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WATSAN VULNERABILITY ASSESSMENT REPORT

BANKE DISTRICT

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Prepared for	Ministry of Science, Technology and Environment, Government of Nepal Environment Natural Resources and Agriculture Department, South Asia Department, Asian Development Bank
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1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Banke District WATSAN Infrastructure

The Banke district is surrounded by Dang district and Indian State of Uttar Pradesh in the east, Bardiya district in the west, Dang and Salyan districts in the north and Uttar Pradesh state of India in the south. It is made-up of 1 Municipality and 46 Village Development Committees (VDCs).

Topographically Banke district can be divided into three parts Tarai plains, Bhabar area in the north and Churia hills. Being a part of plain Tarai area and with flat topography its climate is sub-tropical and hence is relatively warm most of the time except in winter when the weather gets fairly cold with temperature as low as 10ºC with foggy days. The average maximum temperature in the district exceeds 40ºC sometime and thus this district is known to be the hottest in whole of Nepal. Similarly, the average maximum annual rainfall is 1,500 mm and minimum annual is 1,000 mm.

Rapti River is one of the largest rivers in Nepal and it flows through Banke district along with other small rivers such as Man khola, Duduwa khola, Gethi nala, Rohini khola, Jhijhiri khola, Muguwa khola *etc*. Due to its close proximity to India and the connections to different districts in the country by good roads, Banke district is fast growing as an industrial district with many light industries being already established in the area.

Banke district does not possess any water supply and sanitation sector master plan yet. The coverage of piped water supply in the district as per Banke District Profile document of 2070/71 BS(2013/14 AD) is 91.20% and that of sanitation is 42.59%. There is no conventional sewerage system anywhere in the district yet. Hotels, large private houses and public buildings in the district have septic tanks while other small households have dry pit latrines or pour flush latrines with two or single pit.

Basically, the District water supply and sanitation system comprises of the following infrastructure:

- Spring fed stream Intakes of different types
- Transmission Pipes: Mainly HDPE pipes with GI/DI pipes in some places except in Nepalgunj municipality where the water pipelines are of DI, GI pipes.
- Distribution Reservoirs mainly Random Rubble(RR) Masonry or Ferro Cement Type or RCC
- The Reservoirs are mostly semi - underground and in case of urban water supply systems they are RCC Overhead Tanks.
- Break Pressure tanks: They are made of RR masonry
- Distribution Pipes: mainly HDPE pipes
- Public stand Posts: RR masonry types
- Sanitation system comprised of septic tanks and pit latrines

1.2 Criteria for Priority Assets & VA

1.2.1 VA Criteria

Climate change vulnerability in the water supply and sanitation context is a function of a WATSAN asset system's exposure to climate effects, sensitivity to climate effects, and adaptive capacity.

- Exposure refers to whether the asset or system is located in an area experiencing direct impacts of climate change, such as temperature and precipitation changes, or indirect impacts, such as rise in flood levels.
- Sensitivity refers to how the asset or system fares when exposed to an impact.
- Adaptive capacity refers to the systems' ability to adjust to cope with existing climate variability or future climate impacts

1.3 Priority Assets

Based on the VA criteria, 2 urban water supply systems; 2 rural water supply systems and 1 urban/rural septic tank and pit-latrine system have been selected as priority assets in Banke District. The detailed information on each asset is outlined in the baseline report for Banke district. Brief discussion on the asset and its components are outlined below:

1.3.1 Nepalgunj WS System - Urban

Nepalgunj Water Supply System serves mainly the jurisdiction of Nepalgunj Municipality and some peripheral areas. Nepalgunj is the headquarters of Banke district and Bheri Zone.

Nepalgunj water supply system was first constructed in late 1960 and early 70's with the support of Indian Government. Later it was extended and improved under World Bank project in 1980's and the existing system is the remnant of what was done during the World Bank project with minor improvements. Besides the existing piped water supply system; many people still use shallow hand pump water and some dug well water as an alternative source of water supply. The shallow hand pumps are usually 20-30 feet deep and are very vulnerable to pollution due to surface water runoff.

Nepalgunj water supply system is slightly vulnerable to climate change threats due to the following facts:

- Firstly, as mentioned in the above district introduction section, Nepalgunj is one of the hottest places in Nepal; climate change induced threat such as increased temperature will have huge impact on the Nepalgunj's groundwater supplies (expected depletion of water) which are the primary source of water supply system in this district;
- Secondly, since the drainage system within Nepalgunj is not robust; frequent flooding and overland flow conditions were noticed. In addition to this, overflows from the existing unconventional septic tanks are also a frequent nuisance and is a huge contributor to the ground water contamination and seepage into the leaked sections of water supply system. It is also anticipated that due to the increased temperature, more cracks to the pipe system and leakages can be foreseen.

In view of the above, the groundwater source and the distribution / transmission lines are considered to be the vulnerable assets of Nepalgunj WS System.

1.3.2 Kohalpur WS System - Urban

Kohalpur water supply system serves the settlements of Kohalpur Township which consists of Wards 1, 2, 3 and 4 of Kohalpur VDC and Wards of Rajena VDC in Banke district. The present water supply system was constructed under ADB funded Small Towns Water Supply Project in 2065 BS (2008/9 AD). The water supply system is managed by locally constituted Kohalpur Water Supply Users' Committee.

Since the system was installed recently, there were no pipe leakages were identified that might attract intrusion of surface water runoff coupled with overflows from septic tanks. However, the primary water source is the ground water supplies from the deep tube-wells of 200-250 m deep may experience lowered groundwater table due to the rise in temperature as a result of climate change. In view of the above, the groundwater source considered to be the vulnerable assets Kohalpur WS System.

1.3.3 Banke Pit Latrine System – Rural & Urban

The recent site visit and consultation with the local authorities has suggested that pit latrine facilities are most widely used in Lower and Upper Banke. The type of pit latrine used in Banke is usually just a hand dug hole in the ground covered with a concrete slab fitted with a riser and seat surrounded by a superstructure around it. There was no single event that demonstrates that these sanitation facilities were affected by any of the CC 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 and causes public health and hygiene issues.

Banke catchment has very limited interaction with the groundwater and its fluctuation with rainfall events. The majority of the existing pit latrines have been constructed on a rock bed which limits the interaction with the groundwater movement under rainfall events. This means, the pit latrines are free from CC threat such as increased rainfall. But the increased rainfall in the region will attract frequent overflows from the pit latrines/septic tanks that might seep through the cracks within the piped water system and cause severe water contamination that might trigger water borne diseases.

In view of the above, the existing pit latrines are considered to be vulnerable under severe both increased temperature and increased rainfall events.

1.3.4 Khokari WS System - Rural

Khokari water supply system serves Khokari village which makes Ward 9 of Khaskusma VDC in Banke District. Khaskusma VDC is one of the largest VDCs in terms of area in Banke district and located in the southern part touching Dang district.

The water source of Khokari water supply system is a small spring fed stream which is located nearby mountains close to Khokari village. The supply system has a permanent intake structure fitted with small dam/weir across the stream and perforated pipes laid underneath the stream bed. There is no human settlement on the upstream of the intake that might have an impact on the quality of water; however the water collection point is open to pollution from the movement of human and domestic animals going to the forest which is on the upstream part of intake. The transmission pipeline from the intake passes along the stream flow with many crossings at various locations along the stream which might attract submergence of pipeline under increased water level scenario.

In view of the above, the existing intake and transmission pipelines are considered to be vulnerable under increased rainfall and water level in the streams.

1.3.5 Bhamka WS System - Rural

Bhamka water supply system serves the village of Bhamka which makes Ward 5 of Khaskusma VDC in Banke District. Bhamka is a village located on the left bank of Rapti River and is located in the slope of a Churia type mountain range with very limited plain areas.

Bhamka water supply system is slightly vulnerable to climate change threats due to the following facts:

- Firstly, groundwater is the main source of water supply and is accessed through a dug well of 10-15 meters deep. Due to the increased temperature events occurring more frequently for prolonged durations; depletion of groundwater can be foreseen. Reduced flow in Rapti River will also have negative contribution to the recharge of groundwater levels.

- Secondly, majority of the dug wells are located along the banks of Rapti River which are 100 m away. In the event of increased flow induced by increased by rainfall, the existing dug wells will experience complete submergence and filled with sediments.

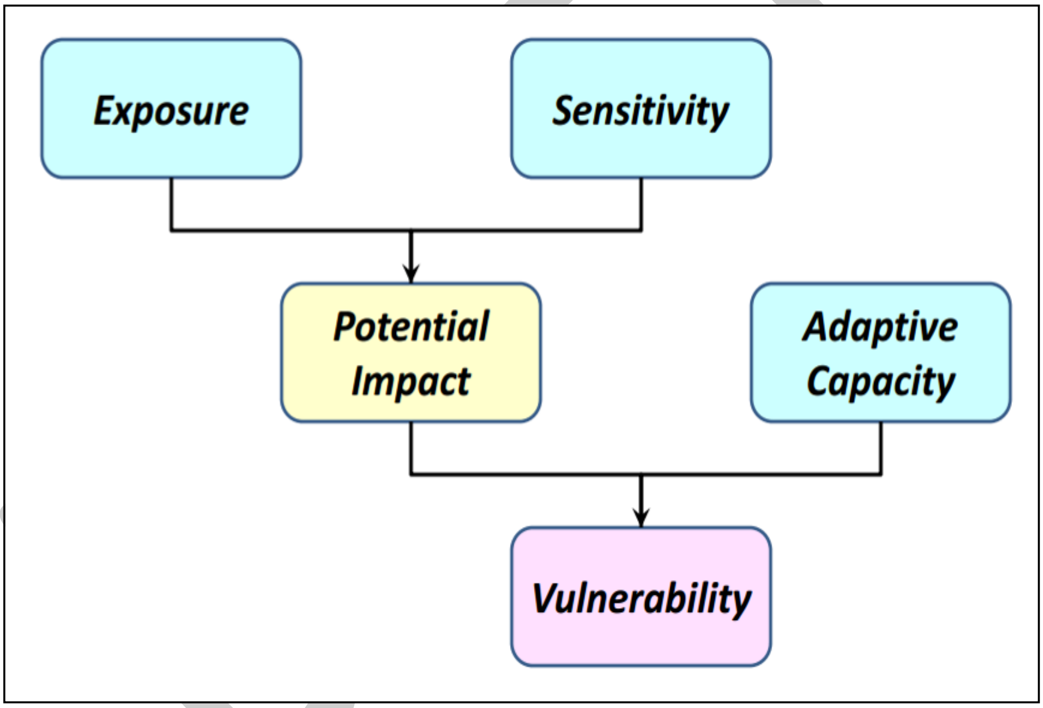
In view of the above, the existing dug-wells are considered to be vulnerable under increased temperature and rainfall scenarios.

2 VULNERABILITY ASSESSMENT METHOD

2.1 VA Method

The VA method followed to assess the vulnerability of water and sanitation asset is widely used technique and tested in several parts of the world:

Figure 2-1: VA Process



<u>Exposure</u> refers to the extent to which an asset comes into contact with climate conditions or specific climate impacts. The greater the exposure, the higher the sensitivity to climate change. For example, assets located in historic landslide zones are more exposed and therefore more sensitive to increased rainfall and localized flood waters. The exposure also takes in to account the critical aspects such as the location of asset, intensity and duration of the climate threat towards the asset and the magnitude of the event.

<u>Sensitivity</u> 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). If a system is likely to be affected as a result of projected climate change, it should be considered sensitive to climate change. It takes in to account the age of the asset, materials used in the construction and its quality, levels of maintenance, any design considerations that protects the asset from any extreme climatic events.

Impact: Once the exposure and sensitivity assessment are performed, based on the assessment the severity of the impact is estimated using the guiding matrix as shown below:

Figure 2-2: Determining Impact

	Exposure of system to climate threat					
Sensitivity of system to climate threat		*Very Low*	*Low*	*Medium*	*High*	*Very High*
	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 availability of a system to accommodate or cope with climate change impacts 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 polices that make such adaptation to happen and the locally available materials to address such adaptation.

Vulnerability Scoring: Based on the impact and adaptive capacity assessments, the vulnerability of the asset against the CC threats is estimated using the guiding matrix as shown below:

Figure 2-3: Determining Vulnerability

		Impact				
Adaptive Capacity		*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*
	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*

2.2 Suitability of VA Method to WATSAN Sector

The approach used for this vulnerability assessment is based on the methodological guidelines prepared by UNEP and Peking University (UNEP, 2009) and are in line with the international VA processes that are widely used in several projects across the globe.

Vulnerability assessment is a tool for identifying potential risks to water resources and sanitation facilities, providing decision-makers with an early warning signal about the need to monitor potential variation over time. This is important in detecting threats early as well as formulating and implementing measures to reduce negative impacts. Vulnerability assessment of water resources and sanitation facilities will also identify gaps in existing information and the appropriate indicators and management measures required for the government to gather such information. Moreover, the assessment enhances public awareness about potential threats.

The current vulnerability assessment process followed for WATSAN sectors is to better understand the existing status of water and sanitation system under the prevailing conditions and to ascertain the most dominant factors that influence vulnerability. The current process helps the decision-makers with options to evaluate and modify existing policies and to implement measures to improve water resource management and sanitation facilities. Specifically, the assessment is suitable and aims the WATSAN issues such as:

- Assess the vulnerability of existing freshwater resources to threats and sanitation facilities that are prone CC threats, and its impact on development options, human well-being and the environment;
- Identify the potential impacts of climate change on WATSAN and ecosystems, and assess the current adaptive capacity of the national water sector;
- Create a knowledge base of scientific data and information on available surface and groundwater sources and the water demand of each sector;

- Evaluate the impacts of environmental change in terms of water resource stress and identify management challenges such as identifying alternative sources;
- Develop the knowledge, policy options;
- Identify gaps in data and research and recommend needs for further studies; and
- Examine water and sanitation issues and functions in selected surface and groundwater basins.

2.3 Climate Change Threat Profiles

The climate change threat profiles for Banke District were prepared by the Hydrological Modeling teams and the information had been passed on to all the experts prior to the field visit. The threat profile is annexed in Annexure 1. The climate change threat profiles for Banke were studied and their relevance to the WATSAN sector is outlined below:

2.3.1 Increase/decrease in precipitation

Looking in to the threat profile for precipitation the following conclusions can be drawn:

- Increasing number of extreme rainfall events – events that now occur every 50 years are projected to occur every 35 years
- Duration of extreme rainfall events with high intensity will occur more often than before.
- Increase in precipitation frequency and volume can be foreseen in future, this may trigger more landslides. Precipitation vs annual recurrence interval curve shows an increase in precipitation occurs more frequently

2.3.2 Increase in temperature

Looking in to the threat profile for temperature the following conclusions can be drawn:

- Increase in average maximum temperature of up to 2.15^{0}C in the summer.

2.3.3 Increase in flows

Looking in to the threat profile for hydrology the following conclusions can be drawn:

- Increased flows in Rapti River due to increase in rainfall is expected.
- Increasing wet season flow on the West Rapti River and earlier peak flow – at Kusum peak monthly average flow will occur one month earlier in July and increase by up to 5%
- Increasing risk and severity of flash floods and increase flood duration during wet season.

3 VULNERABILITY ASSESSMENT RESULTS

The results of the vulnerability assessment are outlined in Annexure 2 of this report. However, a brief vulnerability assessment of three assets within Banke District is outlined below:

3.1 Nepalgunj WS System – Groundwater & Pipelines

3.1.1 Asset Description

The following table describes the important aspects of the Nepalgunj Water Supply System. Below Figures illustrates the condition of source and the transmission pipelines and why they are vulnerable to CC threats.

Source	**Groundwater**
Asset Age	Over 30 years

Operator	Nepalgunj Municipality
Source	5 tube-wells; 4 in operation and 1 not in operation
Transmission Pipeline	DI, GI and CI pipes
Water Treatment Plant	None

Figure 3-1 Deep-tube wells of Nepalgunj WS System

Figure 3-2 Pipe leakage and cross-contamination area

3.1.1 Vulnerability assessment on Nepalgunj WS System Source & Pipelines

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Nepalgunj water supply system.

3.1.1.1Threat – Increased Intensity of Rainfall

Threat: Increased Intensity of Rainfall

The following threats have been identified as likely to impact on the water supply system:

- As per the threat profile (see Annexure 1), on an average rainfall intensities will increase by 65%
- Rainfall events occur more frequently than before.
- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years
- Brings more septic tank overflows and allows the seepage of contaminated water through the cracks of transmission pipelines system

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- The pipelines are not repaired and not leakage-proof.
- Assets (transmission pipelines) are running along the unprotected sanitation system which is prone to frequent overflows and cross-contamination under any rainfall event.
- Duration: Longer duration rainfall events and causing more frequent overflows from septic tanks/pit latrines for prolonged duration throughout the year.
- Intensity: High intensity occurs more frequently this will enhance more frequent intrusion of contaminants in to transmission pipelines.

Sensitivity: HIGH

The sensitivity is ranked as high for the following reasons:

- No good protective measures were in place such as replacement of leaked sections of pipe system or diversion of overflows through a closed pipe system.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- More rain will lead to more flows that trigger more overflows from the septic tanks/pit latrines.
- More rain means, more cross-contamination.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as medium for the following reasons:

- Limited funds available for repairs or replacement of pipelines.
- Additional manpower and technical support can be achieved through the municipality.
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the municipality.

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Nepalgunj WS System is HIGH.

	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

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3.1.1.2 Threat – Increased Temperature

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the source and transmission pipeline.

Threat: Increased temperature

The following threats have been identified as likely to impact on the source point and transmission pipeline:

- Increase in average maximum temperature of up 2.15 °C in the summer

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- Duration: Increased temperature (up to 1.7^{o}C) with longer duration and more frequency is a threat to the groundwater.
- The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source.
- Increase in temperature will have an impact pipe material and cause cracks that might attract more cross-contamination.

Sensitivity: MEDIUM

The sensitivity is ranked as medium for the following reasons:

- The material, design and construction of the groundwater source site have no impact since it is a natural system.

- The pipe material is HDPE which is very robust for extreme temperature conditions; however, the construction and laying practices by unskilled workers in Nepal might pose threat to early cracks if improper coating material is used during the laying process.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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.
- Increase in temperature will have an impact on the pipe material and cause cracks that might attract leakage which eventually contributes to Non-Revenue Water and cross-contamination from frequent overflows from septic tanks.

Adaptive Capacity: HIGH

The adaptive capacity was ranked as medium for the following reasons:

- Additional manpower and technical support can be achieved through the municipality.
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the municipality.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability for the Nepalgunj WS under increased temperature event is MEDIUM.

		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*

3.2 Banke Pit Latrine System

3.2.1 Asset Description

The following table describes the important aspects of the existing Banke pit latrine system.

Area	**Sparsely populated area**
Residential type	Low to medium income group area
Type of sanitation facilities	Pit latrines (combination of dry and wet type pit latrines)
Issues with the system	Decreased biological process due to increased temperature Frequent overflow from septic tanks Could be a major contributor to groundwater and local streams (further research required to confirm)
Operator	Operated by the local water user committees

3.2.2 Vulnerability assessment on Banke Pit Latrine System

Threat: Increased temperature

The following have been identified as likely threats to impact on the biological process of organic matter in pit latrines:

- Increase in average maximum temperature of up 2.15 °C in the summer

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- Duration: Increased temperature (up to 2.15°C) with longer duration and more frequency is a threat to the decreased disintegration process by the bacteria.
- The biological process is very sensitive to the temperature and erratic increase in temperature kills the useful bacteria which are required for the disintegration of organic matter.

Sensitivity: MEDIUM

The sensitivity is ranked as medium for the following reasons:

- The material, design and construction techniques are not directly impacted by the increased temperature.
- No incidents have been recorded in the past in terms of failure of system or any outbreak of any diseases out of bad sanitation.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- Due to the increased temperature, the good bacteria die as the biological process is temperature sensitive; this leaves the organic matter to stay in the system for prolonged period which might cause serious health issues due to the unhygienic activities.
- Children are most vulnerable and affected by mal-areas thus increasing the chances for outbreak of any serious diseases.

Adaptive Capacity: HIGH

The adaptive capacity is ranked as high for the following reasons:

- The organization is technically and financially capable to upgrade the existing pit latrine system to conventional septic tank system.
- The local authorities have good capacity in conducting community awareness programs on public health and better hygiene practices in sanitation sector.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability for the Banke pit latrine system is MEDIUM.

		Impact				
Adaptive Capacity		*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*
	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*

Threat: Increased Intensity of Rainfall

The following threats have been identified as important for the Banke residential sanitation system:

- Rainfall events occur more frequently than before
- Increased number of spill/overflow events from pit latrines
- Increased frequency of overflow from pit latrines
- Increased volume of overflow from pit latrines

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Location: Residential area located in the medium – high intensity rainfall zone
- Duration: Longer duration rainfall events occur more frequently
- Intensity: High intensity rainfall occurs more frequently
- Aspect: South facing slope brings more rainfall runoff in to the site

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Location: Residential area located in the medium – high intensity rainfall zone
- Duration: Longer duration rainfall events occur more frequently
- Intensity: High intensity rainfall occurs more frequently
- Aspect: South facing slope brings more rainfall runoff in to the site

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- ST's fail to function efficiently and effectively.
- More frequent overflows can be observed due to increased precipitation.
- More frequent pollution to the nearest streams.
- Public and children will come in contact with the sewage more frequently.
- Increases the health risks to the residents.
- Increased health care costs and burden on the public health system due to increased visits by sick public.
- Decreased life expectancy due to increased morbidity and child mortality.
- Increased sick leave and lower work productivity.
- Decreased school attendance
- Decreased tourism.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as high for the following reasons:

- The local authority has limited funds for development projects.
- Technical capabilities are readily available within the authority
- Local construction material readily available
- Community volunteers are available to support during any crisis.

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability is HIGH.

		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*
19/08/11	*Very High* *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	Fiji *Low*	*Low*	*Medium*	*High* 11

3.3 Kohalpur WS System – Tubewells

3.3.1 Asset Description

The following table describes the important aspects of the Kohalpur Water Supply System. Below figures represent the components of Kohalpur WS system.

Asset Age	**6 years**
Operator	Kohalpur Water Supply Users' Committee
Source	6 deep-tube wells; 3 in operation and 3 on stand-by
Water Treatment Plant	Yes – Lime removal

Figure 3-3 RCC overhead tank in Kohalpur

Figure 3-4: Kohalpur WTP

3.3.2 Vulnerability Assessment on Kohalpur WS Source

The following sections outline the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Kohalpur water supply system.

3.3.2.1Threat – Increased Temperature

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the source.

Threat: Increased temperature

The following threats have been identified as likely to impact on the source point:

- Increase in average maximum temperature of up 2.15 °C in the summer

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- Duration: Increased temperature (up to 2.15°C) with longer duration and more frequency is a threat to the groundwater source.
- The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source.

Sensitivity: MEDIUM

The sensitivity is ranked as medium for the following reasons:

- The material, design and construction of the source site have no impact since it is a natural groundwater system.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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.

Adaptive Capacity: HIGH

The adaptive capacity is ranked as high for the following reasons:

- The organization is technically and financially capable to manage the problems.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability for the source is MEDIUM.

		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

3.4 Khokari WS System – Intake Point & Pipelines

3.4.1 Asset Description

The following table describes the important aspects of the Khokari Water Supply System. Below Figures illustrates the condition of source and the transmission pipelines and why they are vulnerable to CC threats.

Source	**Groundwater**
Asset Age	Over 15 years
Operator	Khokari Water Supply Users' Committee
Source	Tubewells
Transmission Pipeline	Combination of HDPE and GI pipes
Water Treatment Plant	None

Figure 3-5: Khokari Intake Point

Figure 3-6: Khokari transmission pipeline

Figure 3-7: Khokari transmission pipeline exposed along stream bank

Figure 3-8: Khokari transmission pipeline exposed to open environment

Figure 3-9: Khokari transmission pipeline exposed to open environment

3.4.2 Vulnerability assessment on Khokari WS System Source & Pipelines

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Khokari water supply system.

3.4.2.1Threat – Increased Intensity of Rainfall

Threat: Increased Intensity of Rainfall

The following threats have been identified as likely to impact on the water supply system:

- Rainfall events occur more frequently than before.
- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years
- Increased risk to source and transmission pipelines

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- The source and pipelines are not protected from threats.
- Assets (source point and transmission pipelines) are exposed and in the event of increased flow due to increased rainfall, both source and pipelines will disappear.
- Duration: Longer duration rainfall events will cause long-term damage to the assets due to prolonged duration throughout the year.
- Intensity: High intensity occurs more frequently.

Sensitivity: HIGH

The sensitivity is ranked as high for the following reasons:

- No good protective measures were in place such as protection to source and transmission pipelines.
- Material: Transmission pipelines are of HDPE
- Design & Construction: Poorly laid transmission pipelines

- Levels of Maintenance: Poorly maintained transmission pipelines
- Protective measures: No protective measures for transmission pipelines provided

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- More rain will lead to more flows that trigger severe damage to the source and the transmission pipelines.
- Under severe storm condition, increased flow would trigger more flows that would damage/in some cases the transmission pipeline may collapse.
- Due to the sudden collapse of pipeline, disruption to water supply services can be foreseen to the general public.
- Public and others to rely on private water supply arrangement that would cost more money to the end-user.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as medium for the following reasons:

- Limited funds available for repairs or replacement of pipelines.
- Additional manpower and technical support can be achieved through the municipality.
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the municipality.

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Khokari WS System is HIGH.

		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

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3.5 Bhamka WS System – Groundwater & Pipelines

3.5.1 Asset Description

The following table describes the important aspects of the Bhamka Water Supply System. Below Figures illustrates the condition of source and the transmission pipelines and why they are vulnerable to CC threats.

Source	**Groundwater – deep tube-wells**
Asset Age	Over 30 years
Operator	Bhamka Municipality
Source	5 tube-wells – pumping through solar energy
Transmission Pipeline	HDPE
Water Treatment Plant	None

Figure 3-10 Deep-tube wells with solar panels

Figure 3-11 Exposed pipelines – not protected

3.5.2 Vulnerability assessment on Bhamka WS System Source & Pipelines

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Bhamka water supply system.

3.5.2.1Threat – Increased Intensity of Rainfall

Threat: Increased Intensity of Rainfall

The following threats have been identified as likely to impact on the water supply system:

- Rainfall events occur more frequently than before.
- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years

Exposure: LOW

The exposure was ranked as low for the following reasons:

- Location: The existing groundwater sources across the catchment are exposed to high intensity rainfall
- Duration: Longer duration rainfall events occur more frequently within the asset area
- Intensity: High intensity rainfall occurs more frequently
- Aspect: Steep slopes brings more rainfall runoff that triggers the groundwater to recharge

Sensitivity: LOW

The sensitivity was ranked as low for the following reasons:

- Material: natural ground
- Design & Construction: groundwater sources, no design and construction
- Levels of Maintenance: None required
- Protective measures: No protective measures required

Impact: LOW

From the guiding matrix, it can be seen that the impact is LOW. The justification for low impact is as follows:

- Under severe storm condition, increased flow would bring more water to the catchment and the rain water gets absorbed by the soil and eventually recharges the ground water.
- Increases the water security over long-term.
- Businesses and industries secure uninterrupted water supplies due to the increased water recharge.
- Public and others can positively rely on government water supply arrangement that would cost less money to the end-user.

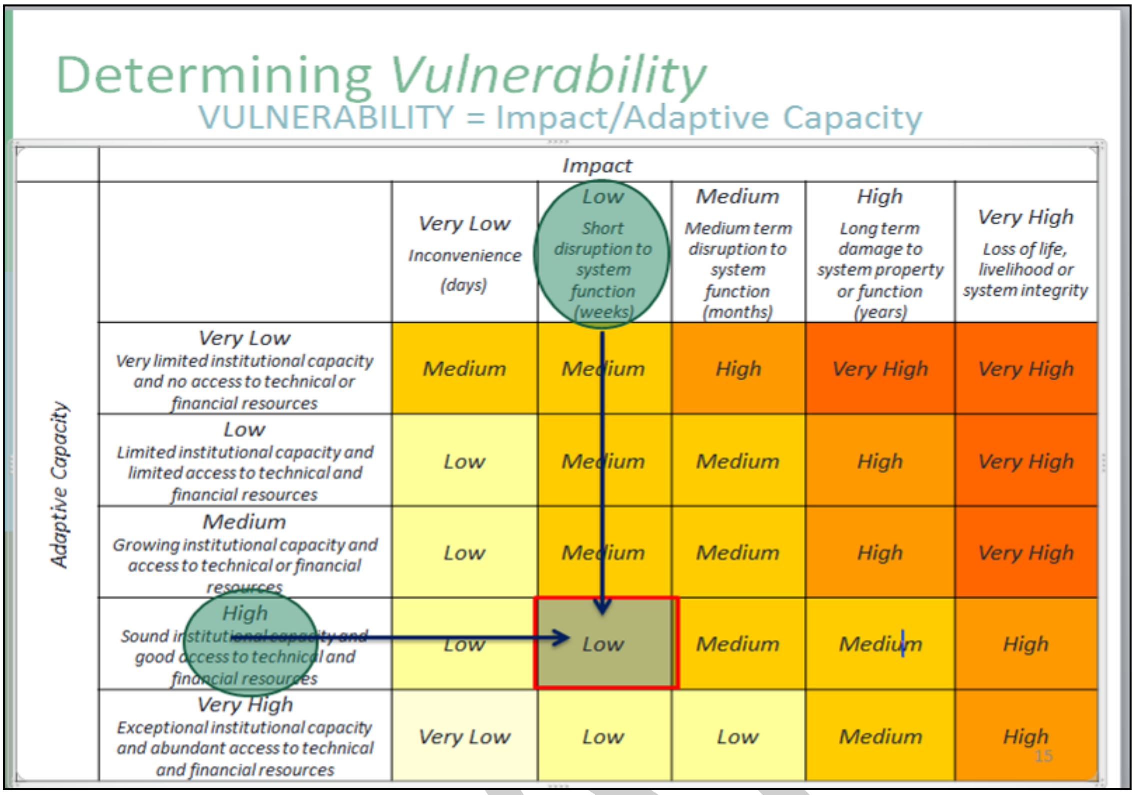
Adaptive Capacity: HIGH

The adaptive capacity was ranked as high for the following reasons:

- The local authorities are provided with adequate funds for development projects
- Advanced technical capabilities are readily available through local consulting firms

Vulnerability Scoring: LOW

As per the below guiding matrix, the positive vulnerability for the Bhamka WS system is LOW.



Adaptive Capacity \ 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
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

3.5.2.2Threat – Increased Temperature

The following threats have been identified as likely to impact on the groundwater sources:

- Increased temperature may deplete the groundwater recharge due to the increased evaporation process
- The groundwater aquifer is predominantly influenced by the level in the Rapti River, this means, due to the increased temperature, the level in the River goes down and eventually depleted groundwater scenario can be observed
- Increased temperature also makes the upper soil to become drier and when it receives the rainwater, the upper soil takes large amount of rainwater to reach the percolation or infiltration state. This means, less water percolates through the soil and retards the groundwater recharge.

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the source and transmission pipeline.

Threat: Increased temperature

The following threats have been identified as likely to impact on the source point and transmission pipeline:

- Increase in average maximum temperature of up 2.15 °C in the summer

Exposure: HIGH

The exposure is ranked as high for the following reasons:

- Duration: Increased temperature (up to 2.15°C) with longer duration and more frequency is a threat to the groundwater.
- The material, design and construction (in all sources) are not having any effect on the sensitivity of the groundwater sources.
- The most likely factor affecting the sources is the underground condition of the recharge system and other conditions that help to hold the water in the roots and sub-soil. There is a need to further investigate in detail to identify the underlying factors that caused the sources to dry up and less recharge this year.
- The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source.
- Increase in temperature will have an impact pipe material and cause cracks that might attract more cross-contamination.

Sensitivity: MEDIUM

The sensitivity is ranked as medium for the following reasons:

- The material, design and construction of the groundwater source site have no impact since it is a natural system.
- The pipe material is HDPE which is very robust for extreme temperature conditions; however, the construction and laying practices by unskilled workers in Nepal might pose threat to early cracks if improper coating material is used during the laying process.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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.
- Increase in temperature will have an impact on the pipe material and cause cracks that might attract leakage which eventually contributes to Non-Revenue Water and cross-contamination from frequent overflows from septic tanks.

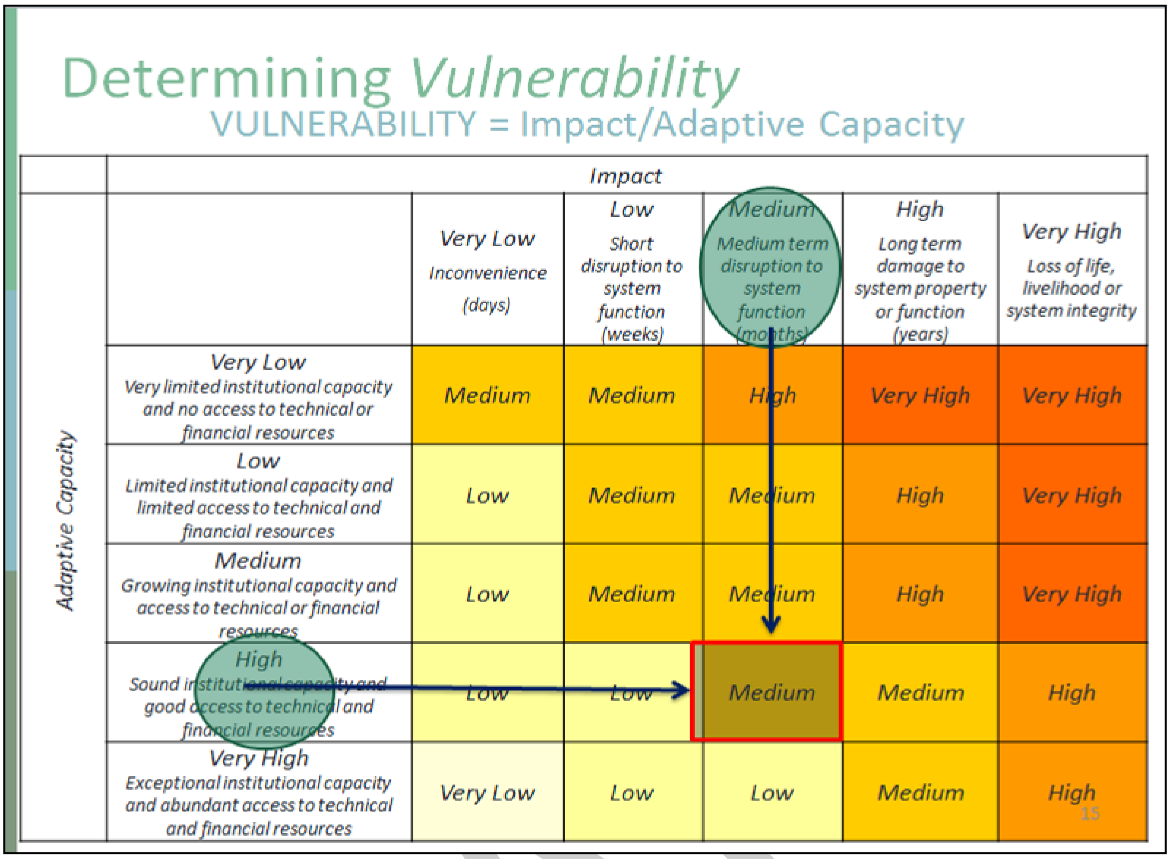
Adaptive Capacity: HIGH

The adaptive capacity was ranked as medium for the following reasons:

- Additional manpower and technical support can be achieved through the municipality.
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the municipality.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability for the Bhamka WS under increased temperature event is MEDIUM.



4 BANKE DISTRICT VULNERABILITY SUMMARY

4.1 Summary of VA Results

4.1.1 Nepalgunj WS System

The table below summarises the vulnerability assessment of the Nepalgunj WS system. The analysis shows that the most vulnerable components of the system are the source and the transmission pipelines and are ranked as high – medium for various climate change threats.

NEPALGUNJ WS SYSTEM					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

4.1.2 Banke Pit Latrine System

The table below summarises the vulnerability assessment of the Banke Pit Latrine System. The analysis shows that the current sanitation practice is ranked as medium vulnerability to increased temperatures and high vulnerable under increased rainfall scenario.

BANKE PIT LATRINE SYSTEM					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

4.1.3 Kohalpur WS System

The table below summarises the vulnerability assessment of the Kohalpur WS System. The analysis shows that the most vulnerable components of the system are the source and the transmission pipelines and are ranked as high for increased temperature scenario.

KOHALPUR WS SYSTEM					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

4.1.1 Khokari WS System

The table below summarises the vulnerability assessment of the Khokari WS System. The analysis shows that the system vulnerability is ranked as high for increased rainfall scenario.

KHOKARI WS SYSTEM					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**

4.1.1 Bhamka WS System

The table below summarises the vulnerability assessment of the Bhamka WS System. The analysis shows that the system vulnerability is ranked as low for increased rainfall scenario and medium for increased temperature.

BHAMKA WS SYSTEM					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	LOW	LOW	LOW	HIGH	**LOW**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

4.2 Most Vulnerable Assets and its Components

Based on the VA performed within Banke District, the following conclusions can be made on the assets and their components:

Nepalgunj WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased Rainfall and Increased temperature	More rainfall and frequent High temperatures occur more frequently and for longer durations	Impacts the operation of intake and damages the transmission pipelines more frequently. Increase in temperature accelerates the process of drying up of sources and causes cracks in the transmission pipelines.	Damages and collapse of source point and the transmission pipelines causes' serious disruption to water supplies to the residents of Banke. Increased flows bring more contaminants to the source and cause serious health issues to the consumers. In addition to this, increased temperature dries

			up the sources and reduces the life span of the pipelines through cracks which attracts more leakage and contributes to large non-revenue water.

Banke Pit Latrine System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased temperature	High temperatures will occur more frequently and for longer durations.	Decreases the biological process of organic matter disintegration due to the killing of useful bacteria.	It causes serous public health and hygiene issues and accelerates the spreading of diseases due to bad sanitation facilities.
Increased Rainfall	On an average rainfall intensities will increase. Rainfall events occur more frequently	Frequent overflows from the septic tank that may overflow through the streets and also pollutes the groundwater and the nearby streams	Frequent overflows from septic tank causes public health and hygiene issues.

Kohalpur WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased temperature	High temperatures occur more frequently and for longer durations	Increase in temperature accelerates the process of drying up of sources and causes cracks in the transmission pipelines.	Increased temperature dries up the sources and reduces the life span of the pipelines through cracks which attracts more leakage and contributes to large non-revenue water.

Khokari WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased rainfall	More rainfall and frequent	Impacts the operation of intake and damages the transmission pipelines more frequently.	Damages and collapse of source point and the transmission pipelines causes' serious disruption to water supplies to the residents of Banke. Increased flows bring more contaminants to the source and cause serious health issues to the consumers

Bhamka WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased Rainfall and Increased temperature	More rainfall and frequent High temperatures occur more frequently and for longer durations	Impacts the operation of intake and damages the transmission pipelines more frequently. Increase in temperature accelerates the process of drying up of sources and causes cracks in the transmission pipelines.	Damages and collapse of source point and the transmission pipelines causes' serious disruption to water supplies to the residents of Banke. Increased flows bring more contaminants to the source and cause serious health issues to the consumers. In addition to this, increased temperature dries up the sources and reduces the life span of the pipelines through cracks which attracts more leakage and contributes to large non-revenue water.

4.3 Lessons and Application to Other Assets

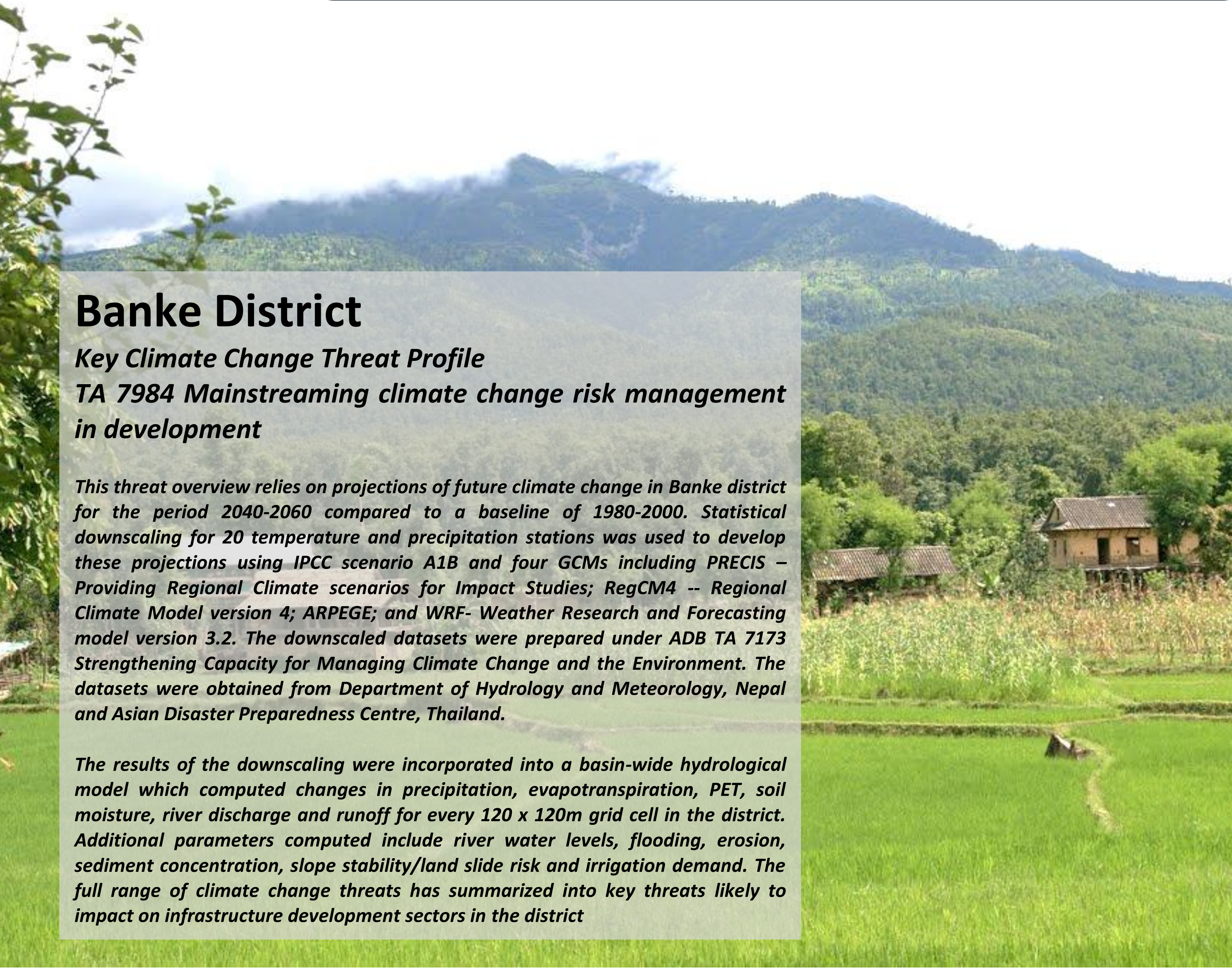
Banke district has both urban and rural culture. The district has both rural type and urban type water supply system that gives an opportunity to understand the impacts of CC threats on both type of assets. The district has gravity water supply system with simple ancillary structures that are vulnerable to various CC threats.

Since the similar type of infrastructure can be seen across the district, this means, the same impacts, vulnerability and adaptation plans can be applied to wider urban and rural areas within the district. Majority of the water supply systems are experiencing similar sort of exposure, sensitivity towards the CC threats and the adaptive capacity of the local authorities towards emergency management is more or less the same. This means, one asset in each sector and one assessment with varied CC threats can be applied in similar sector. Both water supply and sanitation sectors are struggling with lack of funds, inadequate skills and support to combat with CC related threats and events. The water supply sector is lacking control of sediments that are arriving at the source intake and reservoir system. In addition to this, some of the existing transmission pipelines are not well protected from the open environment which is extremely vulnerable to CC events.

Similarly, majority of the residents in urban and rural areas are still relying on old pit latrine system. To date, no adverse impacts due to extreme rainfall events or increase in water level in Rapti River have been recorded. However, in future, the increased temperature may impact the biological process of bacterial disintegration of human excreta which might trigger the outbreak of diseases. In view of this, Banke pit latrine system is a very good example to demonstrate the common problems, impacts and its severity on common public within the Banke district.

ANNEXES

ANNEXURE 1: THREAT PROFILE



Banke District

Key Climate Change Threat Profile

TA 7984 Mainstreaming climate change risk management in development

This threat overview relies on projections of future climate change in Banke district for the period 2040-2060 compared to a baseline of 1980-2000. Statistical downscaling for 20 temperature and precipitation stations was used to develop these projections using IPCC scenario A1B and four GCMs including PRECIS – Providing Regional Climate scenarios for Impact Studies; RegCM4 -- Regional Climate Model version 4; ARPEGE; and WRF- Weather Research and Forecasting model version 3.2. The downscaled datasets were prepared under ADB TA 7173 Strengthening Capacity for Managing Climate Change and the Environment. The datasets were obtained from Department of Hydrology and Meteorology, Nepal and Asian Disaster Preparedness Centre, Thailand.

The results of the downscaling were incorporated into a basin-wide hydrological model which computed changes in precipitation, evapotranspiration, PET, soil moisture, river discharge and runoff for every 120 x 120m grid cell in the district. Additional parameters computed include river water levels, flooding, erosion, sediment concentration, slope stability/land slide risk and irrigation demand. The full range of climate change threats has summarized into key threats likely to impact on infrastructure development sectors in the district

BANKE DISTRICT – KEY CLIMATE CHANGE THREATS

A. **Increasing maximum temperatures** - increase in average daily maximum wet season temperature by up to 2.15 °C

B. **Increasing number of extreme rainfall events** – at Masurikhet events that now occur every 50 years are projected to occur every 35 years

C. **Increasing wet season flow on the West Rapti River and earlier peak flow** – at Kusum peak monthly average flow will occur one month earlier in July and increase by up to 5%

DEFINITIONS

Typical year: The values (temp, rainfall etc) for a typical year is calculated as an average of that day/week/month over the 20 years time series.

Baseline: 1980 -2000

Climate change: 2040 - 2060 (**"2050"**)

Wet season: 15 May to 30 Sept

Dry season: 1st Jan to 14th May and 1st Oct to 31st Dec

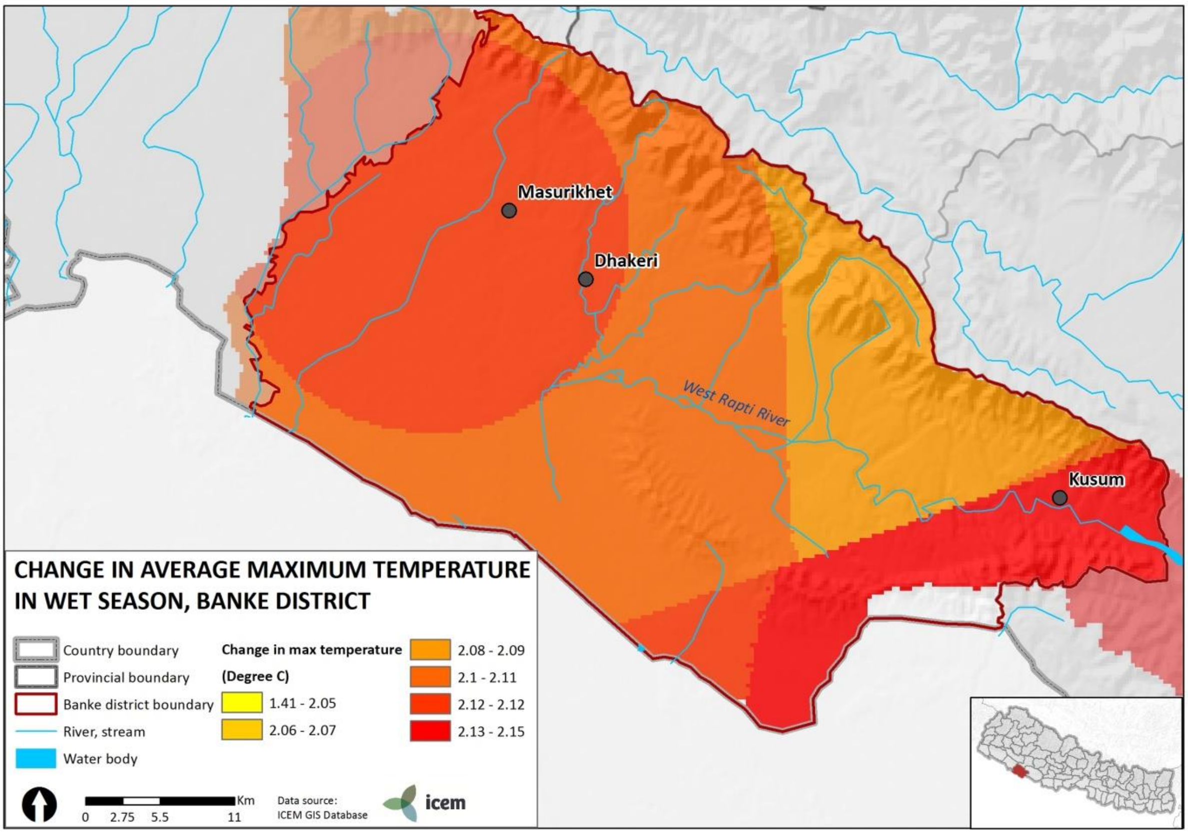
Three point sources used for analysis (represented by grey dots in the maps provided):

- Masurikhet – North-west of the district at low elevation
- Dhakeri – Central-west of the district at low elevation
- Kusum – East of the district at low elevation

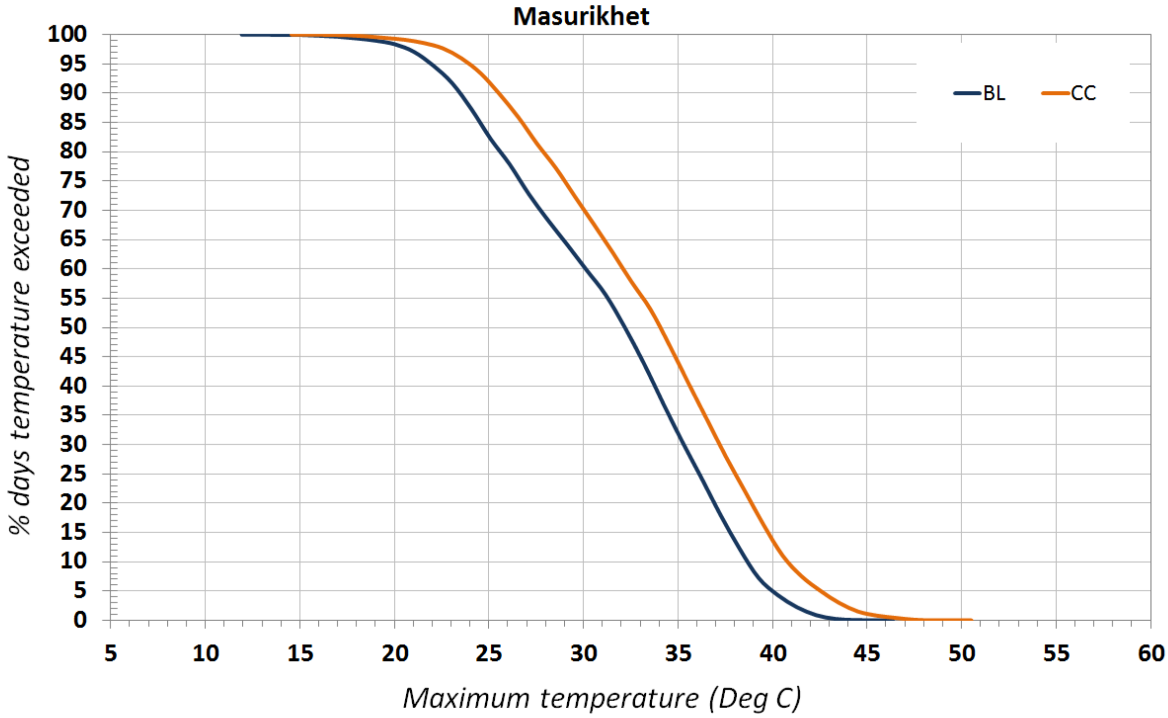
SUPPORTING ANALYSIS

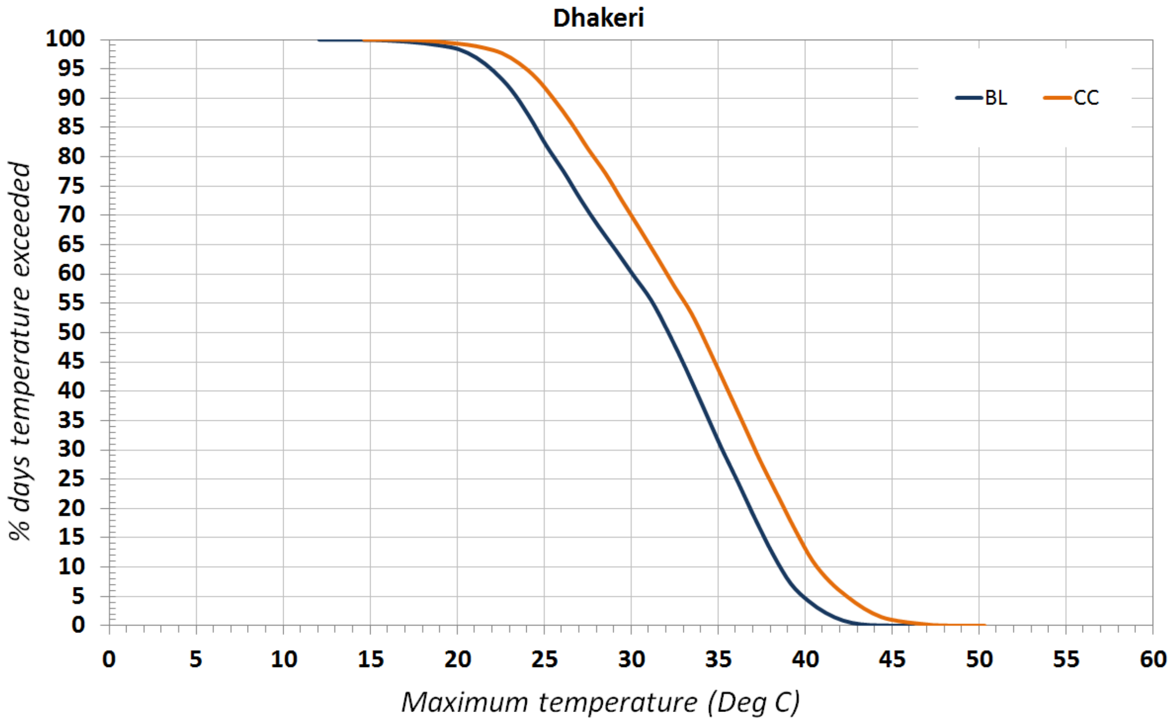
A. INCREASING MAXIMUM TEMPERATURES

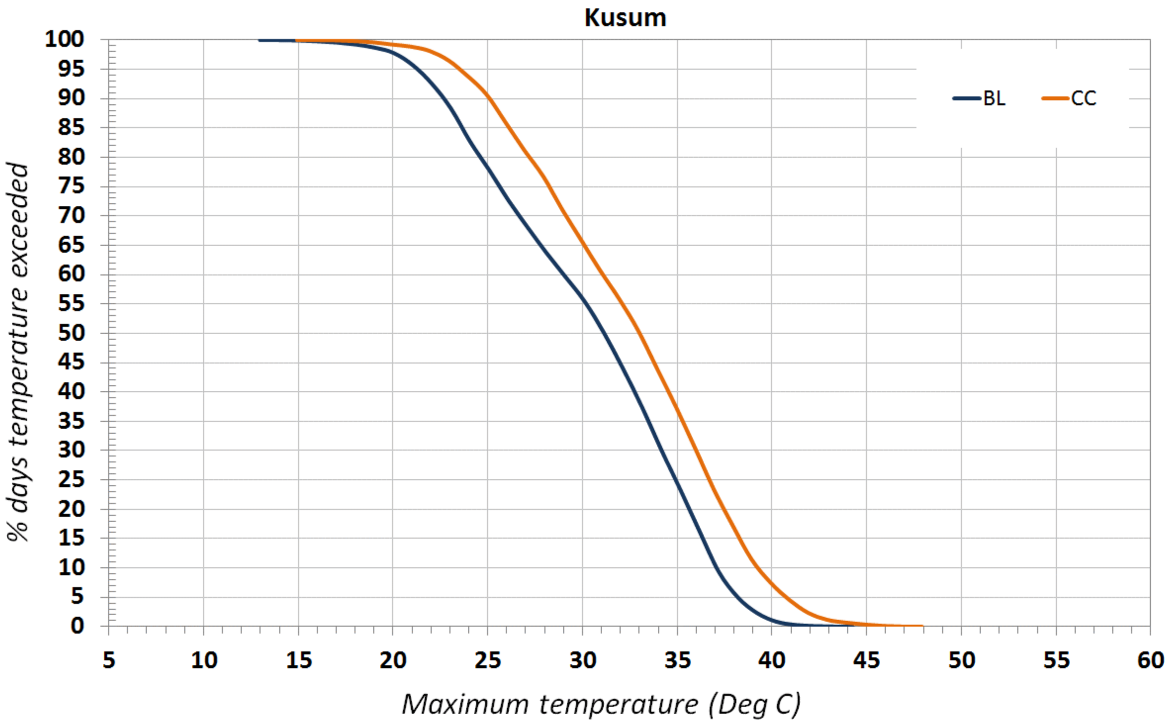
Wet season average maximum temperature change



Daily maximum temperature exceedance curves






Kusum
BL
CC
% days temperature exceeded
Maximum temperature (Deg C)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20
25
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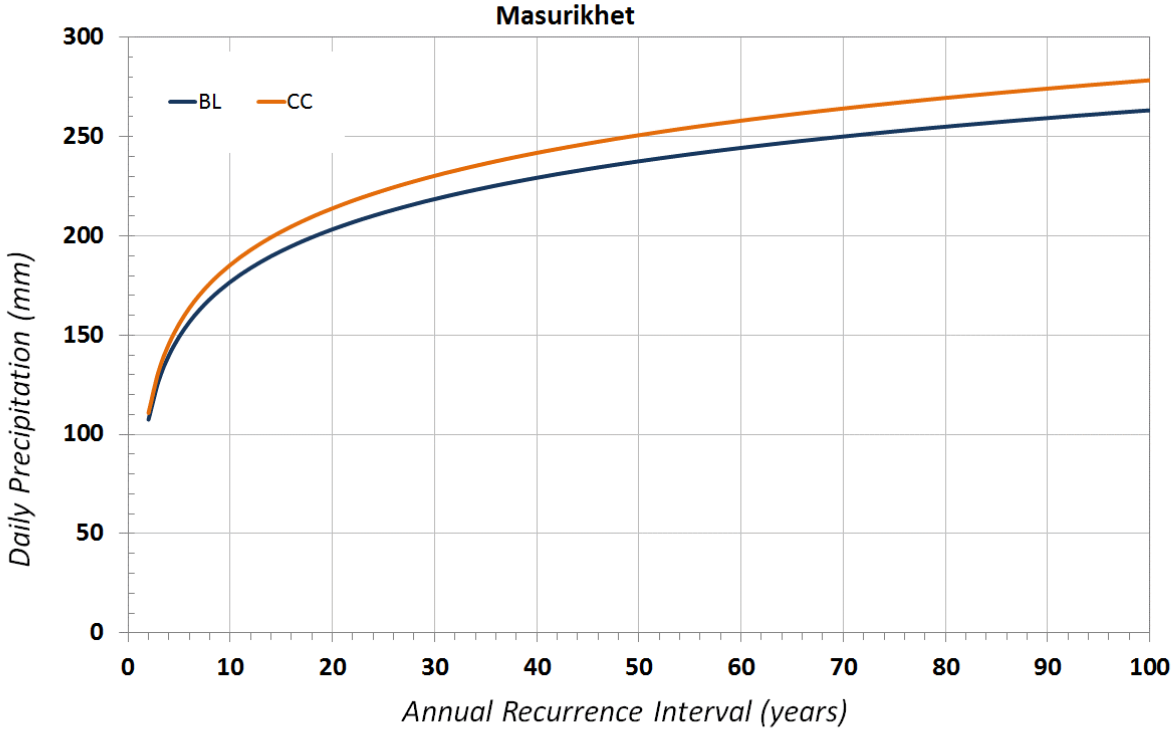
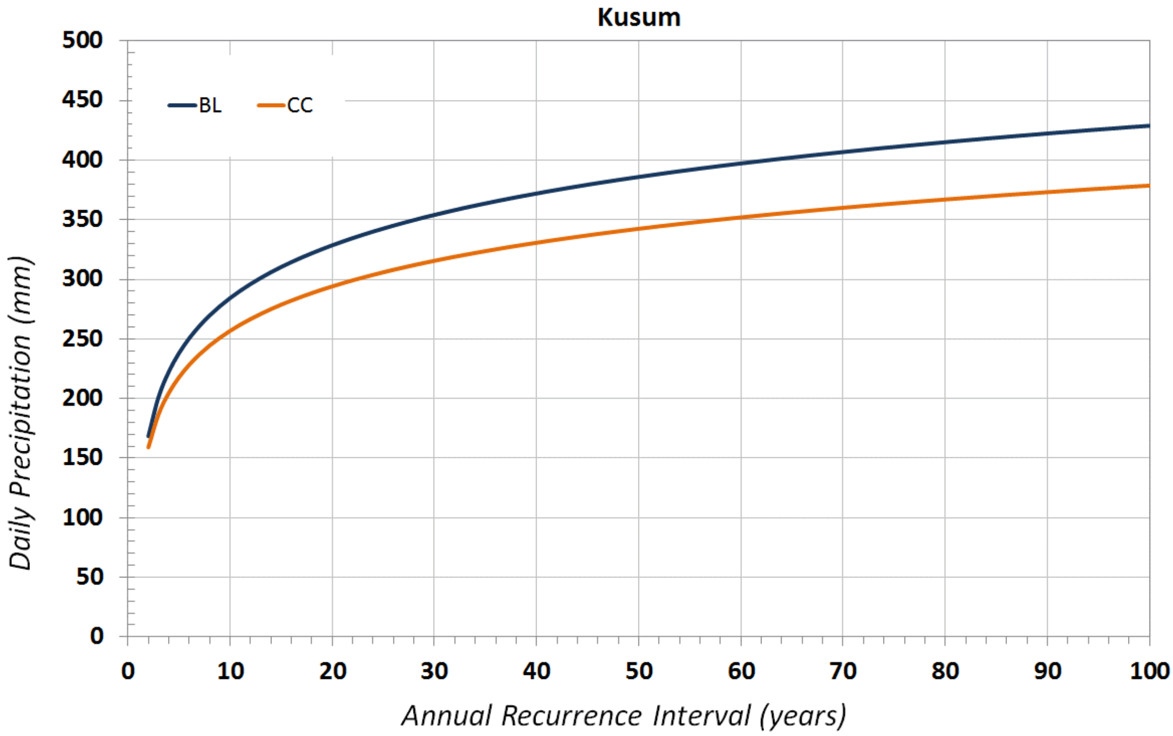
45
50
55
60

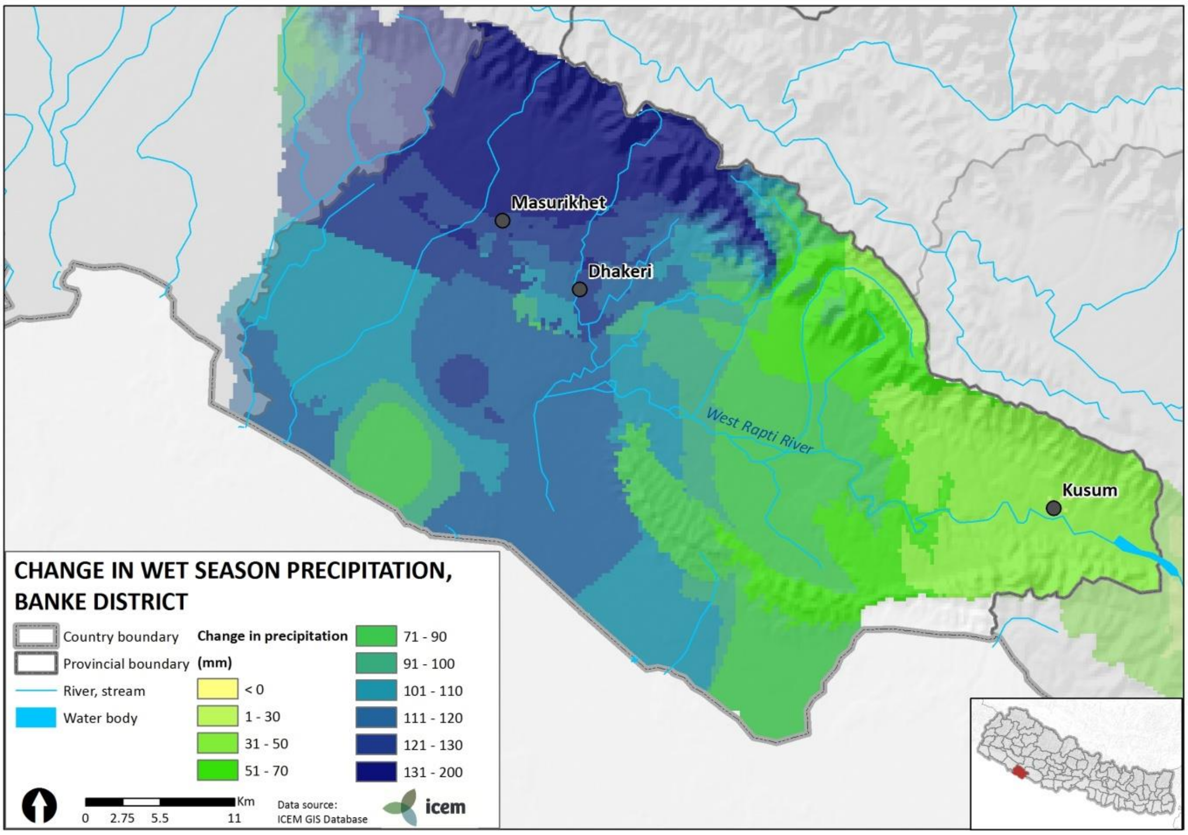
B. INCREASING NUMBER OF EXTREME RAINFALL EVENTS

Change in annual recurrence interval



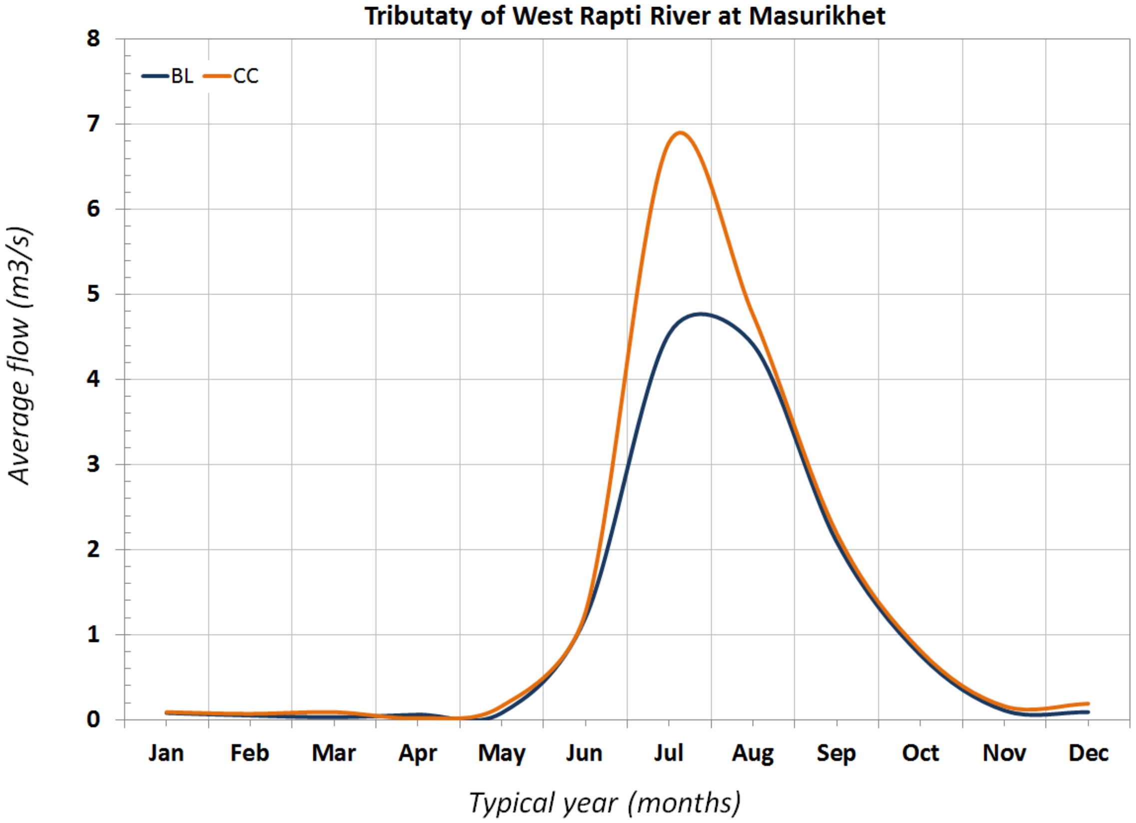


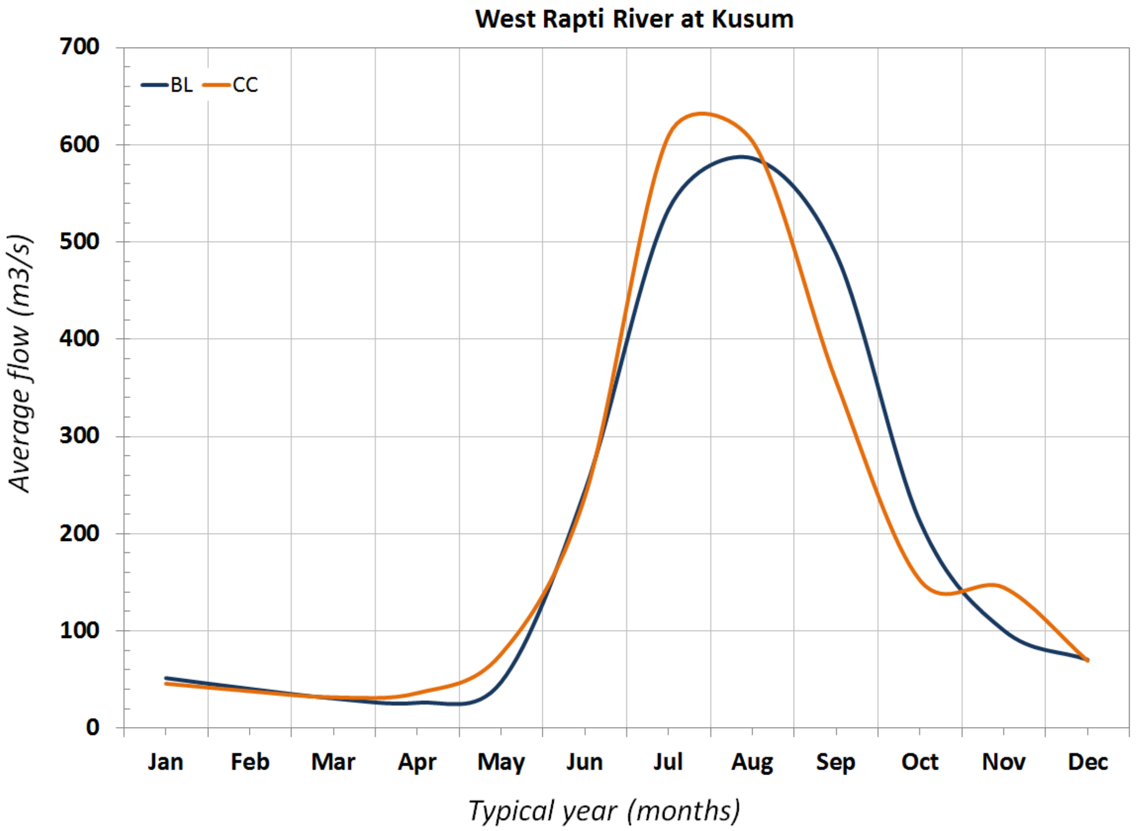
Change in total wet season precipitation



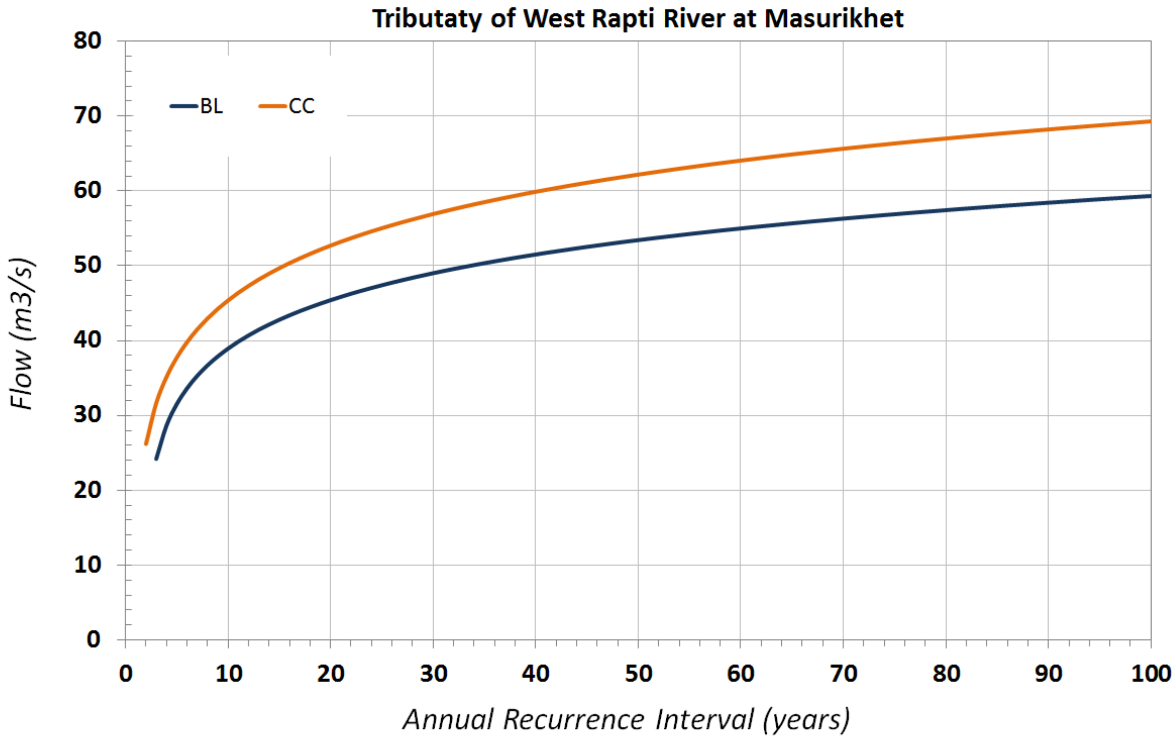
C. INCREASING WET SEASON FLOW ON THE WEST RAPTI RIVER AND EARLIER PEAK FLOW

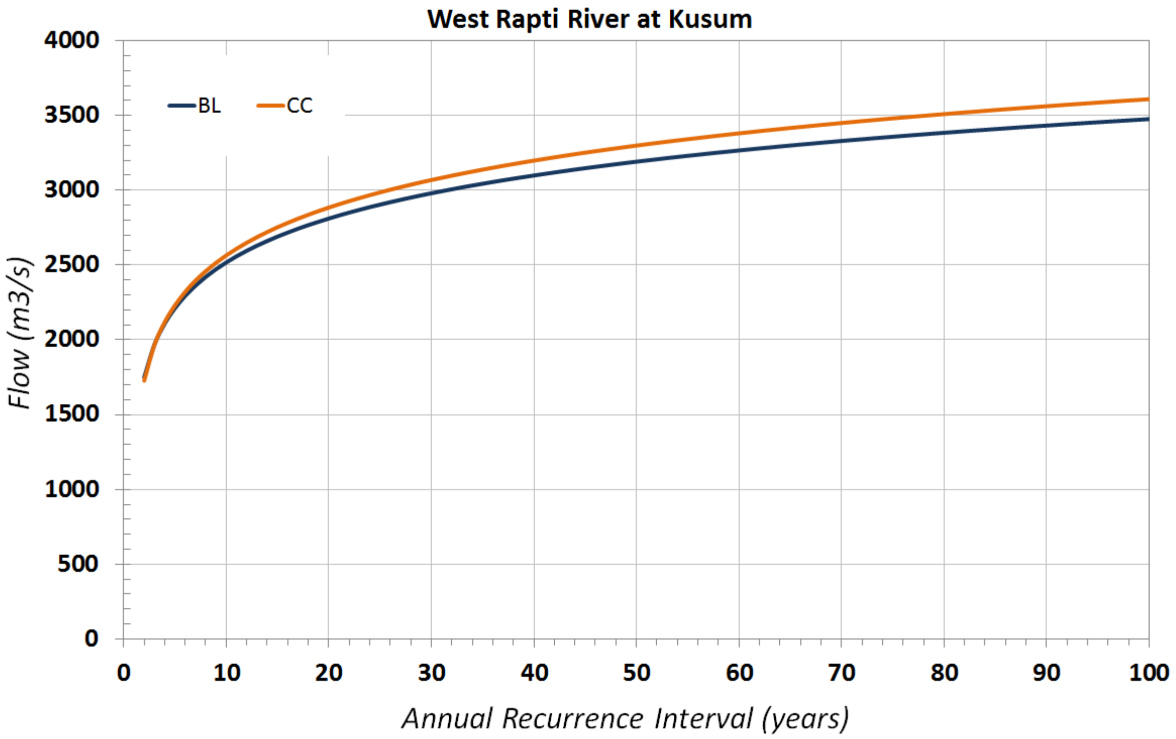
Hydrographs





Discharge return periods





ANNEXURE 2: VA MATRIX

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in temperature	Increase in Tmax up to 1.7°C	H[1 2]	M[3]	H	- Due to the increased temperature, the good bacteria die as the biological process is temperature sensitive; this leaves the organic matter to stay in the system for prolonged period which might cause serious health issues due to the unhygienic activities. - Children are most vulnerable and affected by mal-areas thus increasing the chances for outbreak of any serious diseases.	H[4]	M

[1] Duration: Increased temperature for prolonged duration more frequently will retard the bacterial disintegration of organic matter.
[2] Location: The location of the assets fall under temperature increase zone.
[3] The material, design and construction techniques have no direct impact from increased temperature.
[4] The local authorities have good capacity to enhance the system with the available funds, promoting the communities for better sanitation facilities.

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in precipitation	On an average rainfall intensities will increase by 65%	L[1 2]	L[3]	L	- Under severe storm condition, increased flow would bring more water to the catchment and the rain water gets absorbed by the soil and eventually recharges the ground water. - Increases the water security over long-term. - Businesses and industries secure uninterrupted water supplies due to the increased water recharge. - Public and others can positively rely on government water supply arrangement that would cost less money to the end-user.	H[4 5]	L

[1] Duration: Longer duration rainfall events occur more frequently within the asset area.
[2] Location: The existing groundwater sources across the catchment are exposed to high intensity rainfall. Steep slopes brings more rainfall runoff that triggers the groundwater to recharge
[3] Natural groundwater and no protection required.
[4] Adequate funds available and other related support is locally available.
[5] Material, spare parts and skilled manpower locally available

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increase in temperature	Increase in average maximum temperature of up 1.7 °C in the summer Increasing number of dry days in January, February and June – in the eastern mountains the average number of dry days in June is increasing from 5.5 to almost 7 days	H[6] [7]	M[8]	H	- Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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. - Increase in temperature will have an impact on the pipe material and cause cracks that might attract leakage which eventually contributes to Non-Revenue Water and cross-contamination from frequent overflows from septic tanks.	H[9]	M

[6] Duration: Increased temperature (up to 1.7°C) with longer duration and more frequency is a threat to the groundwater.

[7] Location: The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source. Increase in temperature will have an impact pipe material and cause cracks that might attract more cross-contamination.

[8] The material, design and construction of the groundwater source site have no impact since it is a natural system. The pipe material is HDPE which is very robust for extreme temperature conditions; however, the construction and laying practices by unskilled workers in Nepal might pose threat to early cracks if improper coating material is used during the laying process.

[9] The institution is in good capacity to manage the funds and resources for improvement works.

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in precipitation	On an average rainfall intensities will increase by 65%	H[1] [2]	H[3]	H	- More rain will lead to more flows that trigger severe damage to the source and the transmission pipelines. - Under severe storm condition, increased flow would trigger more flows that would damage/in some cases the transmission pipeline may collapse. - Due to the sudden collapse of pipeline, disruption to water supply services can be foreseen to the general public. - Public and others to rely on private water supply arrangement that would cost more money to the end-user.	M[4] [5]	H

[1] Duration: Long duration of increased temperature will occur more frequently which result in long duration exposure of assets to the increased precipitation threat.
[2] Location: Assets (source point and transmission pipelines) are exposed and in the event of increased flow due to increased rainfall, both source and pipelines will disappear
[3] The pipelines are not repaired and not leakage-proof. No good protective measures were in place such as protection to source and transmission pipelines
[4] Limited funds available however technical and other related support is locally available.
[5] Material, spare parts and skilled manpower locally available

Asset: Kohalpur Water Supply System

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate							
Increase in temperature	Increased temperature (up to 1.7°C) with longer duration	H[1][2]	M[3]	H	Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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.	H[4]	M

[1] Increased temperature (up to 1.7°C) with longer duration and more frequency is a threat to the groundwater source.
[2] The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source.
[3] The material, design and construction of the source site have no impact since it is a natural groundwater system.
[4] The organization is technically and financially capable to manage the problems.

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in precipitation	On an average rainfall intensities will increase by 65%	H[1 2]	H[3]	H	- More rain will lead to more flows that trigger more overflows from the septic tanks/pit latrines. - More rain means, more cross-contamination.	M[4 5]	H
Increase in temperature	Increase in average maximum temperature of up 1.7 °C in the summer Increasing number of dry days in January, February and June – in	H[6 7]	M[8]	H	- Due to the increased temperature, drying-up of sources can be foreseen more frequently. 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. - Increase in temperature will have an impact on the pipe material and cause cracks that might attract leakage which	H[9]	M

[1] Duration: Long duration of increased temperature will occur more frequently which result in long duration exposure of assets to the increased precipitation threat.
[2] Location: The spring sources and the transmission/distribution pipeline are running along the unprotected sanitation system which is prone to frequent overflows and cross-contamination under any rainfall event.
[3] The pipelines are not repaired and not leakage-proof.
[4] Limited funds available however technical and other related support is locally available.
[5] Material, spare parts and skilled manpower locally available
[6] Duration: Increased temperature (up to 1.7^{o}C) with longer duration and more frequency is a threat to the groundwater.
[7] Location: The increase in temperature will enhance evapo-transpiration from the catchment and as a consequence there is less recharge of water in sub-soil and eventually nothing reaches to the source. Increase in temperature will have an impact pipe material and cause cracks that might attract more cross-contamination.
[8] The pipe material is HDPE which is very robust for extreme temperature conditions; however, the construction and laying practices by unskilled workers in Nepal might pose threat to early cracks if improper coating material is used during the laying process.
[9] The institution is in good capacity to manage the funds and resources for improvement works.

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	the eastern mountains the average number of dry days in June is increasing from 5.5 to almost 7 days				eventually contributes to Non-Revenue Water and cross-contamination from frequent overflows from septic tanks.		

There is still a challenge to scientifically relate the sensitivity of spring sources (as assets) to the increased temperatures (as threat) in absence of geo-hydrological data on the catchment and underground recharge system of the sources. Micro-level assessments and detail analyses may be necessary to collect evidences for that purpose. An indication of the sensitivity is that there is already observed fact of drying up of the sources due to the lack of prolonged rainfall events with low intensity which are really helpful for gradual recharge and retaining of water in the sub-soil.

NEPALGUNJ WS SYSTEM

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

BANKE PIT LATRINE SYSTEM

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

KOHALPUR WS SYSTEM

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

KHOKARI WS SYSTEM

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**

BHAMKA WS SYSTEM

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY
INCREASED RAINFALL	LOW	LOW	LOW	HIGH	**LOW**
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**