TA 7984-NEP: MAINSTREAMING CLIMATE CHANGE RISK MANAGEMENT IN DEVELOPMENT

1 Main Consultancy Package (44768-012)

WATER SUPPLY AND SANITATION SECTOR

Sector Adaptation Plan Framework for Guidelines: Synthesis Report on Adaptation to Climate Change

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Pilot Program for Climate Resilience - PPCR3, Mainstreaming Climate Change in Development

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Climate Change Risk Management Framework for Infrastructure Sectors in Nepal	A Guide for developing and implementing Sector Adaptation Plans for Action - SAPAs

EXECUTIVE SUMMARY

1. Introduction

Nepal has a national target to achieve universal coverage of basic water supply and sanitation facilities by year 2017. The present coverage is about 85% for basic water supply and about 63% for basic sanitation[1]. To work toward the achievement of these targets the Nepalese government, via the Department of Water Supply and Sanitation (DWSS) and the Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) in cooperation with various municipal and local government organizations develop, implement and manage a range of water supply and sanitation infrastructure.

There is consensus that the existing and future water supply and sanitation infrastructure assets managed by DWSS, DoLIDAR and supporting agencies are at risk from climate change. Immediate attention and action is required to ensure that WATSAN sector infrastructure is more climate resilient and that new design and maintenance guidelines can be established to improve the resilience of new assets to future climate change. In order to recommend what action will be most effective, it was necessary to gain a better understanding of the specific issues and challenges that are posed by climate change for Nepal's WATSAN sector. ADB and CIF provided the financial support to conduct a comprehensive climate change vulnerability assessment and adaptation planning with key sector infrastructure assets representative of the WATSAN sector in Nepal.

This report, and a supporting series of district-level case studies, has provided the basis for a number of recommendations for action to enhance the climate resilience of WATSAN sector infrastructure in Nepal. The assessment presented in this report identifies climate change threats that will pose significant risk to sector infrastructure systems and ultimately result in health and safety impacts for the communities that are relying on these assets. The findings presented also indicate that climate change is one of the many challenges being faced by the sector. Every year Nepal faces water induced disasters such as flood, landslides, flash floods that impact on WATSAN infrastructure. Water supply and sanitation infrastructure in Nepal is also aging with many key assets having been designed several years ago without taking climate change parameters into account in their designs. The WATSAN sector in Nepal is also facing technical and non-technical issues related to poor institutional capacity. A number of recommendations based on a sector adaptation planning approach are developed to address the findings and threats identified.

The following sections describe the process followed to develop a meaningful adaptation planning exercise and sector climate change adaptation plan for DWSS and DoLIDAR.

2. Target infrastructure assets

A total of eight districts were selected as case study districts. A team of international and national consultants visited these districts over a period of 12 months to collect relevant baseline information including district master plans, records of past weather extremes, sector and site specific trends and interview responses from district and sector experts.

During the baseline assessments, several structural and institutional flaws were identified by the team. Many of the WATSAN infrastructure assets assessed had poor functionality. The depletion of water source capacity, excessive wear and damage to infrastructure assets, and lack of awareness among consumers were found to be the root causes of the poor functionality of the WATSAN assets observed. During the site visits, the teams also observed poor service delivery of water supply and

[1]National Management Information Project (NMIP). Department of Water Supply and Sanitation (DWSS). Access from: http://www.dwss.gov.np/content/49/NMIP_PROJECT. 2014.

sanitation services and flow on impacts for livelihoods including poor access to basic water and sanitation facilities and poor general levels of public health.

To supplement the baseline assessment the consultant team also performed an institutional analysis of DWSS and DoLIDAR. The analysis has identified key weaknesses, strengths, opportunities and threats and helped identify many avenues for these agencies to improve service delivery and strengthen the resilience of WATSAN infrastructure to climate change.

3. Climate change threats

Climate change modelling undertaken by the project team's National & International Hydrological Modelling consultants in close collaboration with the Department of Hydrology and Meteorology (DHM) show that climate change induced threats will vary geographically and include increased risks of floods, landslides, glacier outbursts, drought and other natural calamities.

The threat profiles prepared for the assessment rely on localized projections of future climate change at a district level for the period 2040-2060 compared to a baseline of 1980-2000. The results of the downscaling were incorporated into a basin-wide hydrological model which computed changes in precipitation, evapo-transpiration, PET, soil moisture, river discharge and runoff for every 120 x 120m grid cell in each district. Additional parameters computed included river water levels, flooding, erosion, sediment concentration, slope stability/land slide risk and irrigation demand. A comprehensive sector specific threat profile is available as a separate document.

4. Vulnerability Assessment

The vulnerability assessment process started with the identification of particular climate change related threats to selected water supply and sanitation infrastructure assets in each of the target districts. Having identified the particular threats the exposure of these assets to each threat was assessed. The assessment of exposure was informed by consideration of long-term changes in climate conditions and changes in climate variability, including the duration, magnitude and frequency of possible future extreme events. The sensitivity of the assets was then evaluated by considering factors such as asset design and materials and the level of maintenance required for the asset in question.

A vulnerability assessment matrix was then used to determine the level of climate change impact on each asset based on the evaluation of the asset's exposure and sensitivity. Finally the adaptive capacity of the asset in terms of sector stakeholder's ability to prepare for a future threat and, in the process, increase its resilience and ability to recover from the impact was evaluated. By considering the impact level and the adaptive capacity of the asset a final assessment of the assets climate change vulnerability was reached.

The vulnerability assessments indicate that water supply and sanitation infrastructure assets are at risk from: the drying-up of water sources and poor groundwater recharge; high intensity and duration rainfall events damaging fragile or weak intake assets; rainfall-induced landslide disruption to water distribution pipelines; and damage to water pumping and treatment plants due to increased temperatures.

5. Adaptation Planning

Following the completion of the vulnerability assessment an adaptation planning exercise was undertaken to identify concrete steps to enhance the resilience of the WATSAN assets assessed. A number of short and long-measures were identified as part of an adaptation response to the vulnerabilities identified. The adaptation options identified generally fell into two categories. The first category is non-structural measure including the revision of regulations and existing design guidelines and introducing new policies and guidance as well as capacity building measures for sector experts. The second category is improved management and implementation of existing structural measures, necessary ad-hoc repair techniques, climate resilient structural design and construction and improved operations and management practices. Some examples are included in the table below:

Asset	Potential Climate Change Impact	Short or Long Term	Structural Measure	Non-Structural Measure
Water Supply				
Water sources – Springs, surface water, streams	Drying-up and reduced flow	Short	Water storage measures	Strengthen conservation and protection measures under Water Resources Act – 1992
		Long	Establish deep tube bore-wells	Build community awareness for the protection of water sources
Intake structure	Sediment collection, Collapse of intake structure	Short	Diversion channels	Establish maintenance programs
		Long	Construct new intake structure with screening system	Implement measures to protect upstream forest
Transmission and distribution pipes	Cracks and rupture due to increased temperatures, Leakage and poor delivery	Short	Protect and provide concrete/steel casing with abutments to the transmission pipelines laid along the historic landslide zones	Establish maintenance programs
		Long	Rebuild transmission pipelines with better alignment and temperature resistant materials	Adopt design standards that account for the potential impact of climate change on transmission pipe diameter
Sanitation				
Collection System	Damage to system pipelines due to landslides	Short	Build protective structures to prevent damage from landslide	Use spatial planning approaches to avoid the construction of collection systems in areas prone to landslide
Septic Tanks/Pit Latrines	Overflow from septic tank	Short	Use improved tank design and construction techniques	Establish a licensing system for septic tank contractors, Improve emergency response measures during high rainfall events
		Long	Comprehensive redesign of sewage treatment system to remove groundwater contamination	Provide annual budgets for system operation and maintenance

6. Reforms and Capacity Required

Based on the findings of the climate change vulnerability assessment and adaptation planning exercises a number of policy reforms to enhance climate resilience for the sector as a whole are suggested. In this report a number of specific adjustments to existing guidance are recommended. Revising key existing sector policies and legislation such as the *National Water Plan (2005)* and the *Urban Water Supply and Sanitation Policy (2009)* to acknowledge and account for future climate change will set stronger institutional incentives to take action to strengthen resilience. Ensuring that future legislation and policy such as the Water Supply and Sanitation Sector Policy and Water Supply and Sanitation Act adequately account for climate change will have a similar positive effect.

These preventative, planned approaches to enhancing the adaptive capacity of the sector need to be complemented by training and capacity building efforts with DWSS and DoLIDAR and key sector stakeholders. Capacity building should include general training with climate resilient planning, an introduction climate modelling and the development of climate threat profiles and instruction on the process that was used to formulate a WATSAN Sector Adaptation Plan of Action (SAPA). The aim of such a programme is to strengthen the institutional capacity of both DWSS and DoLIDAR to undertake a similar process of climate change vulnerability assessment and adaptation planning in the future and encourage the regular, periodic development of a sector climate change adaptation plan.

ACRONYMS

ADB	Asian Development Bank
AF	Adaptation Fund
AP	Adaptation Planning
CC	Climate Change
cm	Centimeter
^{0}C	Centigrade
DDC	District Development Committee
DEWATS	Decentralized Wastewater Treatment Systems
DI	Ductile Iron
DOLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DWSS	Department of Water Supply and Sewerage
GI	Galvanized Iron
GIZ	Deutsche Gesellschaftfür Internationale Zusammenarbeit
GON	Government of Nepal
HDPE	High Density Poly Ethylene
Km	Kilometer
LPS	Liters per Second
M	Meter
M&E	Monitoring & Evaluation
MH	Manhole
MoH	Ministry of Health
MoSTE	Ministry of Science, Technology and Environment
NMIP	National Management Information Project
NPR	Nepali Rupees
NRW	Non-Revenue Water
O&M	Operation & Maintenance
RCC	Reinforced Concrete Construction
RR	Random Rubble
STP	Sewage Treatment Plant
TA	Technical Assistance
VA	Vulnerability assessment
VDC	Village District Committee
UNEP	United Nations Environment Programme
WATSAN	Water Supply and Sanitation
WB	World Bank
WC	Water Closet
WHO	World Health Organization
WRI	Water Resources Institute
WS	Water Supply
WUSC	Water User and Sanitation Committee

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1 INTRODUCTION

This synthesis report was prepared as part of the TA – 7984 NEP: *Mainstreaming Climate Change Risk Management in Development Project* supported by ADB with funding from the Climate Investment Fund (CIF), and implemented by the Ministry of Science, Technology and Environment (MOSTE) in partnership with ICEM – International Centre for Environmental Management.

The project involves line departments working together with MOSTE in eight districts to develop and test a vulnerability assessment and adaptation planning approach tailored for their needs. The aim is to distil the lessons of the district experience into reforms at national level for planning and managing more resilient infrastructure. The national agencies are those concerned with infrastructure development throughout Nepal such as irrigation, roads and bridges, water induced disasters, urban planning and water supply and sanitation systems (Figure 1-1).

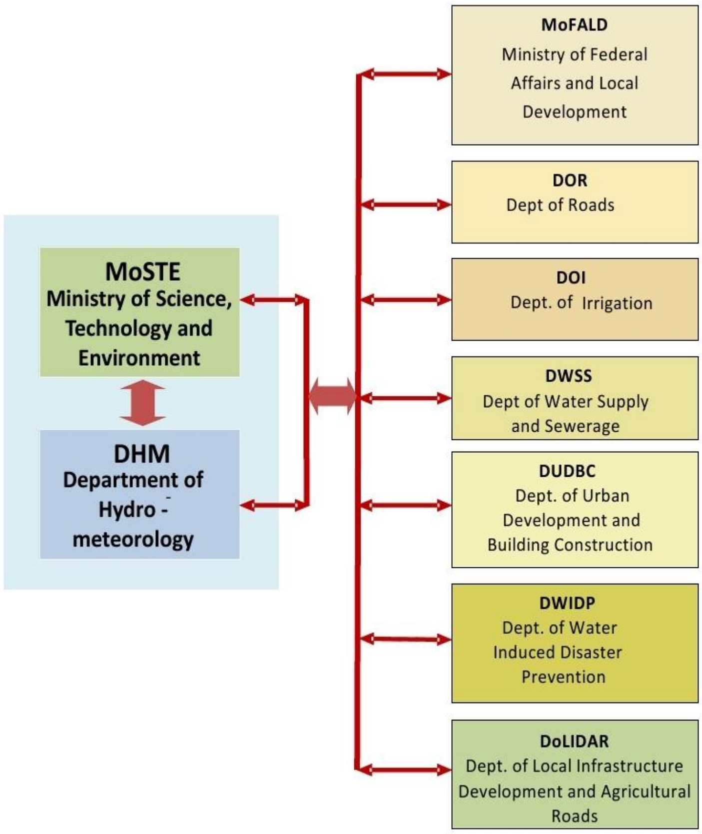

Figure 1-1TA – 7984 NEP infrastructure sector department partners

A core group of technical staff from each of the departments participated in working sessions and missions to the eight districts of Kathmandu, Dolakha, Acham, Banke, Myagdi, Chitwan, Panchthar and Mustang (Figure 1-2) where vulnerability assessments and adaptation planning exercises were conducted for existing strategic infrastructure assets. The target districts were identified by core group members to reflect the diverse ecological zones of the country and varying environmental and social conditions in which infrastructure is built. The district assessments were supported by climate change threat analysis and hydrological modelling at each case study location.

The core group comprised of some 30 members from 9 government agencies with each agency having a wider range of staff involved in the process of setting and implementing reform priorities with support from the project team (Figure 1-3). Sector focal points on the core group have a key role in promoting the climate change mainstreaming in their departments so that the design and management of existing and planned infrastructure progressively adjusts to become more resilient to the most significant projected changes and their associated potential impacts.

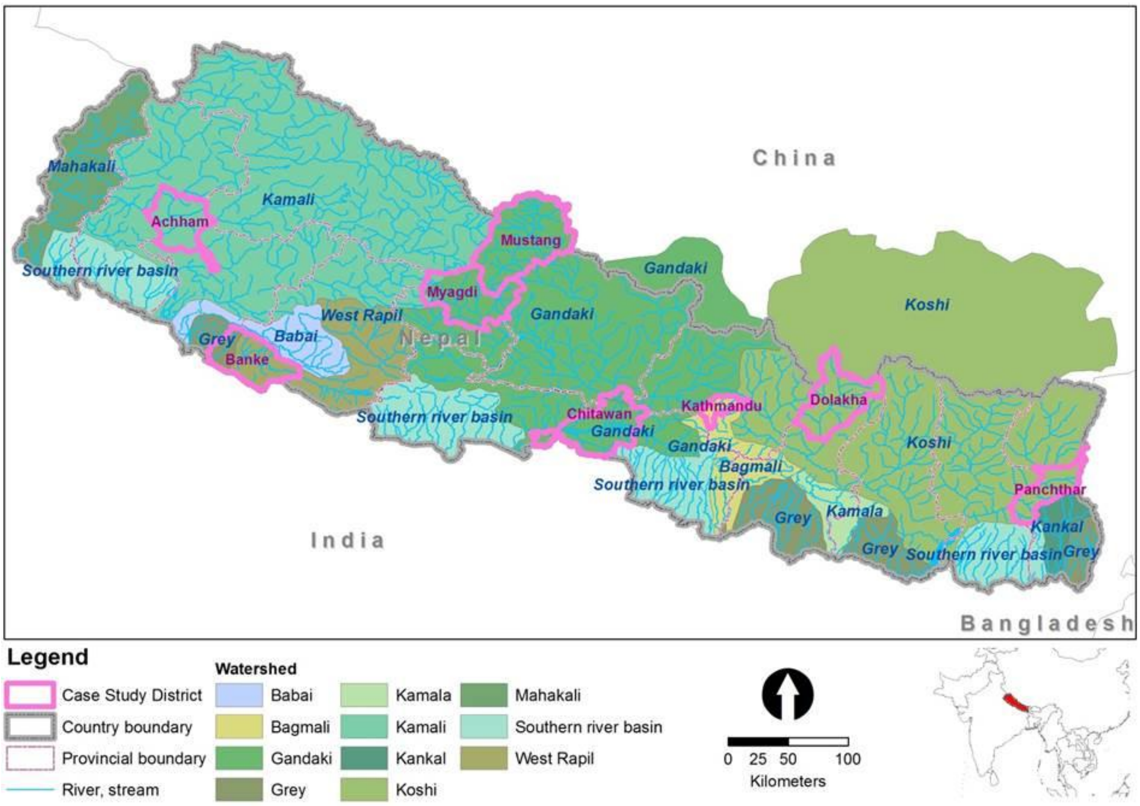

Figure 1-2Target districts for developing an approach to infrastructure vulnerability assessment and adaptation planning

Through the project, a "climate change risk management system" (CCRS) has been developed based on the district and international experience. The CCRS includes tools to facilitate climate change vulnerability assessment and adaptation planning and a dedicated process for the development of *sector adaptation plans for action* (SAPAs) that complement Nepal's existing climate change planning framework consisting of the National Adaptation Plan for Action (NAPA) and Local Adaptation Plans for Action (LAPAs).

The district case studies inform a sector vulnerability assessment and adaptation planning process that demonstrates the elements of a future Sector Adaptation Plan of Action (SAPA) process including the shape of SAPA reports (in the form of sector synthesis reports). The end result of this process is a sector oriented review of climate change vulnerability of key assets and a sector adaptation plan identifying the policy, procedures and structural reform priorities for building resilience in the sector and its infrastructure. The *sector synthesis reports* are being used as the basis for a sector specific training of government staff at the national and district levels on how to give effect to the reforms identified using the SAPA process and to apply the vulnerability assessment and adaptation planning tools developed by the core group and project team.

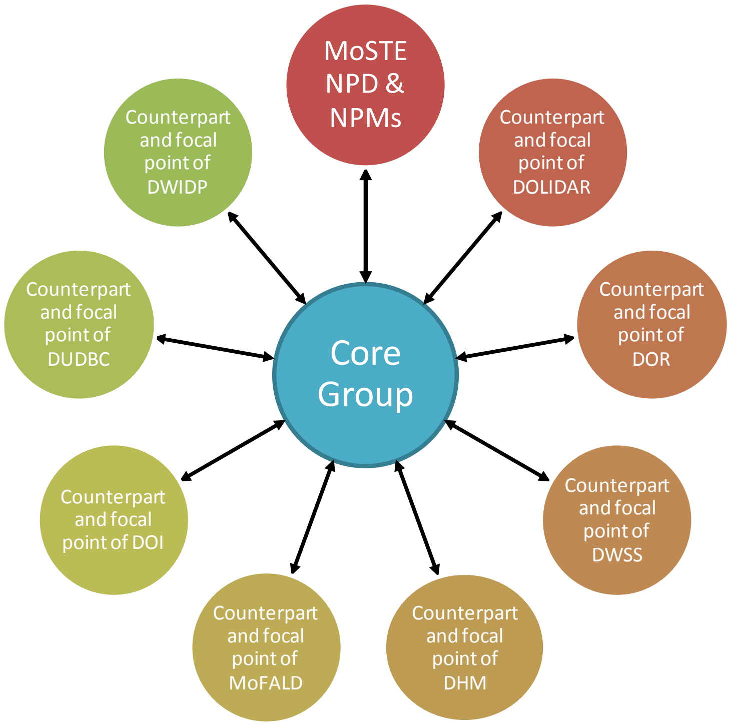

Figure 1-3 Infrastructure sector department climate change core group

This WATSAN Sector Synthesis Report was prepared with DWSS & DOLIDAR and involved a program of consultations in the districts and with the sector core group members and departmental officials. That process culminated in a national workshop at which government WATSAN experts presented and discussed the synthesis conclusions and reform priorities. The government staff closely involved in the WATSAN sector consultations and in the preparation and commentary on this report and the various linked WATSAN sector district reports, climate change threat assessments and institutional analyses are listed in Annex I.

2 WATER AND SANITATION SECTOR IN NEPAL

2.1 CLIMATE-RELATED CHALLENGES TO WATER AND SANITATION IN NEPAL

Nepal has a national target to achieve universal coverage of basic water supply and sanitation facilities by 2017. The present coverage is about 85% in basic water supply and about 63% of basic sanitation[2]. In order to achieve such targets, the government has established plans and programs such as the Small Towns Water Supply & Sanitation Sector Projects I &II, Community Based Water Supply & Sanitation Project and the Rural Water Supply & Sanitation Project.

The delivery of adequate water and sanitation services is intricately linked to climate. As a result, climate change is a major concern for the WASTAN sector in Nepal and may hinder progress toward any targets the sector has set itself to achieve. Already average temperatures in Nepal are rising faster than the global average and rainfall is becoming more unpredictable, which has affected the sources of water supply systems in Nepal. Landslides and flash floods caused by an increase in intensive rainfall events have destroyed intake structures and impacted on water discharge in downstream channels and reservoirs. The destruction of forest has also had a significant impact on the water supply and sanitation sector by hampering opportunities for natural groundwater recharge. The deposition of excess sediment and debris in streambeds has also affected the flow and functionality of existing water supply and sanitation systems. As a result, rehabilitation of water resources is a key concern of communities and water management groups responsible for water supply and sanitation services[3].

Water user and sanitation committees (WUSC) have tried to address these pressing climate-related challenges using a range of techniques and processes. In the cases observed during the field visits undertaken for this project a number of structural measures were observed such as deep bore tube wells to gain access to traditional springs[4]. In some cases communities have been provided with high density polythene pipes and plastered concrete cement for the rehabilitation of transmission pipelines and reservoir structures[5]. As a result, of these interventions some communities are now able to access reliable water sources in areas where previously they could manage only one hour of water supply per day. These successes have had flow on benefits for other productive areas of local economies in rural areas by opening up opportunities for irrigation and agriculture. This experience suggests that action can be taken to strengthen resilience to climate-related threats.

2.2 CHALLENGES POSED BY FUTURE CHANGES IN CLIMATE

Climate-related stress on water resources is expected to become one of the most pressing environmental problems in Nepal[6]. Drying water sources and ground water depletion is likely due to longer dry seasons, increasingly irregular rainfall patterns, and increased incidence of high intensity rainfall events leading to high run-off and less infiltration[7].

The impacts of climate change on water supply and sanitation will present a number of challenges for the delivery of water and sanitation services in Nepal with flow-on effects for public health and the environment. Disruption to service or damaged systems can result in higher costs for basic services, which is a significant problem in a country like Nepal where almost 25 percent of the population lives on less than USD 1.25 per day[8]

[2]National Management Information Project (NMIP). Department of Water Supply and Sanitation (DWSS). Access from: http://www.dwss.gov.np/content/49/NMIP_PROJECT. 2014.
[3]Observations from field visits to ChitwanDistrit, June 2013 and April 2014.
[4]Observations from field visits to ChitwanDistrit, June 2013 and April 2014.
[5]Observations from field visits to Dolakha, Chitwan, Panchthar and Kathmandu Districts. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013.
[6] Water Sanitation and Hygiene: Second Joint Sector Review (JSRII), Ministry of Urban Development. Sector Efficiency Unit, March 2014.
[7]Ibid.
[8]World Bank. World Development Indicators: Nepal. Accessed from: http://databank.worldbank.org/data/views/reports/tableview.aspx. 2010.

In the context of the potential impacts of climate change, the situation for the water supply and sanitation systems is complicated by the generally poor quality of these systems in Nepal. Despite some of the good examples described above, the National Management Information Project (NMIP) estimated that 50% of Nepal's 38,000 water supply systems are not functioning properly[9].The majority of these failures are caused by the combination of poor design practices, inappropriate construction techniques, poor material availability and selection and a lack of regular maintenance of infrastructure.

To prevent the decay and destruction of important system assets and disruption to essential water supply and sanitation services a range of structural and non-structural responses will be required. There is a need for projecting and predicting future climate change and its impact and for incorporating this information into the planning, construction and rehabilitation of infrastructure assets. Communities across Nepal are also in need of further assistance to rehabilitate existing water supply and sanitation infrastructure and construct new facilities that are more resilient to future climate change threats.

Communities also need to be better prepared for potential changes in climate and extreme events. Generally, the awareness of local communities and stakeholders about climate change and its expected impacts was very low in all districts visited for the purpose of preparing this report[10]. Interestingly and importantly there also continues to be a great need to better recognise the climate-related knowledge held by local people. While it is not certain that present adaptation strategies employed by communities will be sufficient in the future they provide a useful starting point from which to evaluate possible action.

It also needs to be acknowledged that women and girls also carry a disproportionate burden for water collection and distribution in Nepal. As a result, gender issues must be integrated into water and sanitation system project development and climate change adaptation plans. Capacity development of government agency officials and community members is needed to fully understand local gender dynamics and how to create an environment conducive to women's full participation in issues affecting water and sanitation given their key role in this sector.

Balancing the roles of women and men in water and sanitation projects will present difficulties. Simply aiming for the greater inclusion of women on WUSCs will not be sufficient. It is necessary to take steps to ensure that women have roles where they become involved in decision making. Care also needs to be exercised to ensure that additional responsibilities do not serve only to increase existing burdens on women and girls.

An important part of enhancing resilience to climate will also entail ensuring that water supply and sanitation services and associated health benefits also reach the poorest communities and peoples. At present the majority of the programs and schemes observed were not reaching the very poor in the community. At an institutional level the institutions responsible for water supply and sanitation in Nepal need to ensure from the planning stages of any intervention that low-caste groups (Dalits) and poor are adequately served so that local adaptive capacity might be strengthened.

2.3 INSTITUTIONAL ISSUES

Alongside the numerous socio-economic, environmental and geophysical constraints to adaptation facing the WATSAN sector in Nepal, there is also a long history of institutional failure that currently complicates the development process and will severely hinder any effective sector adaptation, either strategic or autonomous. Coordination of service and support to the water supply and sanitation sector is ineffective. The institutional arrangements for the sector are fragmented with

[9] National Management Information Project (NMIP). Department of Water Supply and Sanitation (DWSS). Access from: http://www.dwss.gov.np/content/49/NMIP_PROJECT. 2014.

[10] Observations from field visits to Dolakha, Chitwan, Panchthar and Kathmandu Districts. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013.

the roles of key government agencies and other authorities including DWSS, DoLIDAR, WUSCs and local government entities remaining unclear and poorly defined[11]. Operating modalities are agency specific and tend to vary between communities creating confusion for users and an overlap of responsibility[12].

Project formulation and the expansion of services at the sector level also lacks the benefit of master planning approaches to ensure services are provided in a systematic and coordinated way. The roles of DWSS, WUSC, DOLIDAR, donor funded and driven projects and local governments are not clearly separated and their areas of operation are not clearly defined. This has created a situation where the service areas of projects and agencies responsible for the WATSAN sector tend to overlap.

[11]Observations from field visits to Dolakha, Chitwan, Panchthar and Kathmandu Districts. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013.
[12]Ibid.

3 CATEGORIES OF SECTOR INFRASTRUCTURE AND COMPONENTS

This section outlines various types of WATSAN infrastructure in Nepal based on the type of community such as rural or urban.

3.1 URBAN AND RURAL WATER SUPPLY SYSTEMS

Water supply for drinking and domestic uses is an essential basic requirement for households and communities. Water for human consumption in Nepal generally comes from one of two basic sources - water from wells or water from public/municipal systems. Unlike in large urban settlements, for small communities in rural and outback areas, conventional methods of water sourcing, extraction, and supply are not cost effective. This is especially so in the rural areas of developing countries such as Nepal which need simple, alternative methods to satisfy their domestic water needs.

The demarcation between rural water supply and urban water supply is purely based on the type of settlements the system is providing service to. The scale of service in an urban water system is usually relatively larger, more complex and may require advanced technology to operate. Urban water supply systems serve relatively more people and its sources combine and vary including surface water sources (springs, streams/rivers, lakes/ponds etc.) or ground water sources (deep tubewells, dug wells etc.). Urban water supply systems also need to account for a wide range of commercial, industrial, educational, political and social activities. Generally, the greater population density and wealth found in urban areas increase the resources available to maintain the system.

An urban water supply may have components like intakes, transmission lines, raw water reservoir, treatment plants (with functions/elements like coagulation, flocculation, sedimentation, filtration, disinfection etc.), clear water reservoirs(surface reservoirs, underground reservoirs, overhead tanks), pumping stations, distribution lines, private taps, public taps/standposts etc.

In contrast to urban water supply and sanitation systems, rural water systems generally serve a smaller, more scattered population and have fewer resources to draw upon. As a result, rural systems are usually of a simpler design than urban systems. It is usually fed by surface sources like springs, streams, rivers, or groundwater sources like dug wells, shallow hand tubewells. Rural water supply may have components like intakes, transmission lines, water reservoirs (surface reservoirs, underground reservoirs), distribution lines, private taps, public taps/standposts etc. In very rare cases, it may have a deep tube well as a water source and also a treatment plant to treat the raw water.

In Nepal, rural water supply systems are the responsibility of DoLIDAR and DWSS. Urban water supply systems are the responsibility of DWSS, Nepal Water Supply Commission (NWSC) and other locally formed agencies like Kathmandu Upatyaka Khanepani Limited (KUKL), Bharatpur Water Supply Management Board (BWSMB) and Hetauda Water Supply Management Board (HWSMB). There is a growing trend in Nepal to encourage rural communities to manage their own water supply schemes. In most of the case study districts assessed for this project, in practice both rural and urban water supply schemes are being managed and operated by these local Water Users' Boards and Committees with the technical, and occasional, financial support of DWSS or DoLIDAR[13].

A Water Users' Committee is formed via an election among the local community leaders and social workers and generally have representatives from marginal and disadvantaged groups in the communities including local women's groups, Janjatis'(Local Ethnic) groups, Dalits'(disadvantaged Hindu Caste) groups. In many cases there is general consensus and there is no election and committee members are just selected among the aspirants. For these reasons WUCs are considered

[13]Observations from field visits to Achham,Banke, Dolakha, Chitwan, Panchthar, Kathmandu and Mustang Districts.January 2014. January 2014. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013. November 2013..

local community-based organizations and thus water supply scheme operated by such WUC can be also called a Community Managed Water Supply System. International and local non-governmental organizations (NGOs) are also active in the water supply sector, particularly in their support for small, community-based schemes.

In some cases WUCs have been formed to help in constructing water supply systems, but do not continue their activities after completion of the systems. In such cases DWSS or DoLIDAR has to take the lead to reorganize the WUC. It has been found that the central problem in these cases is that the communities did not feel strong ownership of the system[14].

3.1 TYPICAL WATER SUPPLY SYSTEMS

3.1.1 Surface Water System

Surface water sources are derived directly from stream and river flow, or are stored prior to use, usually from behind high- or low-level dams that form water retention lakes anywhere from a few acres to many square miles in size. In Nepal the surface sources usually are streams/rivers and springs. River/stream intake systems are sited where there is an adequate flow and the level allows gravity supply to minimize pumping costs. The quality of the water is also important so the water intake should be upstream at a higher level than densely populated areas or farming areas or cattle watering places. Surface water systems are being widely used in both rural water supply and urban water supply in the right case study districts assessed for this project.

In recent times, loss of forest cover, indiscriminate removal of sand from river bed, clay mining from valley floors and soil erosion in the high lands have caused serious threats to surface water availability.

The quality of water in rivers and streams is also an issue as the water is open to external contamination and during rainy seasons and can get highly turbid. In most urban water supply systems the water is treated at different levels before it is brought to use for drinking. In the case of rural water supply systems it is not uncommon for water to be untreated. However in some cases where the community is health conscious and aware, water can be given very simple treatment such as filtration or disinfection before being used.

3.1.2 Groundwater System

Ground water which is stored in aquifers below ground is filtered and protected naturally from contaminations and evaporation. It has excellent microbiological and chemical quality which require minimal or no treatment. Some ground water has high iron and ammonia contents requiring some treatment. Ground water is harnessed through deep tube wells, open dug wells and shallow tube wells.

Ground water is widely used in urban water supply where the water is harnessed through deep tubewells. In rural water supply groundwater is harnessed through open dug wells and shallow tubewells using hand-pumps. During the case study visits, ground water was found to be widely used in Banke district, Chitwan district and in the urban areas of Kathmandu districts[15]. The capital cost of groundwater development as opposed to conventional treatment of surface waters is relatively modest and the resource lends itself to flexible development capable of being phased-in with rising demand.

3.1.3 Traditional Water Supply Sources

Traditional water sources (TWS) are ancient water supply systems that have strong cultural, social and religious value for local people. These sources can include stone water spouts (Dunge dhara), water holes (kunwa), shallow dugwells (inar) and isolated small springs (muls). TWS play an

[14] Observations from field visits to Achham,Banke, Dolakha, Chitwan, Panchthar, Kathmandu and Mustang Districts.January 2014. January 2014. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013. November 2013..

[15]Observations from field visits to Banke, Chitwan and Kathmandu Districts. January 2014. June 2013 and April 2014. July 2013 and April 2014. September 2013.

important role in Nepal's water supply strategy. Knowledge of traditional water sources is largely maintained by local communities. As water sources are replaced by pipe systems this knowledge of traditional sources is being gradually lost. Central and district agencies responsible for water and sanitation systems have not fully captured information about TWS or factored it into the planning of new systems.

Many communities still rely on TWS despite the fact that they are rated as poor quality water sources. The majority of the communities who use TWS are living in areas not yet accessed by public piped water systems such as hill-slopes, ridges of mountains, foothills and, isolated settlement areas. In Kathmandu district TWS are still common in areas which are not well covered by public piped water systems and other water-scarce communities in urban areas. TWS have been found to be particularly useful when the modern piped network systems fail to provide supply during drought conditions and when piped systems collapse due to natural disasters.

3.1.4 Rain Water Harvesting System

Rainwater harvesting in both rural and urban parts of Nepal is now an accepted freshwater augmentation technology. While the bacteriological quality of rainwater collected from ground catchments is poor, that collected from properly maintained rooftop catchment systems, equipped with storage tanks, which have good covers and taps, is generally suitable for drinking, and frequently meets WHO drinking water standards. DWSS & DOLIDAR are promoting collection and utilization of rainwater harvesting and other appropriate technologies at domestic and community level wherever feasible.

With these systems rainwater is collected usually in a surface tank or in an underground tank by a pipework arrangement. The water is generally used for drinking purposes, other domestic uses and for agriculture use as well. If being used for drinking the water may need some kind of preliminary treatment like filtration and some kind of disinfection like chlorination or boiling depending on the quality of the water.

Rural communities also collect rain water during the rainy season in ponds usually dug near the centre of the village. This rainwater is usually used for hydrating animals and irrigation purposes. Often plastic sheets are used as lining to save water from seepage.

Rain water harvesting systems were initially being promoted by the Government of Nepal in villages and communities in mountainous districts where no regular water sources exist. But now this practice is being promoted in many other water scarce districts including urban areas where water is becoming scarce such as the Kathmandu valley.

3.2 TYPICAL SANITATION SYSTEMS

Good sanitation is achieved when everyone in a community understands the health importance of safe excreta disposal, and takes the necessary practical steps to promote good personal hygiene and public health. This includes access to, and consistent use of, a safe and hygienic toilet. While good sanitation practices were observed in urban parts of Kathmandu and Chitwan, it was found that other districts such as Dolakha, Mustang, Acham, Banke and Panchthar still rely heavily on conventional sanitation facilities such as pit latrines and pour flush latrine with septic tanks[16].

Improving sanitation systems starts with a strong local health team that can identify local sanitation-related health problems and work with residents to remedy them. Key issues are poor hygiene practices, such as open defecation; contamination of water sources; malnutrition caused by worms or on-going diarrhoea, lack of safe and hygienic toilet facilities, lack of facilities for hand washing and inadequate refuse removal. It is crucial to promote understanding of the linkages between water, sanitation, hygiene and health.Traditionally sanitation is given a low priority by local government organizations in Nepal and is relatively high in cost when compared to water supply.

[16]Observations from field visits to Achham, Banke, Dolakha, Chitwan, Panchthar, Kathmandu and Mustang Districts. January 2014. January 2014. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013. November 2013..

3.2.1 Open Defecation

Open defecation is still common in rural areas of Nepal, but is slowly being stopped.Open defecation can pose health risks through contamination. In recent years, it has become a national point of pride in Nepal to put an end to the practice of open defecation. The majority of the communities in the case study districts assessed for this project have announced that they are open defecation free(ODF) including Achham, Mustang, Dolakha, Myagdi, Chitwan and Panchthar.

3.2.2 Pit Latrines

The type of pit latrine widely used Nepal is usually just a hand dug hole in the ground covered with a concrete slab that has a hole or squatting seat/pan fitted with a riser surrounded by a superstructure around it. The human excreta in the pit below the hole/squatting pan accumulates over time and through a process of biological degradation forms manure. After a time the pit is filled and the toilet is either shifted to another site or emptied. Another type of pit latrine is the two-pit latrine. Here two pits are connected to the hole/squatting pan and once one pit is filled the other is used while the first is emptied. Pit latrines are still widely used in rural parts of Nepal including in the case study districts assessed for this project and also some urban parts of Kathmandu and Chitwan where communities are yet to be served by sewage systems[17].

3.2.3 Pour Flush Toilets

A pour-flush toilet is a manually operated flush toilet connected to a septic tank, simple pit or sewage system. Generally this type is most widely used in areas where a piped water system is not available and was found in all of the case study districts both in rural areas and urban areas not connected to a sewerage system[18].

3.2.4 Septic Tanks (Onsite Systems)

Septic tanks are one of the most widely used on-site sanitation technologies in Nepal; particularly in urban residential households and commercial premises. The majority of the existing septic tanks in Nepal consist of a concrete structure that is equipped with a single compartment to collect waste. Generally these systems are not considered to be completely efficient in removing solids, organic matter and pathogenic bacteria from human excreta.

There are no standards for septic tank design and construction in Nepal. As a result, septic tank contractors often construct tanks with sizes that are not appropriate for the size of the household. Generally, the septic tanks installed in Nepal do not comply with international design and construction standards for such systems. Poor design and construction practices increases the risk of septic tank failure. Septic system failure is unpleasant, unsanitary, and a potential source of disease. It can result in groundwater contamination and flow-on contamination in nearby drinking water wells. In some cases septic tanks sludge can overflow back into or outside the house.

Based on the assessments undertaken for this project there appears to be a general misunderstanding regarding the necessary components of a functioning septic tank. While many of the communities in the case study districts claimed to have built septic tanks, in reality these systems were pit latrines with no bottom water-tight seal. This situation seemed to result from poor construction standards and poor understanding of the definition of a septic tank. Although residents are responsible for managing their on-site sanitation systems, it was found that they lack understanding and have low willingness to address sanitation problems[19]. Based on the field visits undertaken for this project the on-site household sanitation systems currently used in Nepal's urban areas were considered insufficient to protect public health and surrounding ecosystems. This problem will continue to grow as urbanization and population densities increase.

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[17] Observations from field visits to Achham, Banke, Dolakha, Chitwan, Panchthar, Kathmandu and Mustang Districts. January 2014. January 2014. July and September 2013. June 2013 and April 2014. July 2013 and April 2014. September 2013. November 2013.
[18] Ibid.

[19] Ibid.

3.2.5 Piped Sewerage Systems

A piped sewerage system is a more advanced type of sanitation system where the sewage of a number of communities is collected with pipes laid underground and directed to a Sewage Treatment Plant (STP). Here the sewage is treated to remove solids and potentially dangerous contaminants. Later the treated effluent is usually released back into water bodies.

Sewage may be conveyed by gravity or be pumped to a sewage treatment plant. Where pipeline excavation is difficult because of rock or limited topographic relief (i.e. due to flat terrain) gravity collection systems may be impractical and the sewage must be pumped through a pipeline to the treatment plant. In low-lying communities, wastewater may be conveyed by vacuum. Sewer pipelines range in size from pipes of 150 mm in diameter to concrete-lined tunnels of up to 3 - 4 m in diameter.

This type of sewerage system is generally being used in urban areas in Nepal. Among the case study districts, piped sewerage systems were in use in urban areas including Kathmandu city and Kirtipur municipality in Kathmandu district, Bharatpur city and Ratnanagar municipality in Chitwan district. A similar systemisbeing planned for Charikot Township in Dolakha district. Nepalgunj city in Banke district is also considering developing a piped sewerage system.

Community sewage can also be collected by an effluent sewer system, also known as a STEP system (Septic Tank Effluent Pumping). At each home, a buried collection tank is used to separate solids from the liquid effluent portion. The liquid portion is then pumped downstream through a small diameter pipe (typically 60mm to 100mm) for treatment. Because the waste stream is pressurized, the pipes can be laid just below the ground surface along the land's contour.

Sewage can also be collected by low pressure pumps and vacuum systems. A low pressure system uses a small grinder pump located at each point of connection, typically a house or business. Vacuum sewer systems use differential atmospheric pressure to move the liquid to a central vacuum station. Typically a vacuum sewer station can service approximately 1,200 homes before it becomes more cost-effective to build another station.

Piped sewerage systems of the types described above where all sewage is pumped out or taken out by gravity from the residential area to a wastewater plant for treatment and further discharged into water source is considered the best solution to reduce risk of groundwater contamination, pollution in streams and rivers and for overall public health. However, this type of system can involve risks and high construction and long-term operational and maintenance costs. Due to insufficient population density and reduce scale these types of system are generally not considered feasible in rural and sparsely populated areas.

The cost of constructing, operating and maintaining a comprehensive piped sewerage system also depends upon the technology adopted for treatment of the sewage/waste water. There are several technologies available for treatment of the waste water/sewage including treatment by stabilization ponds, trickling filters, activated sludge tanks and reed beds. Each technology has potential benefits and drawbacks depending on the conditions. Stabilization ponds and reed bed technologies may be suitable and make economic sense where the climate is warm and land is available. With these technologies the sewage is left to undergo biological reaction in atmospheric conditions in the open sun. Activated sludge technology with mechanical aerators could be better in cases where the quality of sewage is very bad with very high BOD and COD, land is very expensive and not easily available, and power is also cheaply available. With this technology, the bacteria in the sewage are activated by vigorously aerating the sewage with mechanical aerators. Generally, when pumping stations are required to pump the sewage to treatment plants and machinery is required to operate treatment system components like mechanical aerators then the system becomes very expensive.

A range of system types and quality were observed during the course of the project. In Kathmandu a stabilization pond system in Dhobighat was not functioning. An activated sludge treatment plant in Guheswori was in operation. In Bharatpur in Chitwan District the sewage treatment system is a reed bed system. Each of these systems had slightly different management arrangements. The Dhobighat Sewage Treatment Plant is under the management of Kathmandu Upatyaka Khanepani Limited (KUKL) while the Guheswori Sewage Treatment Plant is being managed by the High Power Committee for Integrated Development of Bagmati Civilization (HPCIDBC). The sewerage systems in Bharatpur Municipality and Ratnanagar Municipality in Chitwan district are managed by their respective Municipality administrations.

3.2.6 Community Sewage Treatment System (CSTS)

A Community sewage treatment system is a low capital, low operating and maintenance system purposely designed for populations less able to afford traditional sewerage and treatment. The systems are usually operated by an NGO or members of the community. Community sewage treatment systems (CSTS) are often referred to by their corresponding names in India, DEWATS (Decentralised Wastewater Treatment Systems) and Indonesia, SANIMAS (Sanitation by Communities). The concept has been adopted in many developing countries, including Brazil and many on the African continent.

From a technical standpoint a CSTS relies on processes that require a low energy input and relatively simple capital works. There are up to four treatment stages including settlement of solids, biological treatment in anaerobic conditions, filtration and redox using phyto or plant-based system.

3.3 SYSTEM COMPONENTS

The systems described in the section above are generally comprised on a number of infrastructure components. The choice of infrastructure component in a water supply system and sanitation system is usually dependent on the topography and water resources available. Basically, a district water supply and sanitation system in Nepal comprises the following infrastructure:

- Spring intakes of different types
- Intake structures
- Deep bore tube wells
- Overhead tank system
- Water treatment plant
- Transmission pipes
- Distribution reservoirs mainly RCC, stone masonry, brick masonry or Ferro cement type
- Pumping stations
- Distribution pipes
- Public standposts: RR masonry types
- Pit latrine(on-site sanitation)
- Septic tank system(on-site sanitation)
- Comprehensive sewerage system etc.

Maintenance of completed systems, whether undertaken by WUCs or any other agencies in rural water supply projects, usually consists of making only minor repairs and replacements. As a result, major repairs and system replacement are left to be included in new development projects usually supported by DWSS, DoLIDAR or donor agencies.

3.3.1 Water Supply System Components Assessed

As part of the assessment undertaken for this project visits to all eight case study districts and vulnerability assessment were performed on key critical water supply infrastructure assets. An overview of the infrastructure assets assessed by district is provided in Table 3-1.

Table 3-1 Overview of water supply infrastructure assets assessed by district

Achham					
Spring Sources	Kholas	Intake Points	Transmission pipes	Storage reservoirs	Distribution pipes

Banke				
Spring Sources	Intake points	Transmission pipes	Storage reservoirs	Distribution pipes

Chitwan							
Spring Sources	Tubewells	Intake structures	Transmission pipes	Storage reservoirs	Overhead tanks	PS & WTP	Distribution pipes

Dolakha					
Spring Sources	Intake Points	Transmission pipes	Storage reservoirs	PS & WTP	Distribution pipes

Kathmandu							
Spring & surface water	Tubewells	Intake structures	Transmission pipes	Storage reservoirs	Overhead tanks	PS & WTP	Distribution pipes

Mustang				
Spring Sources	Intake Points	Transmission pipes	Storage reservoirs	Distribution pipes

Myagdi				
Spring Sources	Intake Points	Transmission pipes	Storage reservoirs	Distribution pipes

Paachthar				
Spring Sources	Intake Points	Transmission pipes	Storage reservoirs	Distribution pipes

3.3.2 Sanitation System Components Assessed

As part of the assessment undertaken for this project visits to all eight case study districts and vulnerability assessment were performed on key critical sanitation infrastructure assets. An overview of the infrastructure assets assessed by district is provided in Table 3-1.

Table 3-2Overview of water sanitation infrastructure assets assessed by district

Achham, Banke and Dolakha	
Pit Latrine System	Unconventional septic tank systems

Chitwan and Kathmandu			
Spring Sources	Intake Points	Transmission pipes	Storage reservoirs

Mustang, Myagdi and Paachthar	
Spring Sources	Intake Points

4 TYPICAL CLIMATE CHANGE THREATS AND IMPACTS FOR THE SECTOR

4.1 CLIMATE THREAT PROFILE MODELLING

Studies done by the National & International Hydrological Modelling Team in close consultation with Department of Hydrology and Meteorology (DHM) show that climate change induced threats would affect differently people living in various regions in Nepal, their socio-economic development, biological diversity and other sectors. The results of such climate change induced threats are increased risks of floods, landslides, glacier outbursts, drought and other natural calamities.

District-level climate threat profiles were prepared to assess future climate change impacts on WATSAN systems relying on localised projections of future climate change for the period 2040-2060 compared to a baseline of 1980-2000. Monitoring data and results from the regional dynamic downscaling model PRECIS (Providing Regional Climate Scenarios for Impact Studies) were used for the climate projections. The monitoring data was projected using climate change statistics (averages, variability/variance, number of dry days and extreme values) from the PRECIS results and then interpolated with orographic adjustment into the high resolution grids necessary for development of district-level models. This procedure can be described as combined dynamic/statistical downscaling.

The results of the downscaling were incorporated into the IWRM basin-wide hydrological model which computed changes in temperature, precipitation amounts and intensities, river discharges and flood amounts and runoff for every 120 x 120m grid cell in each district. Hydrological and other processes were computed in each grid cell and the grid cells were connected through mass transport above ground (e.g. rivers and overland flow) and through the soil (e.g. groundwater flow). The model grid was constructed by combining together soil, land use, topography and river networks. Observed and projected meteorological data as well as water utilisation and infrastructure were added to the model together with the grid. Additional parameters computed included river water levels, floods, erosion, sediment concentration, slope stability/land slide risk and irrigation demand.

Despite the limitations in data coverage and quality and time available for model calibration the model represented quite well the hydrological characteristics within each of the target districts. Based on calibration results using historical events, modelling could also be deemed reliable in representing changes caused by climate change scenarios.

The occurrence and magnitude of the above climate threat parameters are presented in Climate threat profile documents.

4.2 THREATS AND IMPACTS ON WATER SUPPLY SYSTEMS

Error! Reference source not found. summarizes the key climate change threats identified during project sites visits and their impacts on various water supply system components reviewed in the district case studies.

Table 4-1Key climate change threats and associated impacts on water supply systems

Water Supply Components	Typical Threats				
	Increased Temperature and Reduced Rainfall (Drought)	Increased Rainfall	Increased Flow in River	Landslides	Flash Floods
Source and Catchment	Drying-up of source points and less	Increased rainfall brings sediments to	In regions where the source is adjacent to the	In hilly/mountainous regions the	Flash floods are a common in all regions of Nepal

Water Supply Components	Typical Threats				
	Increased Temperature and Reduced Rainfall (Drought)	Increased Rainfall	Increased Flow in River	Landslides	Flash Floods
	recharge of groundwater in the catchment. This threat would have a significant impact on water sources in mountainous region where deep-bore tube well alternative as an adaptation measure is difficult.	the source points which are not protected with run-off diversions in majority of the water supply schemes. This is a major issue in hilly and mountainous regions.	existing river streams, the intake structures are threatened by the increased flow and water level in the streams.	sources and catchment condition are threatened by landslide events.	and create risk of damage to the source and catchment.
Intake Structure	No impact on intake structure.	Increased rainfall brings sediments to the intake structures which are not protected with screening arrangements in majority of the water supply schemes. This is a major issue in hilly and mountainous regions such as Mustangand Dolakha.	In regions where the intake structures are adjacent to the river and streams (kholas) the intake structures are threatened by the increased flow and water level.	In hilly/mountainous regions the intake structures are threatened by landslides.	Flash floods are common in all regions of Nepal and can damage intake infrastructure.
Transmission and Distribution Pipelines	Increase in temperature expands pipeline cracks in existing system and causes increased non-revenue water.	Increased rainfall brings more flows that might erode soil around the pipeline and expose them to frequent damage.	In hilly regions, larger sections of the transmission pipelines cross the river streams and increase in WL would cause severe damages to the pipe system	In hilly regions the existing transmission and distribution pipelines are laid along the historic landslide zones which might attract frequent disruption to the water supply due to the failure of pipe system.	More intensified and frequent events would cause damage to the pipelines.

Water Supply Components	Typical Threats				
	Increased Temperature and Reduced Rainfall (Drought)	Increased Rainfall	Increased Flow in River	Landslides	Flash Floods
Storage Reservoirs	Increased temperature may cause severe cracks to Ferro-cement type structures.	Increased intensity and duration of rainfall adds more burden on O&M works due to the arrival of more sediments at reservoir that eventually reduces the storage capacity.	No impact because majority of the reservoirs not in the vicinity of river that experiences increased flow scenario in River.	Structural collapse of storage reservoir due to landslides caused by increased rainfall. This is a common issue in hilly regions.	Flash floods are well known in hilly regions where flows with high velocity overpass the storage structure that might trigger over-topping.
Water Pumping Stations	Increased temperature may cause damage to the equipment.	Intrusion of rain water with sediments in to the PS might cause damage.	If PSs are installed close to rivers liable to flooding is a serious problem	No existing PS is located in historic landslide areas.	Submergence of PS can be foreseen which damages the pumps.
Water Treatment Plant (WTP)	Increased temperature may cause damage to the equipment and structures.	Increased intensity and duration of rainfall adds more burden on O&M works due to the arrival of more sediments at WTP that eventually adds more cost to the process.	No impact because majority of the WTP not in the vicinity of river that experiences increased flow scenario.	Structural collapse of WTP due to landslides caused by increased rainfall scenario. This is a common issue in hilly regions.	Flash floods are well known in hilly regions where flows with high velocity can overpass the WTP structure with resulting damage

4.3 THREATS AND IMPACTS ON SANITATION SYSTEMS

Table 4-2 summarizes the key climate change threats and their impacts on various sanitation system components reviewed in the district case studies and which are an integral part of sanitation infrastructure.

Table 4-2 Key climate change threats and associated impacts on sanitation systems

Sanitation Components	Typical Threats				
	Increased Temperature	Increased Rainfall	Increased Flow in River	Landslides	Flash Floods
Collection System	Increase in temperature enhances the pipeline cracks in existing system.	Increased rainfall brings more flows that might erode the soil around the pipeline and	In hilly regions, larger sections of the pipelines cross the river/ streams and increase in WL	In hilly regions the existing conveyance system are laid along the historic	More intensified and frequent events would cause damage to the conveyance

Sanitation Components	Typical Threats				
	Increased Temperature	Increased Rainfall	Increased Flow in River	Landslides	Flash Floods
		expose them to the open environment leading to frequent damage.	would cause severe damage to the pipe system	landslide zones which might attract frequent failure of pipes.	system.
Sewage Pumping Stations	Increased temperature may cause damage to the equipment.	Intrusion of rain water with sediments could damage the pumps and lead to failure	If PSs are installed close to rivers, liable to flooding is a serious problem	Where PS is located in historic landslide area damage to or loss of the station could occur" Similar problem with earlier column	Submergence of PS can be foreseen which damages the pumps.
Septic Tanks/Pit Latrines	The biological process within the septic tanks is sensitive to higher temperatures which can retard organic matter disintegration and lead to public health issues.	Increase in rainfall scenario triggers frequent overflows from septic tanks.	It is quite likely that the septic tanks will be submerged under such scenario spreading waterborne diseases.	Collapse of septic tanks can be seen in hilly regions where landslides are a common issue.	Flash floods trigger overflows from septic tanks, causing submergence and mix of sewage with rainfall run-off into surface water bodies and ground water.
Sewage Treatment Plant (STP)	Increased temperature may cause damage to the equipment and structures.	Increased intensity and duration of rainfall adds more burden on O&M works due to the arrival of more sediments at STP that eventually adds more cost to the process.	In Chitwan existing STP's are constricted adjacent to the Narayani River which is prone to submergence under flood event.	Structural collapse of STP due to landslides caused by increased rainfall scenario - this is already a common issue in hilly regions.	Flash floods are well known in hilly regions where flows with high velocity pass over the STP structure causing failure and destruction of STP components.

4.4 DISTRICT CASE STUDIES THAT BEST ILLUSTRATE THE THREATS AND IMPACTS

During the baseline data collection, several structural and institutional flaws in existing systems were identified by the team. In general many of the assets observed during the case study visits had poor functionality. The depletion of water source capacity, damage of physical components of infrastructure, old pipelines and lack of awareness among the consumers were perceived to be the root causes behind the functionality problems that were observed. During the site visits the team also observed poor levels of service for local people provided by many components of water supply and sanitation systems in their respective districts and potentially negative implications for livelihoods and public health. Poor functionality due to source depletion and damage to asset structures will bring long-term impacts on the sustainability of the systems and a reduced level of service to consumers. Climate change will only exacerbate these risks.

The following small case studies illustrate systems that demonstrated specific problems with existing water supply and sanitation infrastructure and may be at particular risk to future climate change threats and impacts.

4.4.1 Water Supply System

BOX #1: Transmission pipelines and critical assets along the historic landslide areas

Water supply transmission pipelines and some of the key critical assets such as overhead tanks, intake structures etc. are laid in historic landslide areas as shown in the pictures below.

Left: In Dolakha and Right: Dachi overhead tank, Kathmandu

These pictures show clear examples where key assets have been placed in vulnerable sites. Climate change modelling indicates that more rainfall run-off should be expected in the future which could trigger an increased soil wetness index and more landslides. This could cause serious damage to existing water supply and sanitation and disruption to the water supplies for prolonged periods.

BOX # 3: Intake points adjacent to major rivers are vulnerable under increased flow in the rivers

Intake points/structures are key elements of water supply systems. These structures capture and channel water to storage reservoirs for further distribution to consumers. During the field visits a number of vulnerable intake points with no protective measures were identified. Two examples are depicted below.

Left: Intake point adjacent to Karwa river in Chitwan and Right: Sundarijal intake point, Kathmandu

Due to the increased rainfall intensity for prolonged durations, the level and the volume of flow in the major rivers increases which eventually flushes away the intake structures that are laid adjacent or along the river reach. Such events will also bring more sediment that might clog the intake system and prevent water from reaching downstream water works/distribution systems. In addition to the above, the chances of sediments reaching the consumers are highly likely which can cause serious health issues and lead consumers to reject water supply services.

4.6.2 *Sanitation System*

BOX # 4: Sewage treatment plants adjacent to major rivers subjected to submergence under flood events

Sewage treatment plants (STP) in Kathmandu and Chitwan were constructed adjacent to the existing rivers as shown below. Constructing an STP adjacent to a river is acceptable and is a usual practice. However, no protective measures have been taken against the intrusion of flood waters during high floods. This can lead to a range of problems with the functionality of these assets; particularly during periods of emergency associated with extreme rainfall events.

Left: Guheshwori STP adjacent to Bagmati river in Kathmandu and Right: Bharatpur STP adjacent to Narayani river, Chitwan

BOX # 5: Pit latrines/unconventional septic tanks vulnerable under increased temperature and increased rainfall scenarios

Pit latrines/unconventional septic tanks in high density areas are threatened by increased rainfall (Kharibot Community, Dolakha)

A majority of districts visited as part of the current study indicated that the current practice of septic tank design and construction is poor with many units constructed and designed improperly. Most units were one chamber units and did not have a water tight base. As a result, they operated more like cesspools and allowing influent to be absorbed by the surrounding soil.

These types of tank are susceptible to frequent incidence of overflow during storms or other high intensity rainfall events and also contribute to groundwater contamination. Communities had already observed significant contamination of springs and streams located within the community area. This contamination is largely due to seepage of sewage and overflows from the septic tanks under storm events.

Site visits undertaken for this project suggest that pit latrine facilities are most widely used across Nepal. There was no single event raised by communities during the site visit that could indicate how these sanitation facilities might be affected by climate change induced threats. However, the experience with pit latrines in other parts of the world suggests that increased temperature will have a negative impact on the biological disintegration of fecal matter, thus, resulting the retardation of the process with potential flow on impacts for public health and hygiene.

5 VULNERABILITY ASSESSMENT

5.1 METHODOLOGY

Vulnerability assessment (VA) is a tool to identify potential risks to assets (protection works/structures) for specific threats. It will provide the decision-makers with an early warning signal about the need to monitor potential changes. Thus, at an early stage threats are detected and measures can be taken to reduce negative impacts. VA also identifies gaps in existing information and the necessity to collect such information. The VA method that was followed to assess the vulnerability of water supply and sanitation infrastructure for this project is outlined in Figure 5-1.

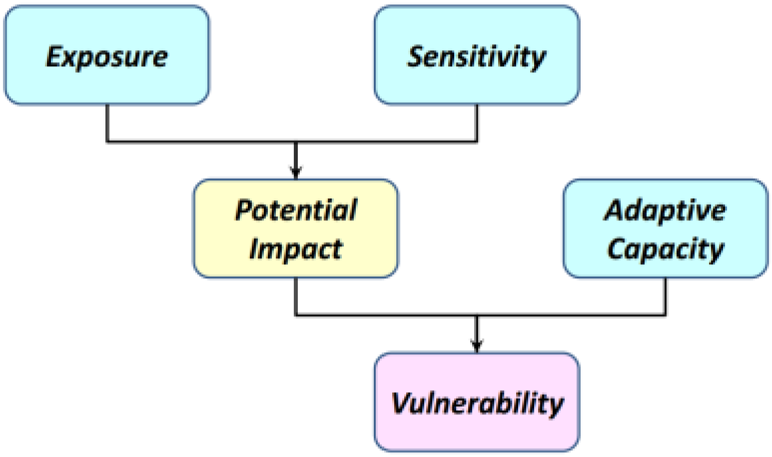

Figure 5-1 Overview of Vulnerability Assessment process

EXPOSURE refers to the extent to which an asset comes into contact with a climate threat or the consequences of a climate threat. The exposure also takes in to account the critical aspects such as the location of asset, intensity, duration and frequency of the climate threat towards the asset and the magnitude of the event.

SENSITIVITY is the degree to which an asset is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., increases in flood water levels).It is the *extent to which* a system is affected by climate change. It takes into account the age of the structure, materials used in the construction and its quality, levels of maintenance, any design considerations that protects the asset from any extreme climatic events.

IMPACT is estimated once the exposure and sensitivity are determined using the guiding matrix as shown in **Table 5-1**

Table 5-1 Matrix to determine impact of climate change

		Exposure of system to climate threat				
		Very Low	*Low*	*Medium*	*High*	*Very High*
Sensitivity of system to climate threat	*Very High*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	High	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Low	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very Low	*Very Low*	*Low*	*Low*	*Medium*	*High*

ADAPTIVE CAPACITY refers to the ability of a system to accommodate or cope with climate change threats with minimal disruption. This takes into account the range of available adaptation technologies and the funds that are available to meet such technologies, local skills and knowledge base, management responsiveness and relevant policies that make such adaptation to happen and the locally available materials for such adaptation.

VULNERABILITY**:** Based on the impact and adaptive capacity, the vulnerability of the asset for the CC threat is estimated using the guiding matrix shown in.

Table 5-2 Matrix to determine Vulnerability to climate change

		Impact				
		Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Adaptive Capacity	*Very Low* *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

5.2 SUMMARY OF VULNERABILITY ASSESSMENTS FOR WATER SUPPLY AND SANITATION SYSTEMS

Table 5-3 provides an overview of the vulnerability assessment exercise for water supply system infrastructure assets.

Table 5-3Highly Vulnerable categories of water supply system infrastructure assets identified in case study districts

Water Supply Infrastructure Asset	Reasons why the component is vulnerable to climate change	Locations applicable
Source – Springs, Streams and Rivers	Drying-up of source and less recharge of groundwater in the catchment is common issue throughout Nepal. This is due to the increased temperature and reduced rainfall for prolonged periods. There is less water available in the WS system that can cater for daily domestic purposes. Less water means reduced consumption with negative impacts on hygiene and sanitation services as well.	*Springs (Districts):Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar* *Streams and Rivers (Districts): Kathmandu, Chitwan, Mustang and Achham* This has a significant impact on water sources in mountainous region where deep-bore tube wellsas an alternative source and adaptation measure are costly and difficult to establish.
Intake Structure	Increased likelihood of intense rainfall and flash floods will lead to collapse of intake structures. This will create serious water supply issues that might cause inconvenience or more serious effects on consumers. In addition good protective measures such as sediment traps at intake point are generally not in place increasing the sensitivity of these assets.	*Districts: Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar* Flash floods are well known to occur in hilly regions where large flows with high velocity may flow over the intake structure eventually leading to its complete destruction.
Transmission and Distribution Pipelines	Failure of highly exposed transmission and distribution pipelines due to landslides is a major potential climate change impact that could result from increased numbers of high intensity rainfall events. Failure can cause serious disruption to water supply and takes several days to reinstate.Increases in temperature can also expand pipeline cracks in existing system and cause increased non-revenue water.	*Districts: Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar* In hilly regions the existing transmission and distribution pipelines are laid along the historic landslide zones resulting in increased exposure and frequent failures which are likely to increase in number and severity.
Storage Reservoirs	Collection of sediment from rainfall runoff in storage reservoirs can be a serious issue; particularly if sediments with organic matter reach residents. Increased incidence of high intensity rainfall events with climate change may increase the risk such events. In some cases where the storage structures are constructed in historic landslide areas these highly exposed assets may also be at risk of total collapse.	*Districts: Dolakha, Kathmandu* Flash floods are well known to occur in hilly regions where large flows with high velocitycan lead to over-topping and the collection of large volumes of solid particles and organic matter in storage structures.
Water Pumping Stations	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance	*Districts: Banke, Kathmandu, Chitwan* In terrain like Chitwan and Kathmandu where there is a need for lifting and gravity

Water Supply Infrastructure Asset	Reasons why the component is vulnerable to climate change	Locations applicable
	of sediment collecting and clogging pumps and interrupting water supply.	systems, pumping stations in these areas will be especially prone to such climate change threats.
Water Treatment Plant (WTP)	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance of sediment collecting in the plant systems leading to an overburdening and deterioration of water quality.	*Districts: Chitwan, Dolakha, Kathmandu* Relevant in flat and hilly terrain.

Table 5-4 provides an overview of the vulnerability assessment exercise for sanitation system infrastructure assets.

Table 5-4Highly Vulnerable categories of sanitation system infrastructure assets identified in case study districts

Sanitation System Infrastructure Asset	Reasons why the component is vulnerable to climate change	Locations applicable
Collection System (sewage pipes)	Failure of highly exposed collection systems due to landslides is a major potential climate change impact that could result from increased numbers of high intensity rainfall events. Failures can cause sewage to resurface leading to serious health issues. Increases in temperature can also expand pipeline cracks in existing system.	*Districts: Chitwan and Kathmandu* In hilly regions the existing collection system are laid along historic landslide zones with frequent failure and disruption. Systems affected by landslides are likely to increase as will the frequency and severity of damage
Sewage Pumping Stations	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance of sediment collecting and clogging pumps and causing overflows from pumping stations.	*Districts: Chitwan and Kathmandu* In terrain like Chitwan and Kathmandu where there is a need for lifting and gravity systems, pumping stations in these areas will be especially prone to such climate change threats.
Septic Tanks/Pit Latrines	Increases in temperature may increase disease vectors. Increased incidence of high rainfall events may lead to overflows from septic tanks through the streets and pollution of groundwater and nearby streams. Frequent overflows from septic tanks causes public health and hygiene issues.	*Districts: Achham, Banke, Chitwan, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar* In both flat and hilly terrains where septic tanks/pit latrines are constructed using improper design & construction techniques in densely populatedcommunities.
Sewage Treatment Plant (STP)	Climate induced strain on STP such as increase in temperature can affect the biological treatment process and also enhance the corrosion within the STP and pipe systems. Increased incidence of high rainfall events may also lead to excess sediment deposits and system breach.	*Districts: Chitwan and Kathmandu* Relevant in flat and hilly terrain.

6 TYPICAL ADAPTATION MEASURES

In this section, adaptation responses are identified based on the sector district case study assessments performed. Adaption planning is all about priority setting. It involves developing a range of adaptation options for each of the significant impact of climate change and then determining priorities for implementation which are built into an integrated adaptation plan. With limited resources it is not possible or necessary to do everything at once – choices need to be made on what is feasible and necessary now and what can be left to later planning cycles.

The main steps of adaptation process that were considered in developing the adaptation measures outlined below were: i)Reviewing the most vulnerable assets; ii)Looking back to define the impacts which require adaptation responses; iii)Defining the adaptation options; iv) Setting priorities among options; v) Integrating adaptation priorities; and vi) Building adaptation packages into plans and projects

6.1 TYPICAL ADAPTATION MEASURES OF WATER SUPPLY SYSTEM

Table 6-1 summarizes the key climate change impacts on various water supply systems identified during project field visits and suitable structural and non-structural adaptation measures.

Table6-1Key climate change impacts and suitable adaptation measures for water supply systems

Water Supply Infrastructure Asset	Climate Change-related Impact	Structural Adaptation Measure	Non-Structural Adaptation Measure
SHORT-TERM ADAPTATION MEASURE			
Source Springs, Surface water, Streams	▪ Drying-up of source, less water in streams and rivers	▪ Identify alternative water supply measures such as tankers and rainwater harvesting and strengthen and rehabilitate traditional water sources	▪ Conservation, protection and better management of traditional water sources ▪ Build community awareness regarding source protection and need for the enforcement of regulations designed to protect water sources ▪ Build capacities in local institutions and government agencies for planning, designing and implementing source protection measures and management ▪ Revise Water Resources Act – 1992 and enforce it with more strict regulatory approaches for source protection ▪ Physical demarcation and protective fencing of the source and catchment area in the watershed and definition of clear management

Water Supply Infrastructure Asset	Climate Change-related Impact	Structural Adaptation Measure	Non-Structural Adaptation Measure
			responsibilities with emphasis on community/user group roles
Intake Structure	▪ Collapse of intake structure ▪ Sediment blocking structure	▪ Protect the intake structure by establishing temporary drainage diversion channels ▪ Establish sediment trap prior to intake ▪ Provision of fine screens at intake point	▪ Provision for adequate budgets for the priority adaptation measures with short and long term objectives ▪ Set up maintenance program with clear responsibilities and regular removal of sediments from the structures
Transmission and Distribution Pipelines	▪ Collapse of pipelines due to landslides ▪ Cracks and leakage due to increased temperature	▪ Protect and provide concrete/steel casing with abutments to the transmission pipelines laid along historic landslide zones ▪ Anti-crack protective coatings to be applied to the pipelines to resist high temperatures	▪ Provide adequate budgets for the priority adaptation measures with short and long term objectives ▪ Establish user group approach to maintenance and management of various sections of the system
Storage Reservoirs	▪ Collapse of structure ▪ Collection of sediment in reservoir	▪ Protect the reservoir structure through temporary retaining walls ▪ Regular removal of sediments from the structures ▪ Provide fine screens and disinfection arrangements at reservoir site	▪ Strengthen local water users committees and capacity of service providers for robust O&M and enhancing service levels for users ▪ Provide adequate budgets for priority adaptation measures with short and long term objectives
Water Pumping Stations	▪ Damage to pumps ▪ More sediment filling/blocking other components	▪ Protect the pumping station structure through temporary retaining walls ▪ Provision of fine screens at pumping station inlet	▪ Provide adequate budgets for priority adaptation measures with short and long term objectives Promote SCADA and Telemetry system which provides real-time control of pumping stations Establish 24/7 O&M staff to address any emergency breakdown of system
Water Treatment Plant (WTP)	▪ More sediment reducing operation efficiencies and	▪ Provision of fine screens at collection chamber	▪ Provision for adequate budgets for the priority adaptation measures with

Water Supply Infrastructure Asset	Climate Change-related Impact	Structural Adaptation Measure	Non-Structural Adaptation Measure
	causing damage		short and long term objectives ▪ Establish 24/7 O&M staff to address any emergency breakdown of system ▪ Training and operating procedures for relevant staff
LONG-TERM ADAPTATION MEASURE			
Source Springs, surface waters, streams	▪ Drying-up of source	▪ Establish deep tube bore-wells where and as feasible ▪ Establish rainwater harvesting techniques ▪ Introduce impounding reservoirs	▪ Build the institutional capacity to collaborate with local forest user groups for protection of local water sources and catchment areas ▪ Build community awareness on protection of water sources and systems
Intake Structure	▪ Collapse of intake structure ▪ Sediment blocking intake	▪ Construct a new intake structure with screening arrangements to evade dirty run off water.	▪ Protect the upstream catchment/forest vegetation that provides initial filtration of sediments entering the downstream system
Transmission and Distribution Pipelines	▪ Collapse of pipelines due to landslides ▪ Cracks in pipes due to increased temperature	▪ Rebuild the transmission pipeline with better alignment and temperature resistant pipe material ▪ Construct a new waste treatment plant between intake and the storage reservoir to provide better water quality and avoid sediments reaching the storage reservoir.	▪ Establish feasibility study approach and environmental impact study assessment for all future pipeline projects to avoid pipes laid in historic landslide and critical zones. ▪ Incorporate climate change elements such as increased temperature into the design process to design a pipe system that is temperature resilient.
Storage Reservoirs	▪ Collapse of structure ▪ Collection of sediment in reservoir	▪ Construct new storage reservoir with screening arrangements to evade dirty run off water and provision of structural support such as gabions and bioengineering.	▪ Protect the upstream catchment/forest vegetation that provides initial filtration of sediments entering the downstream system ▪ Establish feasibility study approach for all future

Water Supply Infrastructure Asset	Climate Change-related Impact	Structural Adaptation Measure	Non-Structural Adaptation Measure
			water supply projects to avoid key structures being placed in historic landslide \ zones that are prone to damage and sediment runoff ▪ Incorporate climate change elements in the design process to design a system that is climate proof and resilient

6.2 TYPICAL ADAPTATION MEASURES OF SANITATION SYSTEM

Table 6-2 summarizes the key climate change impacts on various sanitation system components and suitable structural and non-structural adaptation measures.

Table 6-2Key climate change impacts and suitable measures for sanitation system

Sanitation Infrastructure Asset	Climate change-related Impact	Structural Adaptation Measure	Non-structural Adaptation Measure
SHORT-TERM ADAPTATION MEASURE			
Collection System	▪ Collapse of pipelines due to landslides ▪ Cracks and leakage due to increased temperature	▪ Protect collection system pipelines from landslides to reduce exposure ▪ Apply protective coating to the pipelines that are vulnerable to temperature increase	▪ Establish feasibility study approach and environmental impact study assessment for all future pipeline projects to avoid placing pipe systems in historic landslide zones ▪ Incorporate climate change elements such as increased temperature in the design process to design pipe systems ▪ Provide adequate budgets for priority adaptation measures with short and long term objectives
Sewage Pumping Stations	▪ Damage to pumps ▪ Collection of sediment	▪ Protect the pumping station. structure through temporary retaining walls ▪ Provision of fine screens at pumping station inlet	▪ Provide adequate budgets for priority adaptation measures with short and long term objectives ▪ Promote SCADA and Telemetry system which provides real-time control of pumping

Sanitation Infrastructure Asset	Climate change-related Impact	Structural Adaptation Measure	Non-structural Adaptation Measure
			station and its operation ▪ Establish 24/7 O&M staff to address any emergency breakdown of system
Septic Tanks/Pit Latrines	▪ Overflow from septic tanks	▪ Implement improved design and construction techniques.	▪ Establish septic tank management system ▪ Establish design specifications and construction standards for septic tanks ▪ Establish mandatory licence system for all septic tank contractors ▪ Establish 24/7 O&M staff to address any emergency breakdown of system during an extreme rainfall event ▪ Establish community leaders for septic tank management, operation and maintenance ▪ Promote sanitation technology home-owners awareness programs
Sewage Treatment Plant (STP)	▪ collection of sediment in treatment system ▪ River flows entering in to the STP	▪ Provide fine screens at collection chamber ▪ Provide flap gates at the effluent discharge point/outfall point	▪ Provide adequate budgets for priority adaptation measures with short and long term objectives ▪ Training for staff in operating procedures
LONG-TERM ADAPTATION MEASURE			
Septic Tanks/Pit Latrines	▪ Overflows from septic tanks	▪ Implement comprehensive sewerage system consisting of a combination of both gravity and lifting system (depending upon the terrain) that completely removes groundwater contamination, public health and hygiene issues	▪ Establish 24/7 O&M staff to address any emergency breakdown of system ▪ Training for staff in operating procedures. Provide annual budget for O&M to meet the required training, spare-parts *etc.* ▪ Provide adequate budgets for priority

Sanitation Infrastructure Asset	Climate change-related Impact	Structural Adaptation Measure	Non-structural Adaptation Measure
			adaptation measures with short and long term objectives
Sewage Treatment Plant (STP)	▪ River flows entering into the STP	▪ Closure of effluent discharge points and establishment of an emergency bypass pumping station to operate under flood events	▪ Provide adequate budgets for the priority adaptation measures with short and long term objectives ▪ Provide annual budget for O&M to meet the required training, spare-parts *etc.* ▪ Establish 24/7 O&M staff to address any emergency breakdown of system ▪ Training for staff in operating procedures

7 REFORMS REQUIRED WITHIN SECTOR

Based on the cross-section of district-level case study vulnerability assessments and adaptation planning exercises presented above, a number of entry points have been identified that could serve as the basis of reforms to enhance climate resilience in the water supply and sanitation sector. Entry points included 1) Revisions to design guidelines, manuals and standards; 2) Revisions to policy, planning and legal frameworks; and 3) Strengthening institutional arrangements.

7.1 REVISIONS TO DESIGN GUIDELINES, MANUALS AND STANDARDS

Both DWSS and DoLIDAR have set of volumes for the design of urban and rural water supply and sanitation systems and their components. Understanding climate change induced threats for water supply and sanitation systems is a new concept in Nepal. Efforts to enhance and revise existing design guidance for water supply and sanitation systems will assist in both sensitizing DWSS and DoLIDAR engineers to the potential impacts of climate change on key sector infrastructure and enhance the resilience of future sector infrastructure. Table 7-1summarizes the key points that need to be considered for effective revision of DWSS and DoLIDAR guidelines, manuals and standards for specific sector assets based on the assessment presented in this report.

Table 7-1Climate-induced threats and implications for infrastructure design guidance in the WATSAN sector

Climate Change Threat	Change in Environmental Condition	Design Implications	Remarks
Temperature change	Rising maximum temperature; lower minimum temperature; wider temperature range;	1. Over the long term, possible significant impact on the transmission pipelines subjected to cracks need improved or new materials and protection measures such as surface coating. 2. Need for more robust septic tank designs that account for the effect of increased temperature on treatment biological process.	• The current design practices for transmission pipelines/distribution pipelines/ sewage pipes do not take increased temperature phenomena into account. Due to the projected temperature increase there is an immediate need to revise the existing design guidelines and standards to allow designers to choose climate resilient pipe materials such as HDPE. • Currently there are no stringent design standards or specifications for septic tank design and construction in Nepal. The majority of the existing septic tank structures are designed as pit latrines. Efforts to improve design guidance to account for climate change may also present an opportunity to develop broader guidance for septic tank design in-line with international design standards and specifications.

Climate Change Threat	Change in Environmental Condition	Design Implications	Remarks
Change in precipitation levels	In a worst case scenario more precipitation and intense rainfall events result in greater levels of flooding resulting in more landslides and more rainfall runoff that brings additional sediment loads	1. Increased rainfall causes flooding and triggers more landslides. More landslides proximate to key system assets would pose additional risk of system failure requiring preventative measures. 2. More rainfall runoff with increased sediment loadswill require additional protective measures to prevent excess sediment collecting in intake structures, reservoirs and treatment process equipment. 3. Increased rainfall affects the performance of existing septic tanks and triggers more frequent overflows. Septic tank design needs to account for potential of increased rainfall and build in automatic stabilizing systems.	• A feasibility study should be required for all new infrastructure assets. Revised guidance should specify that water supply and sanitation infrastructure should not be placed in active/historic landslide zones. If it is considered necessary for an asset to be placed in an area proximate to a historic landslide area then special attention should be given to safety measures such as gabion walls. • Current intake structure design guidance does not allow for screening systems at the mouth of the intake system. Guidance needs to be revised to allow possibility of adequate benching and screening facilities. • Design guidance for septic tanks does not account for water infiltration and inundation during high intensity rainfall events. Strengthening the climate resilience of these systems provides an opportunity to establish guidance on this issue.
River level rise	Rising water levels in rivers and kholas increases risks of severe riverine flooding	1. Over the long term, greater inundation of river areas requires more stringent design standards guidance that accounts for flooding. Guidance also needs to facilitate greater protection of infrastructure during flash floods and river over-topping	• In majority of the districts, the intake points are either adjacent to the river or within the river itself. At present infrastructure design guidance does not account for system integrity during high intensity rainfall events and flash flooding. Improving guidance to account for climate change presents an opportunity to include best practice design considerations for existing and future system designs. • Guidance can be further strengthened to stipulate that

Climate Change Threat	Change in Environmental Condition	Design Implications	Remarks
			transmission/distribution/sewage pipelines that are laid along the river banks should be designed with concrete casing protection or an abutment type structure to enhance the system stability against flash and riverine floods. • A feasibility study and environmental analysis should be required prior to any future design and construction work on critical assets along major rivers in Nepal. Major existing WATSAN infrastructure designed and constructed along the river shall be protected with flood relief walls.

In addition to these specific issues related to climate change threats there are a number of general changes to infrastructure design guidance that will enhance the overall climate resilience of water supply and sanitation systems including:

- Revisit the 12-Volumes of design guidelines and standards to identify the entry points and robust design of water and sanitation assets in light of climate change induced threats;
- Formulate Standard Operating Procedures for Community and Municipal Wastewater Treatment Plants and Disposal Management Systems and establish a mechanism for regular monitoring within the design guidelines and standards; and
- Conduct detailed impact assessment of WATSAN infrastructure (at national level) and generate extensive asset database (as recommended by the recent Joint sector review-2014).

Based on the above findings, the National WATSAN Expert reviewed all 12 volumes of design guidelines and standards for water supply and sanitation infrastructure in Nepal. Table 7-2below identifies specific changes to relevant infrastructure design guidance that will enhance overall climate resilience in the WATSAN sector.

Table 7-2Proposed Design Guideline Modifications for WATSAN infrastructure

Volume	Design Guideline	
	Title	Recommended Modification
1	Procedural Guidelines	Page 26, Section 3.3.2, water resources measurements and design issues were not taken CC in to account. While taking flow measurement at source possible impact of climate change should also be taken into consideration.
2	Design Criteria	Page 30, Section 4.4.2, the water consumption has not considered with CC parameter

Volume	Design Guideline	
	Title	Recommended Modification
6	Water Quality & Sample	Page 21, Section 2, shall be in line with the existing Water Safety Plan which is in place
8	O&M Manual : Policy & Procedures	Page 4, O & M measures are not in-line with CC parameters Page 36, Section 5, training shall take CC in to account
10	General Specifications	Page 1, Section 2.2.1, the tests shall be done taking CC in to account Page 19, Section 3.3, it says the design shall be for tropical climatic conditions but CC shall be also taken too
11	Guidelines for Tubewells Program	Page 8, Section 2 and Page 21, Section 5.1.3, Choice of pump and the suction tube-well shall be made based on CC induced GW depletion.

In general, changes to design guidelines, manuals and standards must be approached carefully. In most cases, design standards are based on experimental tests and practical experience that lead to an acceptance by the professional community that the guidance represents safe practice. Major disagreements can occur when changes are proposed to existing standards because of differences of opinion. Changing design practice from assuming a 100-year storm to a 500-year storm requires first evidence from hydrological modeling or other analysis, which the assessments undertaken for this project have attempted to provide. The next step of reform will debate and consensus-building among the professional community to work toward an agreed change in engineering practice.

7.2 REVISIONS TO POLICY, PLANNING AND LEGAL FRAMEWORKS

7.2.1 Key policy, planning and legal framework issues to be addressed

Based on the assessments undertaken for this project the following policy, planning and legal framework issues need to be addressed to strengthen the climate resilience of the WATSAN sector:

Lack of effective Master Plans: Master plans can help sector experts looking to formulate WATSAN projects and expand services to focus their efforts by identifying sector objectives and frameworks for action. From a climate change perspective the presence of a Master Plan can draw attention to climate change threats to the sector and motivate action to tackle these threats. Sector experts at DWSS and DoLIDAR will need adequate support and capacity to develop the sector master plan internally.

Lack of Effective Sector Coordination: Based on the assessment undertaken for this project, coordination within the water supply and sanitation sector is not very effective. The institutional arrangements for providing water and sanitation services are fragmented. The roles of DWSS, WUSC, DOLIDAR, and local government are not clearly defined leading to inefficiency in managing and implementing needed water supply and sanitation projects. Lack of clear sector roles also creates confusion for users who are trying to resolve specific issues with system services. From a climate change perspective these institutional issues can lead to inaction on necessary adaptation or resilience measures as agencies are uncertain who has responsibility for a particular climate change related issue. Coordination can be improved through the development and adoption of sector planning approaches.

Financial management: Linked to the issues above, improved sector planning and coordination will also enhance capacity for financing sector specific projects. At present capacity for financing major sector-specific initiatives is considered low because of complicated implementation procedures and problems with coordination between key stakeholders. Improving the capacity of sector stakeholders to finance their activities in a coordinated manner will be of critical importance to any future sector specific action to tackle climate change and strengthen climate resilience.

Benchmarking and monitoring mechanism of projects: During the assessments carried out for this project it was found that reliable information on service coverage and service delivery is not available. This situation is due to a lack of benchmarking and monitoring and evaluation of water supply and sanitation utilities/projects. Capacity is required within DWSS and DoLIDAR to establish and maintain an asset inventory and management system that gives the authorities better understanding and control on the assets in their sector portfolios. From a climate change perspective improved benchmarking and monitoring practices will allow improved monitoring of assets and systems that may be of particular threat to climate change impacts and development of effective interventions.

Lack of proper maintenance strategy: Linked to the issue above, in general, there is no maintenance strategy for existing water supply and sanitation schemes. Failure to make adequate provision for operation and maintenance has resulted in many WATSAN systems across the country operating below design levels or not at all. Lack of effective operation and maintenance strategies is a clear adaptation deficit that needs to be resolved to ensure a basic level of climate resilience.

Lack of private sector involvement: It is difficult to attract the domestic private sector participants to become involved in the operation and management of water supply and sanitation schemes due to low tariff levels. However, the levels of service possible from a public-only system appear to be poor.There may be a need to investigate Public Private Partnerships (PPP) as a way to attract private investors to participate in the O&M of water supply and sanitation systems.

7.2.2 Specific sector policies in need of review and revision to better account for climate change

National policies formulated for urban water supply and sanitation are listed below and the required revisions (if needed) under each policy are identified:

THE SANITATION AND HYGIENE MASTER PLAN (2010)

This Master Plan explicitly mentions about the impacts of climate change and the potential ways forward for adaptation and mitigation of the problems created due to the scarcity of safe water, lack of public awareness and lack of capacity of people to cope with climate change impacts. Future master planning processes will afford opportunities to strengthen measures for adaptation to climate change impacts.

URBAN WATER SUPPLY AND SANITATION POLICY (2009)

This policy aims to enhance quality of life through the provision of safe, reliable, adequate and enhanced services at affordable prices to the consumers. Compatible infrastructure, appropriate institutional setup, rationalized cost recovery, favourable financing environment, enhanced people’s participation and decision making and appropriate partnership with the private sector are included as core elements. The policy also aims to adopt measures to safeguard the environment and emphasizes achieving a balance with other competing uses of water through adoption of demand and discharge management measures. It is recommended to recognize climate change as an issue to be addressed with this policy and to develop a strategy to do so.

RURAL WATER SUPPLY AND SANITATION NATIONAL POLICY AND STRATEGY (2004)

This policy aims to facilitate water and sanitation access to all rural people in support of the Millennium Development Goals and national water supply and sanitation targets. It provides guidance on water and sanitation service provision in rural areas using community led participatory approaches. Components to address climate change impacts like high intensity rain in short duration and drought for longer period demanding more water, depletion of water in the sources etc. need to be considered/incorporated. Activities to address climate change impacts like high intensity rain in short duration and drought for longer periods need to be considered/incorporated.

NATIONAL URBAN POLICY (2007)

This policy highlights the historical imbalances and haphazard nature of urban development in Nepal. It views the urban centres as catalysts for economic development linked to north-south and east-west access corridors and flags poor sanitation, environmental degradation and lack of services for the urban poor as issues requiring urgent attention. Private sector involvement, participation and investment in infrastructure development are also specifically sought. It is recommended to recognize climate change as an issue to be addressed with this policy and to develop a strategy to do so.

THE NATIONAL DRINKING WATER QUALITY STANDARDS (2005/06)

This document provides water quality standards parameters to be applied to all new urban systems in order to protect the users' rights. In addition to this, it also complements the Environment Protection Act (1997) which requires Environmental Impact Assessments (EIA) or Initial Environmental Examination (IEE) of all new projects and pollution control clearance for all water resource projects. In view of possible climate change threats the quality of drinking water and sewage effluents will result in more regular contamination and at higher levels. As a result, it is recommended that provisions should be added for third party monitoring of the existing water supply and sewage treatment plants to ensure the compliance to national and international standards and legal enforcement mechanism to address the deficiencies or non-compliance of operating agencies.

NATIONAL WATER PLAN (2005)

This Plan is a strategic document which has set the criteria and targets for service level to be maintained in the water sector as a whole. The targets in the plan indicate that universal water supply coverage is to be achieved by the year 2017. This has and will continue to require huge efforts to improve the current situation to provide a basic level of service and to maintain services against poor operation and maintenance practices, system ageing and damage. Climate change is a new challenge that was not adequately addressed when this plan was drafted. Activities to address climate change impacts like high intensity rain in short duration and drought for longer periods need to be considered/incorporated.

NATIONAL SANITATION POLICY AND STRATEGY (1994)

This policy aimed to improve the broad goals of improving health, enhancing health related knowledge and improving coordination among concerned stakeholders. The policy encouraged sanitation programs to adopt an integrated approach combining health, education, water supply and local development. Climate change was not included as a key issue under this policy. It is recommended to revisit this policy, its relationship to later urban and rural strategies on water supply and sanitation and how in combination these strategies could be used to enhance climate resilience.

WATER RESOURCES ACT (1992)

This Act is one of the pioneer initiatives of the Nepalese government for water resources management and regulation. The Act allows the water users to exploit and protect their resources for domestic, irrigation and other needs. The Act and related regulations have provisions for district level decision making to grant the resources for the local user communities. Climate change was not included as a key issue under this policy. It is recommended to revisit this policy so that climate change can better recognized and addressed.

GOVERNMENT OF NEPAL TWENTY YEAR VISION (1997-2017)

GoN investments in urban water supply and sanitation are primarily guided by its Twenty Year Vision Plan(1997-2017).Following a review of the various interim plans and approaches of the TYP, the following areas were identified that could be the focus of future plans to enhance climate resilience:

- Maximum utilization of local water resources through simple local technology including alternative methods of rain water harvesting (RWH);
- Capacity building and training with climate change issues, climate change adaptation and climate resilience;
- Encouraging integrated multi-sector approaches to complex challenges such as climate change (The multi-sector approach encouraged for sanitation and hygiene could serve as an example for future planning of action on climate change).

7.3 STRENGTHENING INSTITUTIONAL ARRANGEMENTS

Based on the institutional analysis of the water supply and sanitation sector that was undertaken for this project there are a number of actions that could be taken to strengthen the institutional arrangements for the sector and thereby enhance the effectiveness of future action to tackle climate change. At present, the mandate given to the DWSS and DoLIDAR limits the scope of their activities to implementation of urban and semi-urban WATSAN schemes only. These agencies also have a secondary responsibility to facilitate rural WATSAN scheme implementation.

7.3.1 Staffing issues

DWSS and DoLIDAR are generally staffed with civil servants with engineering backgrounds. This staff composition was appropriate when DWSS and DoLIDAR were predominantly responsible for the direct construction of WATSAN projects. However, as the modalities of project implementation have changed to facilitate more participation, community involvement and the consideration of social issues such as gender and ethnic equity, and health issues—the need for new skills and competencies has emerged. Developing the capacity to adequately address these issues and those associated with climate change will require further expansion of the range of staff employed within DWSS and DoLIDAR to include sociologists, health workers, environmentalists, and modelling/IT experts.

7.3.2 Operational Issues

Some major operational reforms that have been identified to improve the capacity of DWSS and DoLIDAR to address climate change issues have been identified and grouped into the following categories:

- **Encourage integrated water resource management approaches:** Drying of Water Source was a major problem identified during the climate change vulnerability assessments. The causes of this problem were numerous including uncontrolled construction activities upstream, deforestation and poor watershed/catchment management. This problem is likely to worsen with climate change if a more coordinated approach to spatial and development planning is not adopted. IWRM is one such approach that has a long history of application in a wide range of countries and contexts and could be particularly useful when applied in Nepal.

- **Lack of dedicated climate change-focused work teams:** At present, DWSS and DoLIDAR do not have defined sections or division to address climate change related issues and threats to water supply and sanitation systems. The establishment of dedicated climate change teams would encourage more effective government management of climate-related threats to the WATSAN sector. There is also a strong case to periodically build the capacity of WUCs with climate change issues and specific adaptation interventions. One role of dedicated climate change teams at DWSS and DoLIDAR could be to build the capacity of WUCs on climate change issues.

- **Improve coordination and coordinated program formulation:** As noted above, there is generally poor coordination between agencies responsible for WATSAN assets and programs leading to poor management outcomes and confusion amongst users with respect to water supply and sanitation service delivery. Encouraging mechanisms to harmonize program formulation and delivery may improve service delivery and improve overall capacity of agencies to tackle complex, multi-sector problems such as climate change and climate change adaptation measures. As part of this process planning sections at DWSS and DoLIDAR should be encouraged to interact regularly and share information and plans for climate change programs. The increased involvement of DWSS and DoLIDAR in the deployment of water supply and sanitation services provided by WUCs may also improve general monitoring of service delivery and the overall level of service for consumers.

- **Limited staff compared to number of WATSAN projects:** It is not uncommon for WATSAN sector engineers to be overwhelmed with responsibility for maintenance and monitoring of different water supply and sanitation schemes. During the assessments it was not uncommon to find single engineers responsible for as many as 27 to 44 individual water supply and sanitation schemes. Improved planning and increased funding is required to ensure adequate staffing to monitor and manage existing water supply and sanitation schemes.

7.3.3 Capacity Building within DWSS and DoLIDAR

Capacity within DWSS, DoLIDAR and its line agencies needs to be strengthened to enhance ability to address issues or assets under their responsibility that are affected by climate change or require climate change adaptation interventions. This capacity could take a number of forms including increased budget, new staff with technical training, monitoring & evaluation programs on asset performance, data management, research on climate change adaptation and generation of new scientific information.

Specific training to enhance performance in relation to climate change issues should include general instruction on climate change vulnerability assessment and adaptation planning, project feasibility studies and environmental impact assessment. DWSS and DoLIDAR staff will also benefit from general instruction in climate change modelling and how to interpret climate threat modelling outputs with the Department of Hydrology and Meteorology (DHM). Capacity building should also include instruction on the process that was used to formulate a WATSAN Sector Adaptation Plan of Action (SAPA). The aim of such a programme is to strengthen the institutional capacity of both DWSS and DoLIDAR to undertake a similar process of climate change vulnerability assessment and adaptation planning in the future and encourage the regular, periodic development of a sector climate change adaptation plan.

In developing future training packages on climate change for the water supply and sanitation sector it is recommended that a strong effort be made to integrate these issues into the existing training packages offered by the National Water Supply and Sanitation Training Centre.

ANNEXI: LIST OF GOVERNMENT OFFICIALS PARTICIPATING IN TIFFIN TALK & ROUND TABLE MEETINGS

A) Department of Water Supply and Sewerage (DWSS)

S.N	Name	Position/Organization
1	Mr. Ram DEEP Saha	Director General, DWSS
2.	Mr. Sunil Kumar Das	Deputy Director General, DWSS
3.	Mr. Ram Lakhan Mandal	Deputy Director General, DWSS
4.	Mr. Jyoti Kumar Shrestha	Deputy Director General, DWSS
5	Mr. Khom Bdr. Subedi	Then Deputy Director General, DWSS
6	Mr. Ram Chandra Devkota	Then Deputy Director General, DWSS
7	Mr. Shrawan Upadyay	Chief, Project Rehab Monit, DWSS
8	Mr. Sudarshan Bhandari	Chief, Water Quality, DWSS
9	Mr. Deepak Puri	Chief, Planning & For Aid, DWSS
10	Mr. Bipin thakur	Chief, Electro-mechanical, DWSS
11	Mr. Ujjwol Prajapati	Chief, Progress Monitoring, DWSS
12	Mr. Mohan Bdr. Karki	Chief, CCA & RWH, DWSS
13	Mr. Hari Narayan Niraula	Chief, Account, DWSS
14	Mr. Nanda Bdr. Khanal	SDE,CSEIU, DWSS
15	Ms. Binu Bajracharya	SDE, DWSS
16	Mr.Laxmi Nath Nepal	SDE, DWSS
17	Mr. Purna Jwarchan	SDE, DWSS
18	Mr. Keshab Shakya	SDE, DWSS
19	Mr. Hari Pd. Pandey	SDE, DWSS
20	Mr. Narayan Pd. Acharya	SDE, DWSS
21	Mr. Binod Lal Thakali	SDE, DWSS
22	Mr. Ram Krishna Bhattarai	SDE, DWSS
23	Mr. Narayan Pd. Khanal	SDE, DWSS
24	Mr. Mohan Bdr. Karki	DWSS
25	Mr. Mahesh Neupane	Engineer, DWSS

S.N	Name	Position/Organization
26	Ms. Laxmi Pant	Engineer, DWSS
27	Ms. Anjana Maharjan	Engineer, DWSS
28	Mr. Ramesh Subedi	Engineer, DWSS
29	Mr. Suman Karmacharya	Engineer, DWSS
30	Mr. Arun Kumar Karna	Engineer, DWSS
31	Mr. Gunanidhi Pokharel	Engineer, DWSS
32	Ms. Jyoti Tamang	Engineer, DWSS
33	Mr. Han Heijnen	TL, SEIU, DWSS
34	Dr. Mahesh Bhattarai	PMC, SSTWSSSP
35	Mr. Tivesh Pd. Khatri	DPD, SSTWSSSP
36	Mr. Jwala Raj Shahi	Enginner, DWSS
37	Ms. Jane Nichols	Volunteer, DWSS

B) Department of Local Infrastructure and Agriculture Roads (DOLIDAR)

S.N	Name	Position/Organization
1	Jeevan Kumar Shrestha	DG, DoLIDAR
2	Bhim Pd Upadhyaya	Then DG, DoLIDAR
3	Ram Krishna Sapkota	DDG, DoLIDAR
4	Jeevan Guragain	SDE,DoLIDAR
5	Madhav Bhattarai	SDE,DoLIDAR
6	Ashok Kumar Jha	DE,DoLIDAR
7	Surya Bahadur Singh	Climate Change Management Specialist, ADB
8	Bhupendra Lal Shrestha	SDE , DoLIDAR
9	Kumar Thapa	SDE,DoLIDAR
10	Amrit Shrestha	SDE, DoLIDAR
11	Punya Ram Sulu	Engineer,DoLIDAR
12	Bhagwan Shrestha	Officer,DoLIDAR
13	Siddheswor Shrestha	Engineer, DoLIDAR
14	Sudina Kuikel	Engineer,DoLIDAR
15	Smita Sharma	Engineer, DoLIDAR
16	Shova Shrestha	Engineer,DoLIDAR

S.N	Name	Position/Organization
17	Thalbir K.C	SDE, DoLIDAR
18	Hari Pd Pokharel	S.O,DoLIDAR
19	Sagar Nepal	Engineer,DoLIDAR
20	Ishwor Marahatta	Engineer, DoLIDAR
21	Ashesh Regmi	Engineer, DoLIDAR
22	Maheswori Khadka	Engineer, DoLIDAR
23	Mahesh Pd Yadav	Engineer, DoLIDAR
24	Rajesh Sharma	Senior Engineer, DoLIDAR
25	Rishi Acharya	Under-Secretary, DoLIDAR
26	Badri Pd Dhungel	Engineer, DoLIDAR
27	Ram Sharan Acharya	Engineer, DoLIDAR
28	Ganga Bdr Basnet	SDE, DoLIDAR
29	Laxman Shrestha	Asset Mgmt Engineer, DoLIDAR
30	Shova Manandhar	SDE, DoLIDAR
31	Bishnu Pd Shah	Deputy Team Leader /DRSP/ DRICP-CISC
32	Uma Shankar Sah	SDE, DoLIDAR
33	Bibek Ghimire	Engineer, DoLIDAR
34	Prtiha Chudal	Engineer, DoLIDAR
35	Shankar Pd Pandit	SDE, DoLIDAR

ANNEX II: BIBLIOGRAPHY

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Volume I	:	Procedural Guidelines
Volume II	:	Design Criteria
Volume III	:	Standard Drawings
Volume IV	:	Rate Analysis Norms
Volume V	:	Quantity Estimate with Schedule of Materials & Labour for Standard Components
Volume VI	:	Water Quality and Simple Treatment Units
Volume VII	:	Formats for Project Documentation
Volume VIII	:	Operation and Maintenance Manual: Policy & Procedures
Volume IX	:	Operation and Maintenance Manual: Reference Manual
Volume X	:	General Specifications
Volume XI	:	Guidelines for Tubewell Program a. Community Based Shallow Tubewell b. Pumps
Volume XII	:	Pipe Fittings Requirements and Details