the valley got started only beginning 1960s which accelerated in after 1970s (ICIMOD, 2007). Growth of Kathmandu outside the historic city core started occurring as early as in 1960s. The construction of ring road in mid 1970s created incentive for rapid urban growth beyond the traditional city core, extending to the rural areas in the periphery.

Planned urban development in Nepal started only after 1963. The Town Development Committee Act, promulgated in 1963 and further amended in later years, created the legal basis for preparing and implementing urban development projects (Gyawali, 1997). The first physical development plan of Kathmandu valley was finalized in 1969 (HMGN, 1969). Till this period, the city of Kathmandu was confined to the highlands between the Bishnumati River and the Dhobi Khola in the east-west and between Bagmati River and Maharajgunj in the north-south directions. Low intensity urbanization had occurred on the periphery, leaving large areas of undeveloped land within the city core. The plan adopted a multi-nucleated regional growth model, linking the dispersed settlement in the valley and continuation of existing growth tendencies of the Kathmandu-Patan complex and the development of Bhaktapur by reinforcing transportation linkages. In the decade of 1970-1980, there has been immense expansion of government machinery, trade and tourism and establishment of carpet industries that created impetus for accelerated urban growth due to increased employment opportunities in Kathmandu.

Under the Town Development Implementation Act promulgated in 1972, the Kathmandu valley Town Development Committee (KVTDC) was formed in 1976 to assume the overall responsibility for planning and regulation of urban growth in Kathmandu Valley. In the same year, KVTDC prepared the Kathmandu Valley Town Development Plan (KVTDP), based on the physical development plan of 1969, to manage the city growth. This plan considered three broad zoning concepts: Zone A as the city core (Kathmandu and Lalitpur); Zone B as the city fringe; and Zone C as planned settlements in the rural villages of the region. This plan led to the development of a 28 km long ring road around Kathmandu and Lalitpur municipalities that, in the mid-1980s, significantly accelerated the urbanization and the extended the growth of the city to the rural areas in the periphery (Thapa et al., 2008).

Under the aegis of UNDP and the World Bank, a new 'Structural Plan of Kathmandu Valley', was prepared in 1987 that aimed to provide guidelines for the physical development of metropolitan region for the year 2010. This plan could not be taken up due to major changes in the country's political situations in 1990 that led to reinstatement of multiparty democracy in the country.

By the 80s and 90s, the urban growth of greater Kathmandu was taking place generally in the north-south direction. This was mainly due to the fact that much of the easily accessible land had already been consumed and the land bordering on the west was undulating and difficult to develop, whereas the international airport impeded expansion of the city to the east. Although pockets of inaccessible land still remained undeveloped within

municipal areas, unregulated ribbon development along the principal arterial roads had extended beyond its borders in the surrounding villages. Between 1984 and 2000, agricultural land in the valley decreased from 62 to 42%. If this trend continues, by 2025 there will be no agricultural fields left in this once fertile valley. In 1981, three fourths of the residents were involved in agriculture which in 1991 decreased to one third (ICIMOD, 2007).

A study carried out by Kathmandu Valley Town Development Committee in 2001 revealed that, between 1984 and 2000, land covered by urban settlements had increased from 3,096 to 9,193 ha. Similarly, agricultural land had decreased from 40,950 to 27,570 ha. High population growth, dramatic land use changes and the socioeconomic transformations brought the paradox of rapid urbanization and environmental consequences to the valley (Thapa et al., 2008).

Urbanization gained further momentum after 1990s and low-density urban expansion spread to outlying well-drained 'tars' with easy road access. These new developments were occurring beyond the Bishnumati River in the west and Dhobi Khola in the east. Development of access roads to the villages in the periphery with the connectivity to the ring road gave further impetus to urban expansion, as more areas were made accessible. The government brought an ambitious plan for constructing an Outer Ring Road (ORR) in 2002 to manage the rapid urban growth. Though this plan could not be taken up for various reasons, if this would be implemented, this would further extend the boundaries of the urban areas to the rural interiors.

3.3 Migration

Urbanization has been recognized as a critical socioeconomic process in urbanized areas of Nepal, resulting essentially from population growth as a result of migration from rural to urban areas (Portnov et al., 2007, Sharma, 2003 and Pradhan, 2004). The pace of migration got intensified after 1970s primarily due to concentration of employment and economic opportunities within Kathmandu valley. Rapid influx of migrants in the last three decades resulted to rapid urbanization in Kathmandu.

Out of the total valley immigrants, Kathmandu city alone received 78.6% of the total rural migrants and 64.8% of the urban migrants from other districts. Except Bhaktapur, other cities of Kathmandu valley, Lalitpur (32%), Madhyapur Thimi (27.6%) and Kirtipur (23.2%) have been receiving increasing proportion of internal migrants in the last decades (CBS, 2003). The 2001 census identified five major reasons for migration in Kathmandu valley, which have been trading, high value agriculture, employment opportunities, study opportunities and marriages in Kathmandu (CBS, 2002). Another important reason for rapid migration and population increase in Kathmandu has been Maoists' led armed struggle beginning 1992 and growing insecurity in the villages and urban areas outside Kathmandu. The migration of people is still continuing, even after the signing of peace accord, due to continued political uncertainties in the country (ICIMOD, 2007).

Rapid migration and rise in the population in Kathmandu and its neighboring cities has led to continued expansion of the city core. People have been converting the agricultural lands and areas under vegetation cover into settlements. The public lands along the rivers have been more vulnerable to the continued encroachment by the people, which has led to emergence of several slums and squatter settlements. The squatter settlements have increased from 17 with population of 3,000 in 1985 (MoPE, 1999) to 33 with the total population of 15,000 in 1994 (Thapa, 1994).

Along with new developments within the city fringe and rural villages, shifts in the natural environment and newly developed socioeconomic strains of residents are emerging. Such rapid demographic and environmental changes and weak land use planning practices in the past have resulted in environmental deterioration, haphazard landscape development, that together have been stressing the eco-hydrology of Kathmandu valley (HMGN/UNCTN, 2005; Thapa et al., 2008).

3.4 Climate Change Scenario in Nepal

Climate change in general, and the changes in the rainfall and temperature in particular, have profound effect on farming and water resources. A study made by Practical Action Nepal (2009) on the temporal and spatial variability

•of temperature and rainfall, based on the observed meteorological data for the period 1976- 2005, shows increasing trend in temperature over Nepal. The maximum temperature was found to be increasing at a greater rate (0.05°C/year) than the minimum temperature (0.03°C/year). A number of possible climate change related impacts on human health, agriculture and water resources are expected to affect people, their livelihoods and the environment in Nepal. Local communities have observed increased unpredicted floods, landslides, heavy soil erosions, river cuttings and droughts as major hazards. The communities have been adapting some measures to mitigate adverse impacts of climate change, based essentially on their local knowledge and resources.

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•The study on the climate change perception at the micro level by Joshi (2008) suggests that people have strong perception with regards to the changes in the temperature and precipitation patterns and the disturbances brought to the natural water systems as a result of these changes. People have observed drying of wells, springs and other water sources in different parts of the country.

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•A changing climate brings many challenges in water availability and demand management and in managing the water quality changes. Agriculture, which is the only available means of livelihood for many of the poor, is one of sector which is expected to be most vulnerable to climate change. The changes in the temperature and precipitation patterns are expected to bring major changes in the farming systems and practices, which are expected to produce far reaching implications to the rural economy and livelihood of the people. Increased water demand and decreased water availability as a result of climate change may adversely affect the society and economy (Brookes et al., 2010).

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•Having enough water is only one part of the issue; however, water must also be available in time and space where it is needed the most. The balance between water supplies and human need has come under increasing threat from growing population, urbanization, and the uncertainty in water availability likely from climate change. The water sector must adapt to these changing climatic conditions by seeking alternative water resources and developing improved water management approaches that will reduce pressure on already stressed systems.

3.5 Peri-urban Dynamics

The fringe area of urban core and metropolis have been defined and conceptualized in different ways. Office of Rural and Institutional Development (ORID) used the term Peri-Urban for the first time (DFID, 1999). From the available literature, the general agreement to defining 'peri-urban' has been to mean an area with the mix of urban as well as rural development processes, economy and livelihood, situated on the periphery of the cities (Rohilla, 2005).

In South Asia, 'Peri-urban' does not exactly correspond to the 'suburb' meant in the western literatures, for the reason that this area exhibits special rural related features among which 'agricultural industrialization' perhaps is the most significant, being a key component in the growth of small scale industries creating employment opportunities for the people. 'Peri-urban' area in South Asia has a key role in making the development process follow a continuum, from more urban to semi-urban and rural areas in the periphery (Ruet et al., 2007). Benjamin (2004) as cited in Ruet et al.(2007) indicated that several metropolitan cities use 'Peri-urban' areas for attracting the global industry. Thus, Ruet et al.,(2007) argued that the evolution of 'Peri-urban' structure sheds light on power related aspects of the metropolitan governance.

Marshall et al. (2009) reported that access to water in the 'Peri-urban' and urban areas reflect power asymmetries, socio-economic inequalities and other distributional factors such as the ownership of land. People of 'Peri-urban' areas of Delhi do not get sufficient water in comparison to the people in the city core, essentially due to power inequalities, poverty and exclusion factors. It is estimated that families spend up to 20% of their income on water in some parts of the world. It is common for the poor and marginalized people, living in 'Peri-urban' areas to spend a very high proportion of their income on water (Allen et. al., 2006; Marshall et. al.,2009).

At many instances water privatization is advocated as a solution to inefficient public water systems and the means to improving water access in the urban areas (Marshall et. al.,2009). Even with privatization the 'Peri-urban' areas are likely to remain unserved due to low level of economic incentives for the private service providers to run their business in these areas. In 'Peri-urban' areas, both rich and poor often access water through small and decentralized

water systems, such as, dug wells, tanks, stone spouts and community run pipe water schemes. Although large scale privatization in water services does not exist in South Asia, there are numerous private players involved in the urban settings. They provide water through tankers and bottled water which meets sizable portion of water demand of urban population.

In 'Peri-urban' areas, competing claims on available water resources are most likely which may trigger competition for water among irrigation, domestic supply and industrial uses, as well as among different groups of users in the city and its fringes. When the allocative decisions fail to resort to bases of allocation of water among these uses, may result to conflicts across different uses and users (Marshall et. al.,2009).

3.6 Water Security

Water security comprises of protection of vulnerable water systems, protection against water related hazards such as floods and drought, sustainable development of water resources and safeguarding access to water functions and services. The first comprehensive definition of water security was introduced during the Second World Water Forum in 2000. At the forum, the Global Water Partnership reported that water security, at any level, from the household to the global scale, means that every person has access to enough safe water at a reasonable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and that the environmental services are enhanced (GWP, 2000).

Janabi (undated), ambassador and permanent representative of Iraq in UN, mentioned that if all of the factors mentioned below are completely or reasonably met then water security is said to be achieved. The factors are:

- assurance of accessibility to the water resources in time and space,
- utilization of water resources to achieve economic development,
- ability to manage water resources sustainably,
- ability to balance the competing demands for water,
- long term water sharing agreement with full participation of all stakeholders, and
- environmental protection from pollution and degradation.

The concept of water security offers a new way of thinking on water (Norman et al. 2010). According to Grey and Sadoff (2007), water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks.

"Water security is a priority for future adaptation as well as for the current needs" is the statement quoted by GWP in its technical committee background papers (GWP, 2009a). GWP stated that achieving water security requires cooperation between different groups of water users, and between those sharing river basins and aquifers, within a framework that allows for the protection of vital ecosystems from pollution and other threats. This is based on the argument that water security can only be achieved if high level decision makers take the lead and make tough decisions on different uses of water and implement them. GWP also mentioned the need of investments in infrastructures as well as in the institutions and the information and capacity building, to predict, plan and cope with climate variability to achieve water security.

In categorizing the water security, Iyer (2008) attempted to put water security across following three dimensions based on the opportunities and potential threats associated to water:

i. water needs for diverse purposes (availability, adequacy, reliability, dependence, and vulnerability),
ii. danger posed by floods and other forms of water induced disasters: need for mitigation, management and damage minimization, and
iii. water quality problems: prevention and control of pollution and contamination

He further identified relevance of following acts to achieving water security:

- developing understanding on water sharing on common river systems,
- cooperation in the establishment and operation of effective and timely information and warning systems with regards to the flood flows and in disaster and

preparedness and damage mitigation, involving coordinated coping strategies and sharing of experiences, and

• development of common standards on water quality and the understanding with regard to the maintain water quality across the borders.

In attempt to identifying the elements to help achieving water security, GWP (2009b) argues the presence of following three elements in water secured system:

• plans and policies related to water, incorporated in the national and international development agenda and processes,

• inculcation of thinking and appreciation that investment in water is an opportunity and solution rather than a problem,

• balancing social, environmental and economic priorities as well as balancing institutional and infrastructural solutions.

3.7 Water Supply Situations in Kathmandu Valley

Historically, water supply in Kathmandu was delivered through traditional systems, such as, stone spouts (also called dhunge dhara or lohan hiti), community ponds and tanks and dung wells. The oldest stone spout, located at Hadigaun in downtown Kathmandu, is believed to have been built in 554 A.D and is still in use. These stone spouts function through a network of traditional canals, called 'Raj Kulo', which are drinking and irrigation water supply channels, either feeding these spouts directly or recharging the aquifer systems. Beside stone spouts, dug wells, ponds, water tanks were constructed in different historical periods. Some of them are still in operation and providing water to the residents in different parts of the city. The first piped water system, known as Bir Dhara, was constructed as early as in 1891 that tapped water from Shivapuri hills in the northern part of Kathmandu. This system was meant to provide piped water to ruling families, elites and other high status residents. In 1989, Nepal Water Supply Corporation was established to address the growing water needs and to regulate piped water supply system in Kathmandu valley. Since February 2008, this responsibility has been privatized and transferred to Kathmandu Upatyaka Khanepani Limited (KUKL), which is the main water service-providing agency, delivering water to the residents in different parts of Kathmandu metropolis and municipalities in the valley.

The current status of water supply situation in Kathmandu valley is depicted in Figure 2. KUKL, the water service providing agency in Kathmandu is capable of supplying only 155 and 105 MLD of water during wet and dry seasons against demand of 320 MLD, thus shortages of 125 and 175 MLD in the wet and dry seasons are apparent (KUKL, 2009). This situation has forced people to look for other reliable sources of water supply which has led to the emergence of water vendors and private water service providers in Kathmandu. The water vendors fetch water from different locations and sell water to the residents, institutions and commercial establishments in need of water. This market is essentially unregulated and spontaneous and has been constantly evolving after 1990s with the progressively increasing water scarcity in Kathmandu. Moench and Janakarajan (2006) argue that the emergence of this water market in Kathmandu has been as result of demand of convenient water supply created by the gap left by combined services of traditional sources and piped water supply system in Kathmandu Valley.

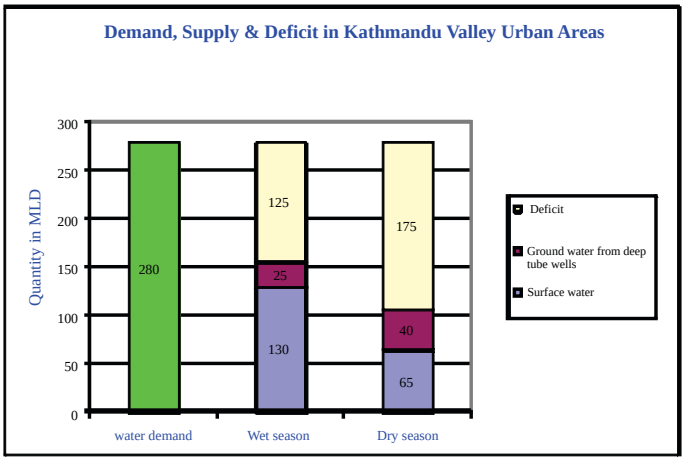

Figure 2 : Water demand and supply scenario in Kathmandu valley urban area
(Source: KUKL, 2009 as cited in Shrestha, 2010)

4. OBJECTIVE AND APPROACH TO SCOPING STUDY

As stated at the outset of this report, the objectives of undertaking the scoping study were, to: i) understand and identify researchable issues best representing the emerging water issues in the peri-urban context of Kathmanduand inferential to broader context of

water insecurity in South Asia, ii) Identifying the study sites representing different contexts and dimensions of water security and providing opportunities to look into these issues through analysis of factors and processes leading to water insecurity, consequences faced by the people and their responses, iii) designing the research for the remainder period of two and a half years, identifying the project milestones, activities to be undertaken and methodological approaches to the activities.

The methodology involved extensive review of secondary sources of information, studies of the 'Peri-urban' sites in and around Kathmandu representing different contexts of peri-urban setting and encompassing different dimensions of water insecurity emerging from urbanization and climate induced uncertainties and consultation with stakeholders and water users. A description of the methodological tools adopted at different stages of the scoping study is provided hereunder:

Reconnaissance:

In the absence of documented information relating to possible 'Peri-urban' locations that would be representative for the purpose of the study, reconnaissance was carried out with the aim of identifying and listing a number of 'Peri-urban' sites in and around Kathmandu and from them selecting possible sites qualifying to be called 'Peri-urban' and possessing water issues of different natures. This stage of work led to identifying total of 8 peri-urban sites for in-depth investigations (Figure 3).

Check list Preparation:

A check list, encompassing demographic changes, exiting sources and use of water and changes in the water supply and demand, established and emerging water issues facing the people and their livelihood and livelihood changes, was prepared with the aim of collecting detailed information from the 8 'Peri-urban' sites that were identified and listed during reconnaissance.

Field study:

The field study at each of the listed 'Peri-urban' site was carried out with the aim of gathering relevant information using the checklist. While the use of the checklist was only one means of data collection, other means used were interaction with the local leaders, functionaries of the local government institutions, functionaries of the water users' groups and the water entrepreneurs involved in water business of different scales.

Informal Meeting:

Informal meeting were organized with the local authorities, people and key informants in the visited sites to discuss the concepts of the research, the problems emerging from water insecurity faced by the people, identification of local institutions and the people engaged thereto and their willingness to participate in the research. Small meetings were conducted at different levels within the area to get people's perception on the urbanization trend and perceived changes in the climate and their impacts on water supply at the local level and initiative on part of the people to address the emerging problems.

Rapport Building:

Preliminary working relationship was built with the local authorities, CBOs and the water managers within the listed sites to analyze their willingness to participate in the research and possible collaboration at different stages of the proposed action research.

Semi-Structured Interviews:

Semi-structured interviews were conducted with the key informants and different social groups at each of the listed sites to identify the emerging water security issues, vulnerabilities of different social groups and impacts on the livelihood resulting from changing water availability and use. The key informants included local leaders, people engaged in CBOs, elderly citizens and members of the social and religious groups.

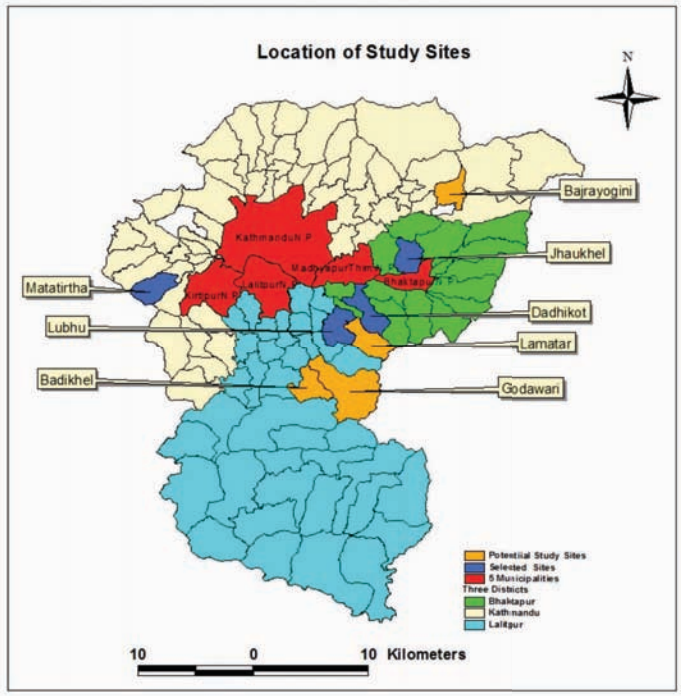

Figure 3 : Location of potential 'Peri-urban' sites

Anlysis of Landuse and Landcover Changes:

Alongside of data collection from the listed 'Peri-urban' sites, land use and land cover analysis for the entire area of Kathmandu valley was carried out for using available remote sensing data sources in order to assess the magnitude and direction of land use and land cover changes in different locations of the valley. This exercise was expected to be useful in identifying the area undergoing rapid urbanization and possible stresses to ecosystem resulting from land use and land cover changes.

Data Source

Satellite imageries from Landsat TM and Landsat MSS were the main data sources used in the analysis. Other supplementary data, such as, digital land use layers prepared by Department of Surveys published in 1995, land use layers prepared and published by the ICIMOD for the year 1978, and Digital Elevation Model (DEM) developed based on the topographic maps were used in the analysis. Landsat imageries were downloaded from USGS Visualization viewer of Earth Resource Observation and Science Center (EROSC).

Image Processing and Analysis

Necessary pre-processing was done on all the satellite imageries used. The digital values were converted into the radiance reflectance values to correct the radiometric and atmospheric distortion using the Model Builder of ERDAS Imagine 9.3. Subsequently NDVI was calculated for each image before starting the image classification process. Vegetation covers were extracted from the NDVI through threshold value. Later supervised image classification was done using maximum likelihood classifier. Due to the similar spectral properties of barren land around the brick factories, problem was encountered during the classification process. Such difficulties were resolved though manual editing using the ancillary data. In this way spatial information of land cover were extracted with hybrid approach of classification, reasoning and manual editing for the various period of 1970, 1980, 1990s and 2010s.

Spatial Analysis

The image processing task produced four different land cover maps for 1976, 1989, 2001 and 2010 on raster format. These maps were then converted into the shape file format. The temporal changes in the land use and land cover for the given periods were then assessed using overlay function in the ARC GIS Environment.

Analysis and Synthesis

The information collected during the field visits were compiled into separate reports for each of the possible site that also included photographs illustrating the state and consequences emerging from urbanization and the water management practices. These reports were circulated among the members of the study team that were useful in developing common understanding about the study sites among the team members. The data collected from the possible 'Peri-urban' sites were analyzed. Each site was then assigned a score based on the types and the dimensions of the water issues facing each site and opportunity to look into these problems in the context of the study framework. The sites that encompassed multitude of the water issues, representative to the water issues emerging from urbanization and climate induced water uncertainties in Kathmandu, were then identified as possible study sites for long term research.

5. MAJOR FINDINGS AND ANALYSIS

5.1 Landuse and Landcover Changes

The analysis of landuse and landcover changes in Kathmandu valley four time periods (1978, 1989, 2001 and 2010) is presented in Figure 4. Kathmandu valley has witnessed dramatic changes in the land use pattern over the last few decades which have been largely due to the rapid growth in the urban population and development of housing units and infrastructure and services. Pradhan and Perera (2005) reported that the build-up area in the valley expanded fivefold from 3,330 ha in 1955 to 16,472 ha in 2000. Similarly, Haack and Rafter (2006) reported that the increase in the urban area between 1978 and 2000 has been over 450 percent.

The land use and land cover changes link to the changes brought to the surface and groundwater hydrology. These consequences are not necessarily limited to local level and are liable to produce consequences to a much larger area. Conversion of open land and areas under vegetation cover to buildup areas would mean increase the rates of overland flow and reduction in the soil infiltration and groundwater recharge. The consequences produced would be in terms of decline in the groundwater level as result of reduced recharge in relation of groundwater withdrawal. According to Metcalf and Eddy (2000), the groundwater level in Kathmandu valley has been estimated to have dropped between 9 meters to 68 m at different locations. The analysis of land use and land cover changes illustrated in Figure 4 are though not useful to draw consequences to surface and groundwater hydrology at the location of the potential study sites, nevertheless these are useful in drawing several inferences with regards to the changes at different periods of time in the Kathmandu valley as a whole.

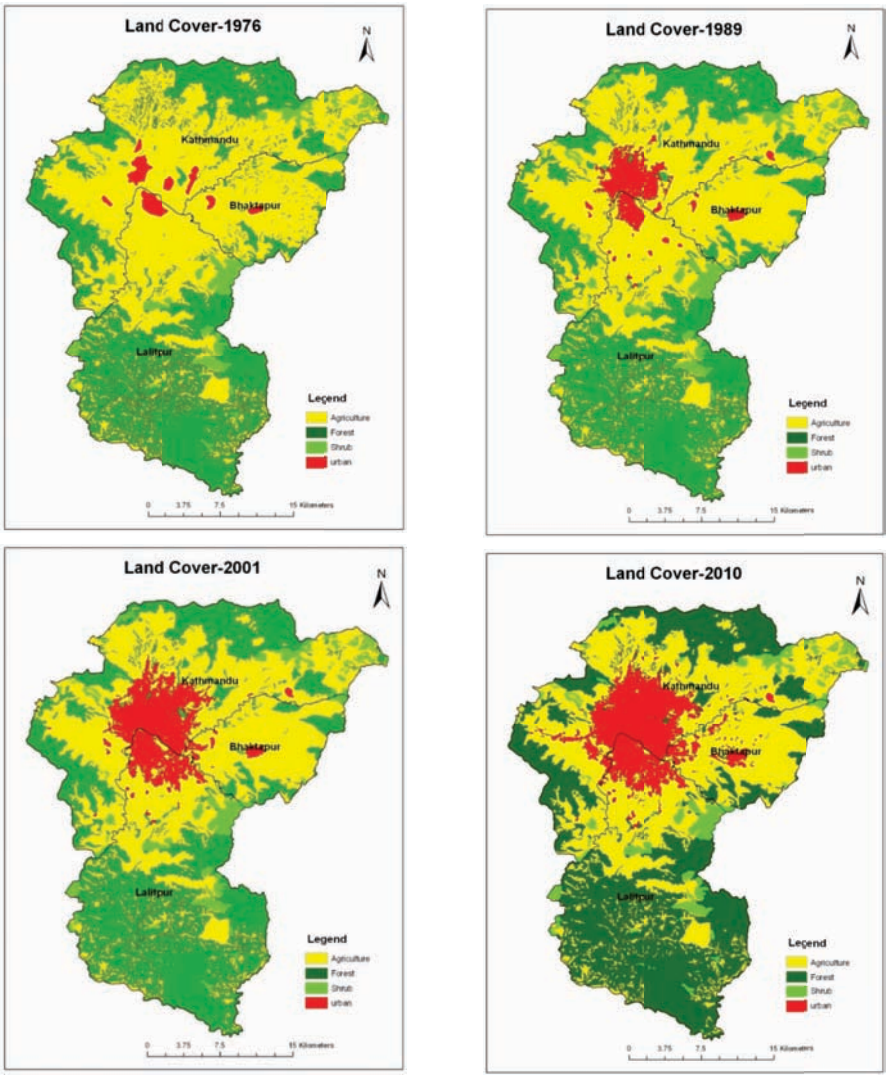

Figure 4 : Land Cover change in Kathmandu from 1976 to 2010

5.2 Peri-Urban Sites Around Kathmandu and the Water Security Issues

This section provides the description of the Peri-urban' sites in and around Kathmandu which were identified to study the state of water security, the consequences from urbanization and climate induced changes and the changes brought to the livelihood of the people. This description includes the water issues facing at each site which has been used as the bases in identifying those for long term future studies.

5.2.1 Site 1: Matatirtha

Matatirtha VDC is located at the western part of Kathmandu District, approximately 5 km away from the ring road, on the lap of Chandragiri hills. The landscape of the VDC is rough and undulating with low to medium agricultural potential. The VDC is inhabitant by 843 households, with total population size of 4182 people (2069-female and 2113-male). VDC, is ethnically, culturally, and socially diverse and has been one of potential destination for tourism within Kathmandu. The demographic profile of the VDC is illustrated in Figure 5.

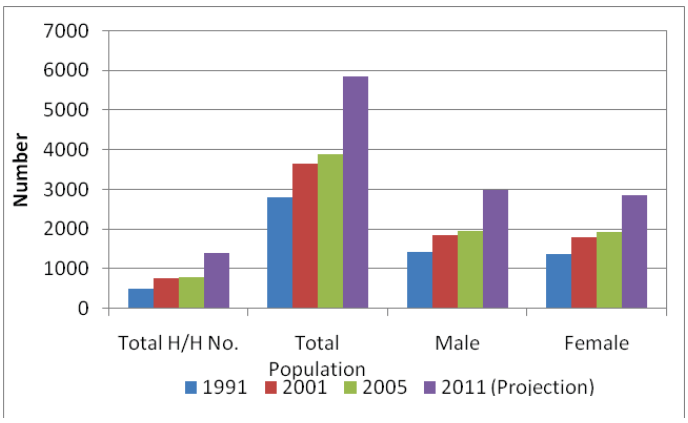

Figure 5 : Demographic Profile of Matatirtha VDC
(Source: District Profile 2010/2011; CBS, 1981; CBS, 1991; CBS, 2001)

Matatirtha VDC is well known for its rich water resources endowment in Kathmandu district. During Rana regime, drinking water from this VDC was supplied to major parts of today's Lalitpur sub-Metropolis and to Kirtipur Municipality. After 2004, because of increasing water scarcity within in VDC, the supply to Lalitpur was stopped. The supply to Kirtipur was stopped only 2-3 years ago. According to the people in the area, drinking water from this VDC has been supplied to adjoining Satungal VDC beginning 1968 A.D. At present, along with the people of Matatirtha VDC, people from neighboring VDCs of Satungal, Naikap, Tinthana are also using water sources of Matatirtha VDC.

The increasing trend of rainfall uncertainty and environmental changes accompanied by increasing population dynamics, including migration of people into the area, the locals are likely to be adversely affected by water scarcity within few years from now. To address the potneial water issues, the VDC has a vision of starting an Integrated Water Supply Scheme by lifting water from the available two major spring sources to an uphill reservoir and supplying water to all the wards of VDC from this centralized reservoir (Box 1).

Gradual shift in the economic base from traditional agriculture to service and commercial farming has greatly changed lifestyle of the inhabitants. Irrigation service has remained quite rudimentary and the agriculture based communities have been essentially dependent on the rainfed farming. This raises further concern about the traditional water right, equity issues, water insecurity and vulnerability of these communities in the context of increasing urbanization and climate change.

Box 1: Integrated Drinking Water Supply System at Matatirtha

The Integrated Drinking Water Supply System is a vision of the community to supply water to the entire Matatirtha VDC, from two major sources: Bhusunkhel and Luwangkot Springs. The foreseen activity is to lift water from both these major sources and store it in a reservoir located in the Chihan Danda within VDC, allowing water to flow under gravity to most of the area of the VDC. The project is foreseen to make an easy access to water for all the villagers. To provide the sense of ownership for the easy operation and management (O & M), a user committee comprising of the local people has been foreseen.

Objectives of the Integrated System:

People in the VDC have foreseen following objectives to the integrated water supply system:

1. To make optimal use of existing natural water resources

2.To avoid the possible water conflict in the VDC
3.To create an authentic database for the support and help from the government and non government donor agencies
4.To create uniformity in the water supply rules within the VDC
5.To create transparency in the water regulatory mechanisms of local government
6.To create uniformity in the tax and tariff rates across the VDC
7.To create mutual cooperation between all the existing institutions

Challenges

To implement this project the challenges foreseen are:
1.Instability of political situations,
2.Lack of budget and
3.Hindrance from other different community drinking water supply committee operating within VDC
Expectations

Matatirtha Integrated drinking water supply is one of the major projects of VDC. To implement this project, huge amount of budget as well as time is required. So, VDC wishes to seek technical as well as financial support from relevant organizations to undertake the project smoothly.
(Source: Informal interview with VDC Secretary and ex-chairperson of VDC)

With the rapid urbanization and increasing water scarcity in Kathmandu, water market has been flourishing in Matatirtha. Water business has been a good source of earning for the land owners with high groundwater table and the water entrepreneurs involved in the operation of tanker trucks. The water business in the form of tanker water supply and water bottling industries are in operation within the VDC. At present, there are altogether 6 deep tubewells in operation, of which one is for local drinking water scheme, one for commercial purpose, two of them are owned by schools and one each by Armed Police Force and Khusi-Khusi Hotel and Resort. Within VDC, there are 15 commercial drinking water entrepreneurs and 13 mineral water factories. From VDC, around 170 trips of water supply by water tanker that approximates to 1.2 million liters of water, is supplied to different places of the Kathmandu Metropolis as well to other parts of Kathmandu valley on a daily basis.

The price of a tanker of water is on an average of NRs. 1,500 for the tanker size of 6,000 liters and NRs. 2,500 for the tanker size of 12,000 liters. Once the water reaches the city, water is sold even at higher costs for those demanding smaller volume of water for domestic needs. In the cases, where a farmer leases out the land for water pumping, each farmer is paid NRs. 200 for every 6,000 liters and NRs. 400 for every 12,000 liters tanker filled. Currently, all the interest has been in harnessing of the income from the rich groundwater and spring sources from the area without any concern for groundwater recharge for sustainable water use.

Though documentation on the water extraction from the area is not yet been available, the current water abstraction in the VDC is more apparent to be higher than the critical abstraction rate. Excessive and unbalanced extraction of water resource has brought concerns among the people with regards to the sustainability of the water resource in the area. The Gorkhapatra, the national daily, on March 12, 2009 featured following news on water extraction at Matatirtha, that reflects on the concerns raised by the people:

The Matatirtha area, which is the source of water in Kathmandu Valley, has been facing water crisis these days. Secretary of Matatirtha VDC Hemraj Luitel told that the locals visited VDC office and expressed rage at water crisis in the area.

"Why should water of the area be supplied to other areas without meeting the demand of the area?" questioned Ram Bahadur Sarki, a resident of Matatirtha VDC Ward No.2. He told that the residents are raising concerns to stop the tanker operators to transport water from Matatirtha to different parts of the Kathmandu Valley.

Secretary Luitel told that the locals here are facing acute water shortage after the tanker operators started to draw water from the main distribution line of the community water supply system despite the fact that there are several locations where from they have been extracting groundwater. He informed that an agreement has been reached between the residents and consumers' committee and VDC officials to manage drinking water in every ward of the VDC.

Figure 6 : Water Marketing

Based on the provisions laid in Local Self Governance Act-1999, that empowers VDC as the custodian of natural resources within the VDC, Matatirtha VDC has formed a nine member monitoring committee with the secretary of the VDC as the coordinator, four members selected from among the water entrepreneurs and three members from among the stakeholders to oversee and monitor the water business in the VDC. The VDC has also put restrictions on the volume of water extraction, enforced from 1st of Shrawan, 2066 B.S. (16th July, 2009). As per this agreement, no one is allowed to use water sources for commercial purposes without the permission of the VDC and also it prohibits the water extraction through deep boring and restricts the water entrepreneurs to dig wells more than 30 feet deep. The VDC started collecting a tax of NRs. 10,000 per year from the water bottling industries and the water tanker operators were made to pay tax of NRs. 1,000 per month for small tanker and NRs. 1,200 per month for large tankers.

The VDC has also laid out regulatory provisions with regards to the protection of the local environment and the water sources. The agreement has laid out frameworks for conflict resolution. VDC possesses right to prohibit water withdrawal by the water entrepreneurs in case of drought condition or natural hazards in the area. Water entrepreneurs must provide water on a fair price to the local people for the development works and in case of water scarcity. Besides these, any sort of water business in Matatirtha VDC must not create any adverse impact, including those relating to the health of the people. If operation of the water business is found adversely affecting the local people, then water entrepreneurs are liable to a fair compensation to such victims.

With the increasing water scarcity within the VDC at present and increasing local opposition, recently VDC officially considered the licensing process as a means of regulating the rampant water extraction. The VDC has vision of promoting water bottling industries while discouraging the tanker water suppliers in the days to come. The restriction on the water tanker entrepreneurs is put a limit on the volume of water extraction from the VDC while the promotion of water bottling industries is expected to create employment for the people, particularly the women, at the local level.

5.2.2 Site 2: Jhaukhel

Jhaukhel VDC covering an area of 5.41 sq. km is located at the northern flange of Bhaktapur Municipality. The VDC is inhabited by total of 8705 people (Male- 4354 and Female-4351) in 1746 households. The changes in the demography of the VDC from 1981 to 2006 are presented in Table-2.

Year	Household number	Male	Female	Total
1981	780	2416	2292	4708
1991	901	2163	2583	4746
2001	1192	3340	3338	6678
2006	1136	3342	3267	6609
2011 (projection)	1746	4354	4351	8705

Table 2 : Demographic Changes in Jhaukhel VDC (1981-2006)
(Source: CBS, 1981; CBS, 1991; CBS, (2001; VDC Profile 2006; District Profile 2010/2011)

Jhaukhel has been major recharge zone of groundwater in Bhaktapur. Khasyang Khusung River works as a border between Bhaktpur Municipality and Jhaukehl VDC.

Changunarayan-Duwakot-Dadhikot Community Drinking Water Supply Scheme has been the drinking water scheme in the area which supplies drinking water to three VDCs- Changunarayan, Duwakot and Jhaukhel for 2.5 hours every morning. This scheme was initiated in 1982 and started functioning in 1993 through public tap connections and extended its service to household metered tap connection since 1994 onwards. The water services started with 75 household level taps has now expanded to cover approximately 1000 households and approximately 300 to 400 additional tap connections are in the process of getting approved. Construction of an additional sump well in the well field of Manohara river has been completed with the aim of expanding the water services in the scheme (Figure 7). Among the nine wards of Jhaukhel VDC, tap water supply has been distributed to eight wards while ward number 9 of Jhaukhel obtains water from Saraswatikhel community water supply scheme of Bode in Thimi Municipality.Figure : Newly Constructed Sump WellGroundwater has been another source of drinking water in Jhaukhel. Rich groundwater in Jhaukhel VDC is major source of dry season drinking water supply in Bhaktapur Municipality. This has led to emergence of groundwater business in Jhaukhel with several water entrepreneurs investing in the development of groundwater for commercial uses.

Figure7 : Newly Constructed Sump Well

The area under the VDC is geologically grouped into two belts, the water scarce northern belt and water rich southern zone. Deep wells and individual dug wells are the sources of water in the area. The groundwater in Jhaukhel VDC has been undergoing rampant extraction by the water entrepreneurs. Commercial groundwater extraction has been reported from Wards 6, 7 and 8 of the VDC. There are 17 water bottling industries in operation in the VDC at present that essentially extract groundwater for commercial uses (Figure 8). Among the 17 bottling industries that are in operation, only seven of them are registered with Department of Cottage and Small Industry while the others have been extracting groundwater illegally.

Figure8 : Water Marketing

Fig. 5.4: Water MarketingResidents of Jhaukhel VDC have started worrying that the subsidence of land in the VDC may result due to excessive extraction of groundwater through deep boring and anticipate acute water shortage if the extraction of groundwater continues at the same rate. Commercial water extraction from dug wells and deep boring at individual level is growing and has been emerging as a source of good income in the southern belts. Increasing water extraction in this area has started resulting to lowering of groundwater table in the northern belt of the VDC. This has become a source of concern among the people in the area (Box- 2). People in this belt have been raising their voice against the rampant groundwater extraction and marketing in the southern belt. They had gone on delegation to VDC office on several occasions and asked for immediate regulation of these activities. This forced VDC to issue a public notice on prohibiting illegal private water tankers suppliers. However, water tankers suppliers are still continuing in the absence of effective enforcement mechanism.

Box 2: Growing water conflict

Water business of different scales has been a reliable income source for many households in the southern part of the VDC with rich groundwater endowment. This has also been the issue of concern among the people in the northern part who are being affected by rampant groundwater pumping.

The incident shared by a recognized water entrepreneur makes to re-think the conflict emerging from groundwater pumping. This individual holds a water bottling industry with water treatment technology installed in place. Once a close friend of his visited the bottling plant. Very warmly received this friend turned to be problem; because he allegedly reported the water extraction to a reputed daily newspaper. The motive of the friend is unannounced but clear is the conflict hidden among the individuals.

Sadaula (1993) estimated that the volume of Jhoukhel sand deposits is about 1,508,475 m3. In Jhaukhel, a family got three licenses out of seven issued licenses in the VDC, plus one more license in the name of a company in Duwakot. As per rule, one person can hold at the most one license and a company can hold three licenses. Dongol (unpublished report) estimated that if site is in operation, a contractor can earn one to three billions of rupees per year. This means, more the number of licenses, the morepowerful is the contractor. Contractors use money

Figure 9 : Loading sand in Mini-truck

power to mobilize gundas at the site all the time so that local people cannot raise their voice against them and if by chance a voice is raised, it would be suppressed by using muscle power. The only concern of the mine operator is extraction of maximum amount of sand from each site without any concern for the environmental degradation in the area. As a result of rampant sand mining accelerated soil erosion and land degradation is seen at all the sand mining sites at Figure : Damage of agricultural land due to sediment flow from the sand mining siteJhaukel (Figure 10). Farmers in the area also report of damage caused to their crop lands and standing crops due to increasing sediment flow from the sand mining sites. Lack of safety measures in these mining sites pose threats to the life of the laborers involved in sand extraction. Frequent accidents at these sites due to collapse of the wall of the mine pit have occurred in the past, resulting to the loss of life of the mine worker.

Figure 10 : Damage of agricultural land due to sediment flow from the sand mining site

Similarly, Brick industries have been flourishing haphazardly in wards 6, 7 and 8 of the VDC. Sada (2010) has reported 12 brick factories in the VDC extracting 33.5 million liters of groundwater per annum. Not only groundwater, these factories also cause damage to the fertile top soil rendering the land totally unfertile.

The changes in the landscape due to sand mining and brick industries and the alarming groundwater exploitation are the growing concerns relating to water security in the area. These processes and the consequences to water security in the VDC are linked to the processes of rapid urbanization in Kathmandu and Bhaktapur. The exploitation of groundwater and haphazard exploitation of natural resources in the area are beginning to conflict with the livelihood of the people.

5.2.3 Site 3: Godawari

Godawari VDC, one of the important tourists' destinations, is located on the lap of the Phulchoki hill, about 10 km to the east of Kathmandu. Godawari VDC has total population size of 5074 people (Male-2552 and Female-2522) in 1043 households.

The urbanization trend in Godawari is mainly due to the migration of people from its rural areas. Godawari is a well known for water sources for the urban areas of Kathmandu. VDC has ample and reliable water sources and impressively systematic water supply services developed with the local initiative and resources (Figure 11). Water supply services handled by Godawari Drinking Water and Sanitation Users' Committee, was originally initiated in 1994 A.D with the registration of two natural spring sources, distributing water among 390 households. At present this scheme supplies water to all the nine wards of the VDC. This organization has been functioning as an independent local organization, entirely supported under local initiative. This organization has not received financial support of any form for the development of the water supply scheme either from the government or non-governmental organizations. This organization has been mobilizing financial resources through contributions made by the water users for the infrastructure development and water tariff collected from among the users based on the volume of water consumed. At present a graded water tariff is in place where the users are required to pay the water tariff at the rate of NRs. 10 for 10,000 liters, NRs. 25 for 20,000 liters and NRs.4000 for hundred thousand liters or more of water consumed per month. The charge for new tap connections at the household level has been increased from initial NRs. 4,200 per tap to NRs. 11,500 per tap at present. Institutional consumers are charged on a flat rate. For instance, an educational institution- Xavier School located within the VDC, is charged NRs. 5,500 per month and is supplied water with a ½ inch diameter pipe while a Beer Factory operating in the area is charged NRs. 16,000 per month for water supply with 1 inch diameter pipe.

Figure 11 : Protection of Water Reservoirs

Residents within VDC have gained access to continuous water of reasonable quality and the water supply services in the VDC have expanded substantially since its development. Public taps have been maintained for the water supply to those consumers who are unable to afford the financial contributions to obtain the connection. The 24 hours uninterrupted tap water supply is seemingly an evidence for the easy available potable water supply in the VDC. The present focus of this organization lies on expanding the area served and is in the process of registering additional seven natural water spring sources to expand the water supply among newer consumers.Figure : Drying of SourcesAn increasing trend of drying of natural springs is shared by an elderly staff of Godawari Drinking Water and Sanitation Scheme. He assessed the reduction from 8 lps (liters per second) during 1994/95 A.D which has remained only one fourth of the original rate. He attributed the reduction in the available supply to the loss of the forest area and vegetation cover in the headwater of the spring sources.
In the past, commercial water tanker supply was operational in the VDC however due to intense pressure from the neighboring VDCs to ensure water supply for

themselves from water sources originating from Godawari VDC, the supply to water tanker was stopped from 2007 onwards. The conflict emerging from tanker water supply in the VDC continued to draw attention of the civil administration and media from 1997 to 2002 A.D which was resolved with the handing over of Mathillo Kunakhola, one of the prominent natural spring sources in the area, for the management of water supply to the neighboring Harisidhi VDC.

Figure 12 : Drying of Sources

5.2.4 Site 4: Badikhel

Badikhel VDC, located in Lalitpur District is inhabited by 579 households with population size of 3212 people (Male- 1656 and Female- 1556). The main occupation of the residents in the VDC continues to be farming though some households are also involved in jobs in the government and private organizations. The residents of the VDC are also involved in bamboo based handicrafts which has been additional source of supplemental income for the people living in wards 4, 5 6, 7 and 8 of the VDC. Natural springs and stream sources have been major sources of water supply in the VDC which make this VDC rich in water resources endowment.

The major spring sources that have been tapped for the community based water supply schemes are Chandol, Thulokhola, Khasemara and Gulendaha. Among these sources, Chandol spring supplies water to wards 6, 7 and certain regions of ward 2. Water services in ward number 2 are maintained from the Khasemara source which also supplies water to wards 1, 3 and 8 of the VDC. Thulo khola has been used as water source by ward 4 and 5 while ward 9 of the VDC depends upon the Gulendaha spring. Gulendaha spring also has a history of operating a water mill which however got nonfunctional years back.

The water supply management in the VDC has been more on a personal effort. With adequate water sources at a considerable distance, individual households have diverted water from the nearby sources with their own initiative and resources. Water supply in ward 6 and 9, which are located uphill, accessibility to water has been major concern in these wards.

Mr. Kamal Pahadi, a member of Chandol water supply scheme, mentioned that with improved technology intervention of piped water supply, the water access of the residents has been satisfactorily improved over time. His impression has been consistent with those of Mr. Raghunath Acharya and Mr. Shyam Krishna Acharya, the employees in Tripura Beverage, a water bottling industry in the VDC. This has been the first water bottling industry started in the VDC in 2006 and the number of bottling industries has now increased to 7.

With regards to the commercial water use in the VDC, the 7 water bottling industries have been users of the water on a commercial scale. All these industries are registered with the Department of Cottage and Small Industries. Two other water bottling industries are likely to be started soon. The water entrepreneurs mentioned of restrictions by the VDC on commercial water extraction from Gulendaha spring source. These industries need to pay a water tax of NRs. 50,000 to VDC office and NRs. 25,000 to the respective wards for the water extraction.

A government led drinking water scheme is in the process of being development, tapping water from Gulendaha spring source. Pipe laying has been completed to provide water up to Harisidhi VDC which has been planned to be extended to cove other VDCs in Lalitpur. In respect to the prior appropriation right of the local inhabitants, government has donated a pump and invested in building a water reservoir in ward 9 of the VD where from this spring source originates. Development of this facility has to some extent eased water access of the people for dual uses- domestic use as well as irrigation in small area using the overflow from the reservoir.

Raj kulo, the historical irrigation canal built long time back is still functioning and supplies water to wards 4 and 9 of the VDC. The available supply of this canal has however reduced to meet the irrigation needs of the

people. Scarcity of water appears during June-July, at the time of the paddy transplanting, and during December-January for the planting of potato.

The VDC has been gradually undergoing the process of urbanization. The construction of new houses is mainly as a result of inter-ward migration from uphill wards to the lower lands. The inhabitants also reported that relatively well to do residents of the area have already shifted to the core city areas. The trend of migrant developing new settlements into the area has been on the rise. Land developers are involved in the development of the agricultural land for the purpose of housing plots.

5.2.5 Site 5: Sankhu

Sankhu includes three VDCs- Bajrayogini, Pukhulachi and Suntole. This area has been proposed to be developed as a new municipality in the valley with the merger of the three VDCs- named Sankharapur Municipality. These three VDCs include population size of 3880, 2746 and 4417 people, respectively. In the course of the field study, inquiries on the state of water security and related issues were made only in Bajrayogini VDC which has been the most populous area and undergoing rapid social and economic transformation.Figure : Urbanization in Sankhu VDC

In Bajrayogini VDC, wards 1, 2, 3, 4, 5 and 6 are in the process of rapid urbanization while wards 7, 8 and 9 are still predominantly rural areas (Figure 13). The piped water supply system developed in the VDC is maintained by Kathmandu Upatyaka Khanepani Limited (KUKL). The system is based on water supply from spring source in Lapsiphedi forest. Tap connection at the household level is provided on the recommendation of the VDC functionaries and the households are required to pay NRs. 4,000 per tap connection. KUKL has employed three staffs for the operation and maintenance of the piped water supply system and collection of water tariff from among the users.

Extraction of water for commercial uses has not yet started in the VDC, however the extraction of groundwater for domestic use has been on the rise with the development of wells in every newly constructed houses in the area. In most of the newly constructed houses, people have started building wells to meet part of their domestic water needs. This trend is expected to increase in future as more and more houses get constructed in the area. This VDC has 24 hours uninterrupted water supply however the system does not have water treatment facility therefore the quality of water served is questionable. The water supply till the date is perceived to be sufficient by the residents in most parts of the VDC however their major concern has been proper management of the available sources and systematization of the services. The VDC is in the process of constructing two reservoirs with the investment of NRs. 40 lakhs which are expected to further improve the water supply services in the VDC.

Figure 13 : Urbanization in Sankhu VDC

Land entrepreneurs are involved in buying and selling of land in the area and in developing housing plots for residential uses. This has resulted to rapid conversion of agricultural land into settlements. This area is known for potato production in Kathmandu valley which has been major source of households' income in the past. Irrigation within the VDC is provided by a Raj Kulo, which derives water supply from Sali Nadi. The available supplies at the source has been decreasing over time as result of continued deforestation in the headwater of the stream and also transfer of water from the spring sources feeding to Sali Nadi to several drinking water schemes on the upstream.

5.2.6 Site 6: Lubhu

Lubhu VDC is more than 700 years old traditional Newar settlement that lies about 10 km northeast of Kathmandu. This traditional and historically important VDC,

predominantly inhabited by Newars, has population size of 12000 people in 2000 households. The area of the VDC is approximately 2.95 square kilometers.

Lubhu has been facing water scarcity for domestic needs in the recent times for two reasons: reduction in the share of available supply from the water source and increase in the number of people served by the water supply system. The people in the VDC have been getting water supply from Chapakharka spring located in Bisankhu Narayan VDC, Dovan River and several dug wells and stone spouts in the area. The Chapakharka spring source has been in use since 1981. This source supplies water to five VDCs- Lamatar, Sirutar, Bisankhu Narayan, Tikathali and Lubhu. The original agreement for water sharing at the source was to distribute half of the water to Lubhu VDC and remaining half among the four other VDCs- Lamatar, Bisankhu Narayan and Tikathali. However, the water from the source, at present, is distributed equally among the five VDCs which has reduced available water supply in Lubhu from this source.

To meet the deficit water needs, the VDC has developed another water supply system with water tapped from Dovan River. At present, total of 52 public taps have been installed, each serving approximately 100 households. The quality of this water is poor therefore the households use this source for other domestic needs- cleaning and washing, and continue to depend on Chapakahrka source for drinking water needs. Figure : Non-functional public tap at Lubhu

A users' committee has been constituted to oversee the operation and management of the system and collect water tariff of NRs. 10 from each household served by the public taps. The users' committee is also in the process of developing a filtration tank and water treatment facility at Dhovan River so that quality of water supply from this source could be improved. The proposed development is expected to reduce dependence of this VDC on Chapakharka source for the drinking water needs. The piped delivery system at Chapakharka source passes through a hilly terrain where landslides occur frequently, thus disrupting the water supply services derived from this source (Figure 14). In such events, people from Lubhu need to fetch drinking water from adjoining Lamatar VDC on motor bikes and public vehicles. For fetching of water the people need to pay NRs. 5 per gagri (traditional pot, on an average of 15 liters capacity) of water to water source owner at Lamatar. People in this VDC have been facing this hardship for quite some time.

The people in this VDC have been using water from a traditional Rajkulo developed with water derived from Dhovan River for irrigation needs. However, this system has now become non-functional due to decreased water supply at the source and continued lack of maintenance and management. The people now depend on rainfall for all the agricultural water needs.

5.2.7 Site 7: Lamatar

Lamatar VDC, inhabited by 1,497 households with population of 7572 (Male-3805 and Female- 3767), is adjoining to Lubhu VDC in Lalitpur district. It has two major sources of water, namely, Gaumati River and Sindhumati River. Besides these, VDC has numbers of springs and public wells which are used as source for drinking water and irrigation. Despite having number of water sources, the available water sources in the VDC remain largely unutilized.

In the VDC, wards 1, 5 and 6 are considered water rich with large number of springs, stone spouts and public taps developed from Chapakharka spring source. Compared to these, other wards of the VDC lack dependable access to domestic water supply. People in other wards have made initiative of developing small water supply systems, tapping nearby spring sources, with their own resources. Thulaghar water supply scheme and Rasilodol water supply system, developed by the people in the area, derive water from two different sources. Thulaghar system has source on Chisapani Pakha that supplies water to approximately 13 public taps. With the drying of the source however the number of water taps in operation has been reduced. Similarly, Rasilodol system, which has been supplying drinking water to ward 3, 4 and 7 of the VDC, has also been drying. Though exact number of operational public taps from this system is not known, existence of about 7 public taps per ward was mentioned, with each tap serving 20 to 25 households. Beside these, residents of the VDC have developed small private piped water supply system, tapping the available spring sources, each serving 2 or 3 households.

A privately owned spring water source located in ward 1 has been selling water to water tanker operators for the commercial purposes. The land owner of this source was not required to obtain permission of any kind from the VDC for the commercial use of water.

The people in the area have been depending on traditional wells for irrigation, though in part of the area irrigation water is also available from Singari Rajkulo. The available water supply from this irrigation system has been decreasing over time. Also, the operation and management of this system has weakened over time. People in the area have not been putting their time and energy in the maintenance and upkeep of the system. Though farming continues to be major source of livelihood for the people, the people in the area have been fast shifting from agricultural to non-farm livelihood. This is the reason that they lack incentive in investing their time and energy in the maintenance and management of irrigation infrastructures in the VDC.

5.2.8 Site 8: Dadhikot

Dadhikot VDC covers an area of 6.27 km2 and has a population size of about 7,244 people (Male- 3623 and Female- 3621) in 1,352 households. Most of the households are dependent upon agriculture for their livelihood. Among 1,157 households in the VDC, 903 are involved in agriculture as primary occupation, followed by 124 in government jobs and 60 in business. Considering all the households in the VDC, 84.09% of the households have access to pipe water, 12.10% of households use water from stone spouts, 0.95% households use water from sump wells, and 2.25% use dug wells while 0.61% households use water from other sources (VDC, 2006).

People in Dadhikot VDC have been meeting their drinking water needs from a number of sources that include dug wells, sump wells, tube wells, stone spouts and piped water supply, obtained from stream and spring sources. Currently, there are 8 community drinking water schemes functional in Dadhikot VDC. All of the water supply schemes in Dadhikot VDC are under community management and each serving minimum 30 to maximum 824 households. Though these schemes received external assistance of some form in the initial construction and development, there have been also substantial community investments in their construction. The construction of piped drinking water scheme in the VDC started only after 1984. There has been significant increase in the number of schemes developed in the VDC after 1995, due to increase in the population and rapid pace of urbanization after this time.

The current users of community managed drinking water schemes had been using different sources of water to meet their drinking water and other domestic needs in the past. The shift from one source to another resulted primarily due to increase in the demand resulting from the growth in the population and also degradation of the source due to increasing pollution and for other causes. During 1970s, the people in the area were dependent exclusively on sump wells and stone spouts. The growth in the population in the area led to search for alternative source of water. They also used water from the streams by constructing small tanks by the side of the stream bank to collect water to meet their washing and bathing needs.

Figure 15 : Mahadev Khola Raj Kula

In late 1970s, people of Dadhikot and neighboring Katunje VDC joined together and developed Katunje-Dadhikot drinking water supply scheme. This was the beginning of the availability of piped water supply in the area. Later the water supply to Dadhikot was stopped due to conflict between these two VDCs resulting from water sharing arrangement. However people from Dadhikot started looking for other more dependable source. This led them to develop other community drinking water schemes in the VDC in mid 1990s. Dadhikot, being easily accessible and located close to Kathmandu and Bhaktapur, continues to be the preferred destination for new settlers. In order

to keep pace with the growing demand of water, construction of a deep tube well was carried out in 2008 at a cost of NRs. 17,600,000. Initiative for the construction of a water reservoir for additional 200 m3 in size is in progress which is expected to complete by the end of 2010.

Figure : Mahadev Khola Raj KulaBeside drinking water, people of Dadhikot are also struggling for irrigation water with the upstream Gundu VDC. Mahadev Khola Raj kulo is the only source of irrigation for this VDC (Figure 15). During the period of water scarcity, all the water available in the irrigation system is used by upstream farmers leaving very little water for use by the people of Dadhikot, who now increasingly depend on rainfed farming.

Figure : Wastewater Irrigation practiceIn the areas where irrigation water is not available, farmers either use dug wells or use waste water for irrigation. Sada (2010) observed large scale use of wastewater for irrigation, with the water pumped from Hanunate River (Figure 16). This water use is mainly for vegetable production by small holders which has been major source of earning for them. He also noted gradual reduction in the use wastewater for irrigation, especially during the dry season, due to increasing pollution level in the river during this period. He also observed that as many as 62 % of the farmers in the area own their own pump for lifting wastewater from the river for irrigation.

Figure 16 : Wastewater Irrigation practice

Land speculation is another issue in Dadhikot. Being attached to Madhyapur Thimi Municipality and also near to Kathmandu, land buying and selling and development of land for housing plots has been undergoing in the area for last several years. This is resulting rapid conversion of agricultural lands to non-agricultural uses.

5.3 Selection of Potential Sites for Long Term Study

As stated earlier in this section, the objective of the listing a number of possible peri-urban sites in Kathmandu and identifying water security issues at each of these sites, through filed level studies and interaction with key informants and stakeholders, was to identify potential sites which could be representative to established and emerging peri-urban water issues in Kathmandu valley. The sites encompassing large number of water security issues, emerging from social, ecological, institutional and policy processes and climate induced uncertainties, were considered potential sites for long term future studies, envisaged under peri-urban water security project. These sites, by virtue of embedded and nested water issues, were expected to provide opportunity to look into large number of researchable issues simultaneously.

In order to arrive to rational bases for the selection of the potential peri-urban sites, the issues from each of sites were classified to converge across 8 attributes: i) State of landscape change and land use transformation, ii) State and Processes of Social and Livelihood Transformation and Heterogeneity, iii) State of Flow of Goods and Services for Urban Needs, iv) Multiple Claimants, Contestation and Conflict on Water Source, v) State of Institutions and Institutional Lacunae, vi) Changing Ecology and Ecological Stresses, vii) Perceived Climate Change Impacts, and vii) Perceived Water Insecurity. These attributes were then assigned scores depending upon the state of changes in each of the attributes over time as: 0= no change at all; 1= very low; 2= low; 3= moderate; 4= high and 5= very high. These scores assigned to each of the 8 attributes at each site were then added up to obtain total score obtained by each site (Table- 3). A site obtaining high score was considered potentially suitable for longer term studies.

This exercise led to identification of four potential sites for long term studies- Jhaukhel (34), Matatirtha (33), Lubhu (28) and Dadhikot (27). Jhaukhel and Dadhikot located in Bahktapur district, Matatirth located in Kathmandu and Lubhu located in Lalitpur adequately represent the different contexts of urbanization and urbanization induced stresses. Jhaukhel typically represents a case where water security is becoming a concern for the people due to large scale extraction and spectrum of commercial use of groundwater and ecological stresses resulting from sand mining and land development. Matatirtha is a site which provides opportunity to look into the initiative underway by the local government in regulating the commercial water use. Lubhu provides opportunity to look into the water management practices in traditional Newari settlement, typical of Kathmandu valley, and also livelihood stresses resulting from water quality and reduction in the irrigation water supply. Dadhikot has been the area undergoing the process of rapid land use changes, where water is becoming a critical commodity for the livelihood of the people. People have been using different sources of water simultaneously to maintain their livelihood, including the use of wastewater for irrigation.

3.RESEARCHABLE ISSUES AT THE SELECTED SITES

The researchable issues at the selected study sites and action points/approaches to addressing the identified issues is presented in Table- 4. These researchable issues have been identified based on the site specific studies carried out during the scoping phase. While some of the issues like changes in the water availability and management resulting from urbanization and urbanization induced land use and land cover changes and observed and perceived changes in the climate induced water uncertainties are common to all the study sites, other issues are specific to the sites based on the extent of exploitation of water and other natural resources and the ecological and livelihood stresses emerging there from. While this table identifies issues specific to the study sites, the issues of general concerns cutting across the study sites and focusing more to the analysis of climate induced water uncertainties and policy analysis with regards to the water security in Kathmandu valley in general and capacity building of local institutions have been identified separately as overall issues/concerns.

Characteristics / Sites	State of landscape change and land use transformation	State and processes of social and livelihood transformation and heterogeneity	State of flow of goods and services for urban needs	Multiple claimants, contestation and conflict on water source	State of institutions and institutional lacunae	Changing ecology and ecological stresses	Perceived climate change impacts	Perceived water insecurity	Score
Matatirtha	Medium (3)	Medium (3)	Very High (5)	Very high (5)	High (4)	High (4)	High (4)	Very high (5)	33
Godawari	Low (2)	Low (2)	Moderate (3)	Low (2)	Medium (3)	Moderate (3)	Medium (3)	Low (2)	20
Lubhu	Very high (5)	Moderate (3)	Very low (1)	High (4)	Moderate (3)	High (4)	Medium (3)	Very high (5)	28
Lamatar	Low (2)	Low (2)	Low (2)	Low (2)	Medium (3)	HIgh (4)	Moderate (3)	Very low (1)	19
Badikhel	Low (2)	Moderate (3)	High (4)	Medium (3)	Medium (3)	Medium (3)	Very low (1)	Very low (1)	20
Jhaukhel	Very high (5)	Moderate (3)	Very high (5)	Very high (5)	Medium (3)	Very high (5)	Medium (3)	Very high (5)	34
Sankhu	Medium (3)	Very low (1)	Very low (1)	Very Low (1)	Low (2)	Low (2)	Low (2)	Low (2)	14
Dadhikot	High (4)	High (4)	Moderate (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	High (4)	27

Table 3 : Matrix for Site Selection

Site	Issues	Approaches/Action Points
Jhaukhel	• Commercial groundwater extraction and water marketing and resulting conflicts. • Incentive structure of the water entrepreneurs investing in groundwater development. • Water extraction in the brick industries and the resulting consequences to land degradation and agricultural productivity. • Dynamics of sand mining, actors involved and their incentives and resulting environmental and livelihood consequences. • Stakeholders' concerns on sand mining and groundwater extraction. • Concerns and local initiatives for regulation and control of sand mining and groundwater extraction. • Livelihood changes and pattern of shifts from agricultural to non-farm livelihood its implication to water use at the community and household levels. • Perceived changes on the climate induced water uncertainties and the spontaneous adaptation to uncertainties at the household and community levels.	• Baseline situation and stakeholders' analysis. •Documentation and mapping of groundwater extraction and quantification for different uses (domestic and agricultural uses and commercial exploitation) •Mapping of spectrum of water businesses, actors involved in water marketing and profiling of the consumers served. •Documentation and mapping of water extraction in the brick industries. •Documentation and mapping of sand mining, quantity of sand extraction, actors involved in sand mining and their incentives. •Analysis of environmental and livelihood consequences emerging from groundwater extraction, sand mining, conversion of agricultural land to settlements and water consumption in the brick industries. •Changes in water demand at the community and household levels as a result of changing livelihood. •Analysis of vulnerability of different groups of people to emerging water stresses and their adaptive strategies. •Identification of local institutions (formal and informal) and their roles in environmental conservation, including conservation and management of water resources.
Matatirtha	•Changing pattern of water availability and water sharing arrangements with the neighboring VDCs. •Changing water demand due to demographic and livelihood changes. •Commercial water extraction for urban needs, actors involved in water business and their incentives. •Emerging concerns with commercial water extraction and initiatives of the local government in regulation of commercial water extraction and its effectiveness. •Environmental and equity issues emerging from commercial water extraction. •Livelihood changes and pattern of shifts from agricultural to non-farm employment and its implication to food security and water demand at local level. •Perceived changes in climate induced water uncertainties and spontaneous adaptation to uncertainties at the household and community levels.	•Baseline situation and stakeholders' analysis •Analysis of changing patter of land use and livelihood changes and its implication to food security and water demand. •Documentation of changing pattern of water availability and water demand as result of demographic changes and the changes in the land use and land cover. •Documentation and mapping of commercial water extraction, quantity of water extracted by source, consumers served, actors involved in commercial water extraction and their incentive structures. •Environmental and equity concerns emerging from commercial water extraction, impacts on different groups of people and their responses. •Local initiative on regulation of commercial water uses and its effectiveness and replicability to similar situations. •Analysis of vulnerability of different groups of people to emerging water stresses and their adaptive strategies.

Site	Issues	Approaches/Action Points
Lubhu	• Implication of urbanization induced land use and land cover changes on ecosystem services and water yield. • Changes in water governance and management practices as a result of urbanization and changing livelihood opportunities. • Implication of Land use changes and shifts from agricultural to non-farm livelihood to food security and water demand at local level. • Perceived changes in climate induced water uncertainties and spontaneous adaption to uncertainties at the household and community levels. • Response to water stress at the community and household levels	•Baseline situation and stakeholders' analysis. •Resource Mapping and analysis of changes brought to water resources as a result of anthropogenic and other forces. •Analysis of eco-hydrological linkages of land use and land cover changes and resulting changes on ecosystem services and water availability. •Comparative analysis of agricultural and non-farm livelihood on household economy. •Analysis of traditional water governance and management as a result of urbanization and changing livelihood opportunities. •Analysis of changes in agricultural water demand as a result to introduction of improved agricultural technologies and crop cultivars. •Analysis of vulnerability of different groups of people to emerging water stresses and their adaptive strategies. •Response to emerging water stresses at the community and household levels, including transaction cost in household level water management and changing gender roles thereto.
Dadhikot	•Urbanization induced land use and land cover changes, including conversion of agricultural land to non-agricultural uses and the actors involved thereto. •Implication of land use shift on water demand and food security, including changes in the flow of food commodities for urban consumption. •Implication of livelihood changes on household level water demand. •Community investment in the development and management of water infrastructures and services. •Practices of wastewater irrigation and perceived and observed health consequences to the irrigators and consumers of agricultural produce. •Perceived changes in the climate induced water uncertainties and spontaneous adaptation to uncertainties and the household and community levels.	•Baseline situation and stakeholders analysis •Analysis of pattern of land conversion from agricultural to non-farm uses, actors involved in land development and incentives of land owners and land related entrepreneurs. •Urbanization induced livelihood changes and the changes brought in the farming system and practices and its implication to agricultural water demand. •Community response to changing water demand and investment in the development of water infrastructures and services. •Documentation of the practices of wastewater irrigation, farmers involved in wastewater irrigation and perceived and observed health consequences to the wastewater irrigators and consumers of agricultural produce. •Analysis of vulnerability of different groups of people to emerging water stresses and their adaptive strategies. •Response to emerging water stresses at the community and household levels, including transaction cost in household level water management and changing gender roles in household level water management.

Site	Issues	Approaches/Action Points
Lubhu	Water Stress Resulting from Climatic Uncertainties and Anomalies.	•Time series analysis of hydro-meteorological data to assess the changes brought to water balance and extent of water stress resulting from climatic uncertainties and anomalies specific to the study sites. •Assessment of perceived climatic uncertainties and anomalies based on responses of the people at the study sites.
	Policy Review	•Review of existing urban development policies and development strategies to identify: i) the extent of sensitivity of the policies and development strategies to water security in the urban and 'Peri-Urban' areas and the linkages thereto, ii) dependence of the urban areas to the natural resources of the fringe and rural areas in the periphery and the impacts of urbanization on the natural resources, and iii) policy gaps in addressing the existing the future water security in the urban and 'Peri-Urban' areas. •Policy review with regards to the management and use of natural resources, including groundwater in the context of Kathmandu Valley.
Matatirtha	Capacity Building of Local Level Institutions and People	•Identification and key stakeholders' and local institutions concerned directly and indirectly with the water management at the identified study sites. •Stakeholders' consultation with regards to changing water security at the study sites and the emerging concerns thereto. •Initiation and facilitation for the creation of multi-stakeholders' platform for their enhanced roles in the management of water and other natural resources specific to the study sites. •Sensitization workshops and training for the capacity building of local level institutions and their personnel.

7. RESEARCH DESIGN AND ACTION PLAN

The action plan of the project foreseen for the three years duration of the project (July, 2010-June, 2013), that identifies important project milestones, activities to accomplish and expected outcomes, is presented in Annex- 1 (a, b, c, d, e and f). The project milestones and activities have been identified for successive six months duration of the project in order to keep track on the activities to be accomplished in successive six months duration. Important features of this action plan have been as stated hereunder:

i. Stakeholders' participation in the identification of study sites and relevant researchable issues from each site.

ii. Stakeholders' workshop as means of sharing of research outcomes among key stakeholders and the community members from the study sites.

iii. Formation of a Project Advisory Committee, with representatives from relevant government institutions, research organizations and development agencies, providing advise on important issues and also facilitating the undertaking of the project activities.

This is also foreseen as important means of information dissemination at relevant levels.

iv. Integration of research findings in the capacity building of stakeholders and local level institutions.

v. Formation of multi-stakeholders' platform as entry point and means to addressing water security issues on a sustained basis.

vi. Dissemination of relevant project outputs through communication materials, peer reviewed publications and presentation of technical reports/papers in technical meetings, talk programs, seminar, conferences and symposia.

vii. Networking and information exchanges among the team members engaged in 'Peri-Urban' Water Security Research at four locations (Kathmandu, Gurgaon, Hyderabad and Khulna) under the project.

8. SUMMARY AND CONCLUSION

This scoping report has been prepared with the aim of developing a working document that could be used in scheduling and undertaking the project activities foreseen over three years duration (July, 2010-June, 2013) of the project on 'Peri-Urban' Water Security in four emerging urban areas in South Asia- Kathmandu (Nepal), Gurgaon and Hyderbad (India) and Khula (Bangladesh). The report has been prepared based on six months long scoping study accomplished during July 12-December 31, 2010. The report begins with time series of changes in the demography of Kathmandu valley and the resulting consequences to the land use changes, ecology and environmental services and changes brought to the water supply and demand. This has been analyzed in the context of resulting water stresses in the rural and urban fringes in the periphery of urban core of Kathmandu valley. While this analysis was underway, relevant literatures on 'Peri-Urban' water issues in different parts of the world were reviewed in order to contextualize the existing and potential waster security situations in the 'Peri-urban' areas of Kathmandu valley. This became the entry point to identifying the key research questions and sub-questions that would be relevant to be addressed while approaching action research on 'Peri-Urban' water security in Kathmandu Valley.

Upon identifying the key research questions, a systematic procedure was followed in identifying relevant research sites, representing complex and nested water security issues that would be relevant to addressing the emerging 'Peri-Urban' water security concerns in Kathmandu and also inferential to the regional context. Relevant information were collected from total of eight possible study sites that led to identification of four sites- Jhaukhel, Matatirtha, Lubhu and Dadhikot for long term study. The information collected from the study sites provided the basis to identifying the researchable issues specific to the four study sites and also representative to water security concerns in the 'Peri-Urban' Kathmandu.

A research plan, outlining important project milestones, activities to accomplish and their outcomes was developed. The project milestones and activities to accomplish were identified for successive six months duration of the project period in order to keep track on the activities to accomplish and the outcomes expected. While designing the research plan important features that were integrated into the project design, included: i) stakeholders' participation in the identification of research issues and setting out research agenda, ii) stakeholders' workshop as means of sharing project outcomes among relevant group of stakeholders and community members from the four study sites, iii) integration of research findings in the capacity building program, iv) formation of a project advisory committee to advise on important issues relating to the project, v) creation of muti-stakeholders' platforms as means to addressing the established and emerging water security issues at the four study sites on a sustained basis, and vi) development of relevant communication materials and peer reviewed publications in educating and empowering the local community and also enriching the knowledge base on 'Peri-Urban' water security and management in the context of Kathmandu and in other parts of the world.

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