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WATSAN VULNERABILITY ASSESSMENT REPORT

KATHMANDU DISTRICT

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	Environment Natural Resources and Agriculture Department, South Asia Department, Asian Development Bank
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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
DWSS	Department of Water Supply and Sewerage
GI	Galvanized Iron
GIZ	Deutsche Gesellschaft für 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
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
ToR	Terms of Reference
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
%	Percentage

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1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Kathmandu District WATSAN Infrastructure

The Kathmandu district has in total 57 VDCs and two municipalities' viz. Kathmandu Metropolitan and Kirtipur Municipality. The central water supply system being operated and maintained by Kathmandu Valley Water Limited (KUKL) covers the metropolitan areas and some areas of VDCs tap supplies from transmission line that runs along different sources. Similarly, larger area of the Kirtipur Municipality is served by the KUKL operated system.

There are at present 36 ongoing projects in the district by RMSO. The regular O&M of the completed projects is the sole responsibility of the Water Users Committees (WUC). The nature of the ongoing projects is to manage the survey, design, implementation and supervision of the WSS projects in the peripheral rural and semi urban settlements of the valley. The areas which are not covered by the KUKL fall under the responsibility of the regional office.

Kathmandu valley has many water supply schemes that are operated both under gravity system and also pressurized system. The sanitation facilities are combination of simple septic tank system and fully comprehensive sewerage system that runs under gravity with wastewater treatment facilities in Guheshwori. The design of the infrastructure required for the rural water supply system has been standardized by DWSS. The standard designs are being used for the design and construction of the system components. Basically, the District water supply and sanitation system comprises of the following infrastructure:

- Spring intakes of different types
- Intake structures
- Deep bore tube wells
- Overhead tank system
- Water treatment plant
- Transmission pipes: Mainly HDPE pipes
- Distribution reservoirs mainly RCC or Ferro Cement type
- Reservoirs are mostly semi underground with CGI roofing.
- Pumping stations
- Distribution pipes: mainly HDPE pipes
- Public stand posts: RR masonry types
- Septic tank system
- Comprehensive sewerage system with sewage treatment plant

The report covers the vulnerability assessment for both rural and urban assets and is clearly indicted in each description.

1.2 Criteria for Priority Assets & VA

1.2.1VA 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 water supply systems and 1 sewage treatment plant have been selected as priority assets in Kathmandu District. The detailed information on each asset is outlined in the baseline report for Kathmandu district. Brief discussion on the asset and its components are outlined below:

1.3.1 Sundarijal WS System - Urban & Dachi Overhead Tank - Rural

Sundarijal rural intake is located on the east bank of Bagmati River, about 30 meters north of the Sundarijal power house. The collection chamber is in the foothills of the eastern hill about 100 meters below the intake.

There is an old overhead tank in Dachi which is in need of some repair and maintenance but it is still functioning. New overhead tank which is constructed recently is of 450 cu.m capacity which will be fed from the large new pipes laid in the replacement of the older ones. Both the old and new reservoirs will be functional once the project is completed. There is a collection chamber about 100 meters downstream of the intake. In the rainy season, the water is sufficient in the source but in the dry season, the yield bound to go down.

1.3.2 Mahadevsthan WS System- Urban

The asset is located in the western part of the district in the foothills of the valley just south of the Thankot Check Post. The water supply system has two spring sources (Matatirtha and Golchhap) and two underground sources with deep hole boring. There are altogether three water storage tanks and two pumping stations. The total numbers of private and public connections are 1,500 and 200 respectively. The length of the transmission and pumping mains is 100 meters whereas the length of distribution pipeline is 100 meters. There are altogether 3,500 households partially or fully served by the public and private connections in all wards of Mahadevsthan VDC.

1.3.3 Guheshwori Sewage Treatment Plant - Urban

Summary of details for the sewerage treatment plant is provided below:

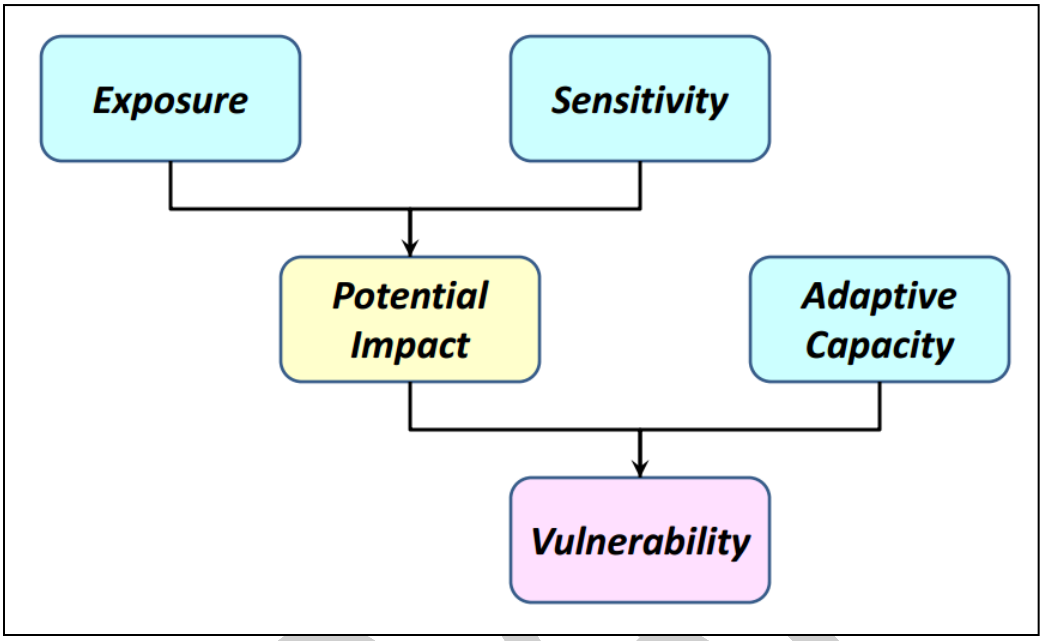
- Asset located adjacent to Bagmati River and behind Pasupathinath Temple
- The only working STP in Kathmandu, Capacity: 190 L/s (PE: 275,000 @ 60L/h/d consumption)
- Mechanical oxidation process with primary and secondary level treatment
- Efficiency is only 60% (source: STP staff)
- STP receives combined flows (sewage + storm)
- Flows above capacity are discharged to Bagmati River d/s of Temple
- STP is suffering from intermittent power supply
- 14 drying beds available – none in operation

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



Exposure 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.

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). 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, locals 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				
		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*

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 Dolakha 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 Dolakha 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:

- Duration of extreme rainfall events with high intensity will occur more often than before. For example, 40mm/hr rainfall intensity has duration of 10 minutes; in future 100mm/hr rainfall intensity will fall for the same duration.
- 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. More precipitation can be seen in the catchment than that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 30 years.
- On an average the rainfall intensities will increase by 76%.

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 3^0C.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 30^0C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

2.3.3 Increase in flows

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

- Increased flows due to increase in rainfall is expected.
- Increase in flood water levels in Bagmati River has a huge impact on the effluent discharge pipe from Guheshwori STP.
- The highest projected flood level at the discharge point is not known at this stage.

3 VULNERABILITY ASSESSMENT RESULTS

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

3.1 Sundarijal WS System (Urban) & Dachi WS System (Rural)

3.1.1Asset Description

The following table describes the important aspects of the Sundarijal and Dachi Water Supply System. Figure 3-1, Figure 3-2 and Figure 3-3 show a typical view of the water supply system.

Asset Age	40 years
Operator	Water Supply and Sanitation Users' Committee
Source	U/s of Bagmati River – Not well protected
Overhead Tank	RCC made but constructed on historic landslide area
Water Treatment Plant	Sand filters

Figure 3-1: Source and intake point

Figure 3-2: Dachi overhead tank

Figure 3-3: Overhead tank constructed on historic landslide area

3.1.1 Vulnerability assessment on Sundarijal Intake

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

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 70%
- Rainfall events occur more frequently than before.
- Rainfall events occur more frequently than before, 5 year events now occur at every 2 years
- Increased risk of sediments arriving at the intake.

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Asset (pipe type intake structure) is located d/s of large waterfall which brings huge flows from uphill catchment.
- The intake has no permanent structure and is just simple pipe that collects water.
- The transmission pipelines that receive water from the intake site are highly vulnerable to landslides that are around the asset.
- Duration: Longer duration rainfall events and raise in water level in the intake source zone occur for prolonged duration throughout the year.
- Intensity: High intensity rainfall and increased water level in the river occur more frequently.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Material used in the construction of intake pipe is not long-term sustainable and is not in good condition.
- The design and construction of intake is not appropriate.
- No good protective measures such as sediment trap at intake source and to the transmission line against any landslides.

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 with rich sediments and may block the intake pipe and in some cases it may drift the pipe and knock it towards the hard boulders.
- More rain means, the land around the intake and transmission line are more subjected to severe landslides which would damage the assets and cause disruption of supplies to the residents.

Adaptive Capacity: MEDIUM

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

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

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Sundarijal Intake 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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3.1.2 Vulnerability assessment on Sundarijal Intake Pipe & Transmission Pipeline (Urban)

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

Threat: Increased flow in the river

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

- Peak monthly average flow in wet season will increase by up to 68%
- In water level terms: Approx. 0.5m from the current highest flood level

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Asset (pipe type intake structure) is located d/s of large waterfall which brings huge flows from uphill catchment.
- The intake has no permanent structure and is just simple pipe that collects water.
- The transmission pipelines that receive water from the intake site are highly vulnerable to landslides that are around the asset.
- Duration: Flood events occur for prolonged duration throughout the year.
- Intensity: High flows and water levels in the river occur more frequently.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Material used in the construction of intake structure is of concrete and is acceptable.
- The design and construction of intake is not appropriate.
- No good protective measures against sediment trap at intake source and to the transmission line against any landslides.

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:

- Higher water level in the river means, more pressure on the intake pipe that may damage the structure and eventually pushes the structure out of its original position.
- The increased water levels may bring more sediments and boulders from u/s that may damage the foundation pillars of transmission lines.

Adaptive Capacity: MEDIUM

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

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

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Sundarijal intake and transmission pipelines is HIGH.

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

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3.1.3 Vulnerability assessment on Dachi Overhead Tank (Rural)

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

Threat: Increased rainfall

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

- As per the threat profile (see Annexure 1), on an average rainfall intensities will increase by 70%

- Rainfall events occur more frequently than before.
- Rainfall events occur more frequently than before, 5 year events now occur at every 2 years
- Increased risk of landslides around the overhand tank site.

Exposure: VERY HIGH

The exposure was ranked as very high for the following reasons:

- The rural overhead tank which is not in operation at the moment is located exactly on the landslide area.
- The overhead tank is vulnerable to landslides from all sides.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Materials used in the construction of overhead tank are of concrete and are acceptable.
- The design and construction of intake is appropriate BUT NOT THE LOCATION.
- No good protective measures against any landslides.

Impact: HIGH

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

- More rain will lead to more flows, this means the soil and the land around the structure may erode and the structure may collapse within no time.
- More rain means, the land around the intake and transmission line are more subjected to severe landslides which would damage the assets and cause disruption of water supplies to the residents.

Adaptive Capacity: MEDIUM

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

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

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Dachi Overhead Tank is VERY 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*

3.2 Mahadevsthan WS Spring Sources

3.2.1 Asset Description

The following table describes the important aspects of the Mahadevsthan water supply spring sources. Figure 3-4 to 3-7 show details of the spring sources system.

Asset type	National pilgrimage site
Location	Asset is located in the western part of KTM Valley on the south of Thankot Check post at the foot hills of Chandagiri mountain.
Source type and numbers	There are 4 sources (1 – Matatirtha, 2 small springs, 1 deep bore well with pumping)
Number of reservoirs	WS system has 5 storage reservoirs (of different capacities) with a total capacity of 1200 cum
Connections	There are 1,500 private connections and 20 public stand posts served by the WS system.
Operator	The system is operated by the local water users committee which has now 14 full-time staff and well-furnished office for tariff collection and other day-to-day management activities.
Capacity of Operator	The water users committee is competent and highly motivated to manage the WS system as required.
Investment from Operator	The users committee has invested in construction of 550 cum storage reservoir and 104 m deep bore well together with all the electro-mechanical systems.

Figure 3-4: Mathathirth Source

Figure 3-5: Mathathirth Reservoirs

Figure 3-6: Golchhap Water Source (Dry)

Figure 3-7: Mahadevsthan WS Source Reservoir

3.2.2 Vulnerability assessment on Mahadevsthan WS Sources (Urban)

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

Threat: Increased temperature

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

- On an average the temperature will increase up to 3^{o}C (as per the Hydrological Modeling inputs)
- Increased temperature for longer durations will occur more frequently than before.

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Duration: Increased temperature (up to 3^{o}C) with longer duration and more frequency is a threat to the springs.
- 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 was ranked as medium for the following reasons:

- The material, design and construction of the intake sites (in both the springs) are not directly affecting the sensitivity of the springs.

- 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.

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:

- 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 was ranked as high for the following reasons:

- The organization is technically and financially capable to manage the problems and operate their WS system.
- The only support they may need is for design and installation of water treatment system to improve the water quality from the traditional springs of Matatirtha sources and other additional sources they want to include into the system as replacement to the existing but dried up sources.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability for the Madevsthan water supply spring sources 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*

3.3 Guheshwori STP (Urban)

3.3.1 Asset Description

The following table describes the important aspects of the Guheshwori sewerage treatment plant. Figure 3-8 and 3-9 show details of the location and processing steps of the treatment plant.

Asset location	Adjacent to Bagmati River and behind Pasupathinath Temple
Capacity of STP	190 L/s
Treatment process	Mechanical oxidation process
Efficiency	60%
Dying beds	14, none in operation
Effluent discharge	Directly into Bagmati River

Figure 3-8: Asset location

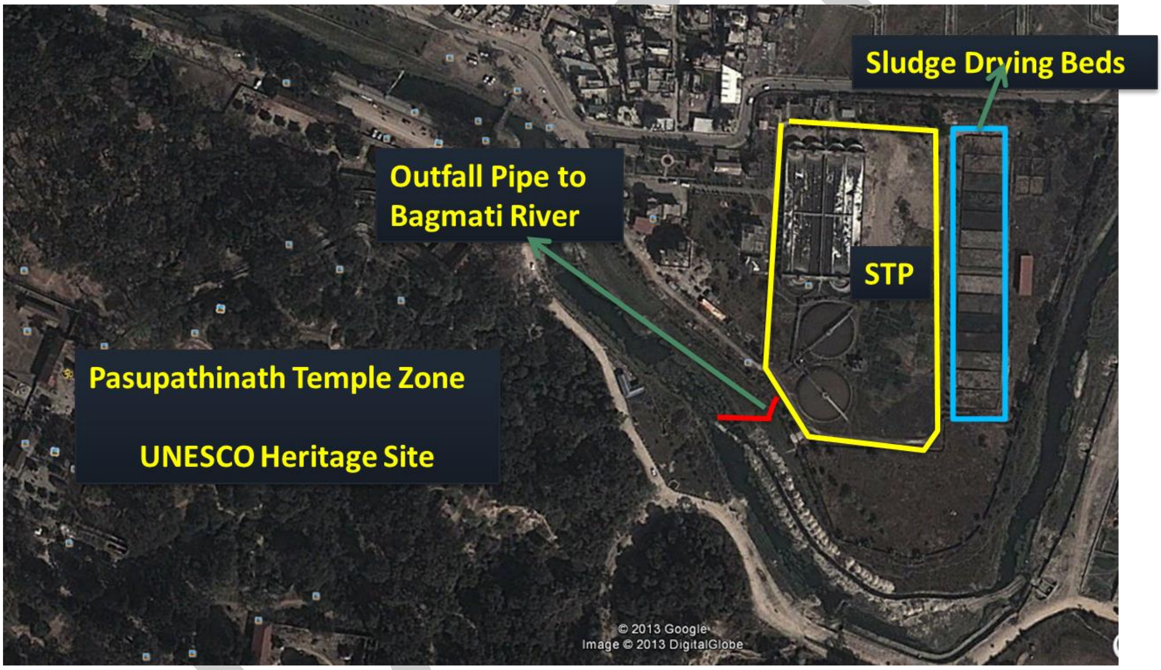
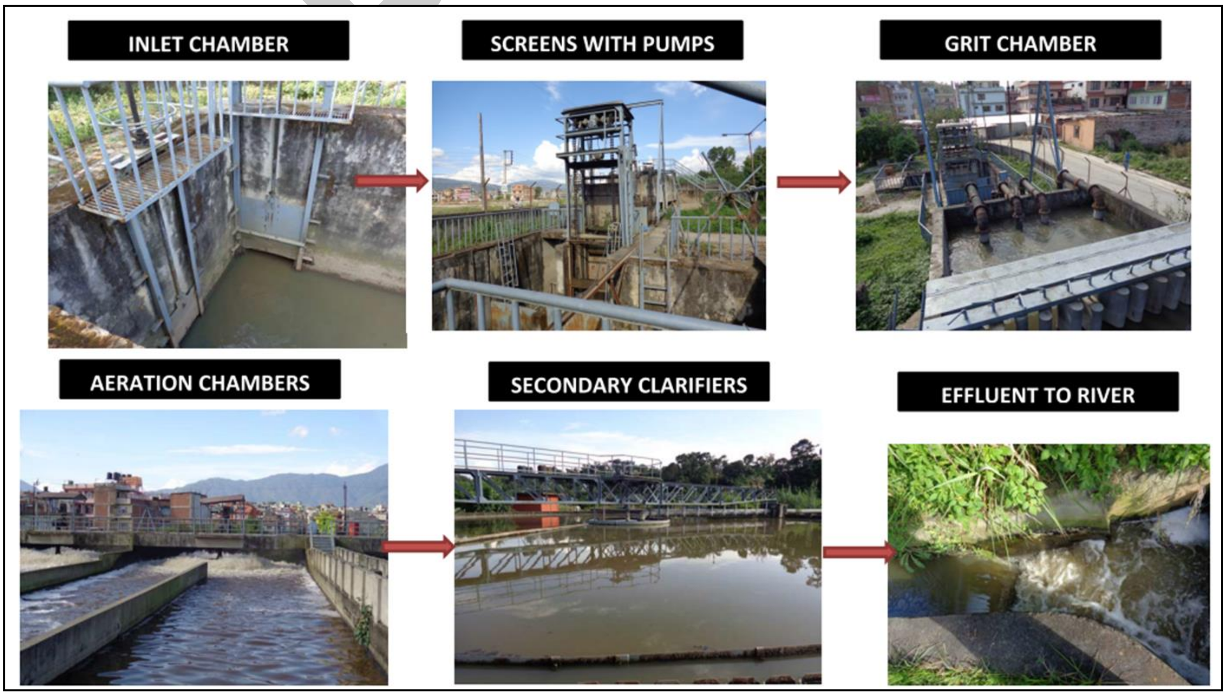


Figure 3-9: STP Photos



3.3.2 Vulnerability assessment on Guheshwori STP - Rainfall

The following section outlines the decisions undertaken in setting the levels exposure, sensitivity and adaptive capacity for the Guheshwori sewerage treatment plant as threatened by increased rainfall intensities.

Threat: Increased rainfall

The following threats have been identified as likely to impact on the treatment plant:

- On an average rainfall intensities will increase % not known at this stage (as per the Hydrological Modeling inputs)
- Rainfall events occur more frequently than before, 5 year events now occur at every 2 years

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Location: Asset (Guheshwori STP) is located behind the Holy Pasupathinath Temple and falls within the high rainfall zone
- Duration: Longer duration of rainfall events will occur more frequently.
- Intensity: Increased intensity of rainfall occurs more frequently.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Materials used in the construction of STP are above acceptable level.
- The design and construction is adequate and fit for the purpose but not SAFE.
- Increased O&M costs are foreseen due to more sediment through increased rainfall.
- No good protective measures against increased flow (emergency pumping arrangement) to pump the sewage under severe storm conditions.

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 untreated sewer overflows to the Bagmati River.
- More rubbish arrives at STP that may block the inlet chamber and also more sediment in sewage means more load on the current treatment process.
- Decreased precipitation means, more concentrated sewage reaches STP that attracts more energy and complex processing techniques, adds more burden on STP budget.

Adaptive Capacity: VERY LOW

The adaptive capacity was ranked as very low for the following reasons:

- Limited funds available.
- Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas.
- Technical capabilities are not readily available, need more trained staff.
- No emergency pumping arrangements if STP is shut-down for any reason.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Guheshwori STP is VERY HIGH.

		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*

3.3.3 Vulnerability assessment on Guheshwori STP – Flow in Bagmati River

The following section outlines the decisions undertaken in setting the levels exposure, sensitivity and adaptive capacity for the Guheshwori sewerage treatment plant as threatened by increased flow and water levels.

<u>Threat: Increased flow in Bagmati River</u>

The following threats have been identified as likely to impact on the treatment plant:

- Peak monthly average flow in wet season will increase by up to 68%
- The water levels will go higher

<u>Exposure: VERY HIGH</u>

The exposure was ranked as very high for the following reasons:

- Location: Asset is located behind the Holy Pasupathinath Temple. The location of the asset is exposed to extreme flood levels.
- Duration: Increased water level in Bagmati River is throughout the year this means longer durations.
- Intensity: High flood levels will occur more frequently than before.

<u>Sensitivity: HIGH</u>

The sensitivity was ranked as high for the following reasons:

- Materials used in the construction of STP are above acceptable level.
- The design and construction is adequate and fit for the purpose but not SAFE.
- Increased O&M costs are foreseen due to the intrusion of flood water into STP.
- No good protective measures against increased flow (emergency pumping arrangement) and flap gates at the discharge point to Bagmati River.

<u>Impact: `VERY HIGH</u>

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

- Danger of flood waters entering into the STP site and cause serious damage to the STP.
- Higher water level in the river means, effluent cannot be discharged under gravity, need pumping arrangements (increased energy needs) or else, backup flows in the system that may trigger pipe surcharges, MH flooding and WC flooding.
- Danger of STP site washed away.
- Public health issues will arise.
- Danger of flood waters entering into the STP site and cause serious damage to the STP.
- Higher water level in the river means, effluent cannot be discharged under gravity, need pumping arrangements (increased energy needs) or else, backup flows in the system that may trigger pipe surcharges, MH flooding and WC flooding.
- Danger of STP site washed away.
- Public health issues will arise.

Adaptive Capacity: VERY LOW

The adaptive capacity was ranked as very low for the following reasons:

- Limited funds available.
- Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas.
- Technical capabilities are not readily available, need more trained staff.
- No emergency pumping arrangements if STP is shut-down for any reason.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Guheshwori STP against increased flow in Bagmati River is VERY 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

3.3.4 Vulnerability assessment on Guheshwori STP – Temperature

The following section outlines the decisions undertaken in setting the levels exposure, sensitivity and adaptive capacity for the Guheshwori sewerage treatment plant as threatened by temperatures.

Threat: Increased temperature

The following threats have been identified as likely to impact on the treatment plant:

- Increase in average maximum temperature of up to 3^0C (as per the Hydrological Modeling inputs)
- More intense temperatures occur more frequently and for longer durations

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Location: The location is exposed to high temperature risks.
- Duration: Increased temperatures will be throughout the year this means longer durations.
- Intensity: High temperatures will occur more frequently than before.

Sensitivity: HIGH

The sensitivity was ranked as medium for the following reasons:

- Materials used in the construction of STP are above acceptable level but are not heat proof.
- The design and construction is adequate and fit for the purpose but not SAFE.
- Increased O&M costs are foreseen due to replacement of corroded pipe lines.
- No good protective measures against increased temperature (no corrosion protection measures to the pipe system and also to the equipment within STP).

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:

- Bagmati River has delicate ecosystems that will be negatively affected if the added water is much warmer. Effluent will likely need to be cooled before discharging, adding cost and energy needs to the process.
- Rate of biological reactions is temperature dependant so increased temperature will have huge impact on the treatment process as well as on corrosion of collection system pipes.
- Major greenhouse gases evolved from STP are CO2, CH4 & N20, this means STP will contribute to climate change

Adaptive Capacity: VERY LOW

The adaptive capacity was ranked as very low for the following reasons:

- Limited funds available.
- Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas.
- Technical capabilities are not readily available, need more trained staff.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Guheshwori STP against increased temperature is VERY 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*

4 KATHMANDU DISTRICT VULNERABILITY SUMMARY

4.1 Summary of VA Results

4.1.1 Sundarijal Intake and Dachi Overhead Tank

The table below summarises the vulnerability assessment of the Sundarijal Intake and Dachi Overhead Tank. The analysis shows that the most vulnerable components of the system is the overhead tank which was ranked as very high vulnerability to increased rainfall due to landslide issues.

SUNDARIJAL RURAL INTAKE STRUCTURE					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTIVE CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
INCREASED FLOW	HIGH	HIGH	HIGH	MEDIUM	**HIGH**

DACHI RURAL OVERHEAD TANK					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED RAINFALL	VERY HIGH	HIGH	VERY HIGH	MEDIUM	**VERY HIGH**

4.1.2 Mahadevsthan WS Spring Sources

The table below summarises the vulnerability assessment of the Mahadevsthan water supply spring sources. The analysis shows that the system is ranked as medium vulnerability to increased temperatures.

MAHADEVSTHAN WS SPRING SOURCES					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTIVE CAPCITY	VULNERABILITY
INCREASED TEMPERATURE	HIGH	MEDIUM	HIGH	HIGH	**MEDIUM**

4.1.3 Guheshwori STP

The table below summarises the vulnerability assessment of the Guheshwori sewerage treatment plant. The analysis shows that the system is ranked as very high vulnerability to increased temperatures rainfall, flow and temperatures.

GUHESHWORI STP					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTIVE CAPCITY	VULNERABILITY
INCREASED RAINFALL	HIGH	HIGH	HIGH	VERY LOW	**VERY HIGH**
INCREASED FLOW	VERY HIGH	HIGH	VERY HIGH	VERY LOW	**VERY HIGH**
INCREASED TEMPERATURE	HIGH	HIGH	HIGH	VERY LOW	**VERY HIGH**

4.2 Most Vulnerable Assets and its Components

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

Sundarijal Intake and Dachi Overhand Tank

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased Flow	Increased flow events occur more frequently and in huge volume	Brings more sediments to the source and also affects the historic landslide to collapse again around the Dachi overhead tank	More sediment with organic matter reaching the residents would cause serious health damages to the consumers. Collapse of Dachi overhead tank will cause serious disruption of water supply to the nearby residents.

Mahadevsthan WS System Sources

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased temperature	High temperatures will occur more frequently and for longer durations.	Drying up of water sources	Need to find alternative sources in advance to avoid complete drying up of existing water sources.

Guheshwori STP – Septic Tank System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased Rainfall, increased flow in Bagmati River and Increased temperature	More rainfall and frequent Increased flow for longer durations may happen more frequently High temperatures occur more frequently and for longer durations	Impacts the operation of STP and damages to the equipment happens more frequently. Increased water level in Bagmati River will induce backing-up flows within the system and triggers the temporary shut-down of STP. This further causes u/s surcharge and overflow from manholes. Increase in temperature affects the biological process and also enhances the corrosion process within the STP and pipe system.	Failure of STP causes serious damages to the process, to the equipment and also causes health & hygiene issues to the residents that are connected to the system. In addition to this, more raw sewage will be discharged into Bagmati River that causes serious damage to the water quality and the species within the river.

4.3 Lessons and Application to Other Assets

Kathmandu 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 both gravity and pressure system of complex 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 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 areas are connected to the existing comprehensive sewerage system and the rural part rely on septic tank systems. The problems associated with the operation, maintenance and frequent overflows under severe storm event are the common issues. In view of this, Guheshwori STP is a very good asset to demonstrate the common problems, impacts and its severity on common public within the Kathmandu valley.

ANNEXES

ANNEXURE 1: THREAT PROFILE

ANNEXURE 2: VA MATRIX

KATHMANDU DISTRICT – KEY CLIMATE CHANGE THREATS

A. **Increasing maximum temperatures** - increase in average maximum temperature of up 1.85°C

B. **Increasing intensity of rainfall events**

C. **Increasing number of extreme rainfall events** – events that now occur every 5 years are projected to occur every 2 years

D. **Increasing wet season flow on the Bagmati River** – peak monthly average flow in wet season will increase by up to 68%

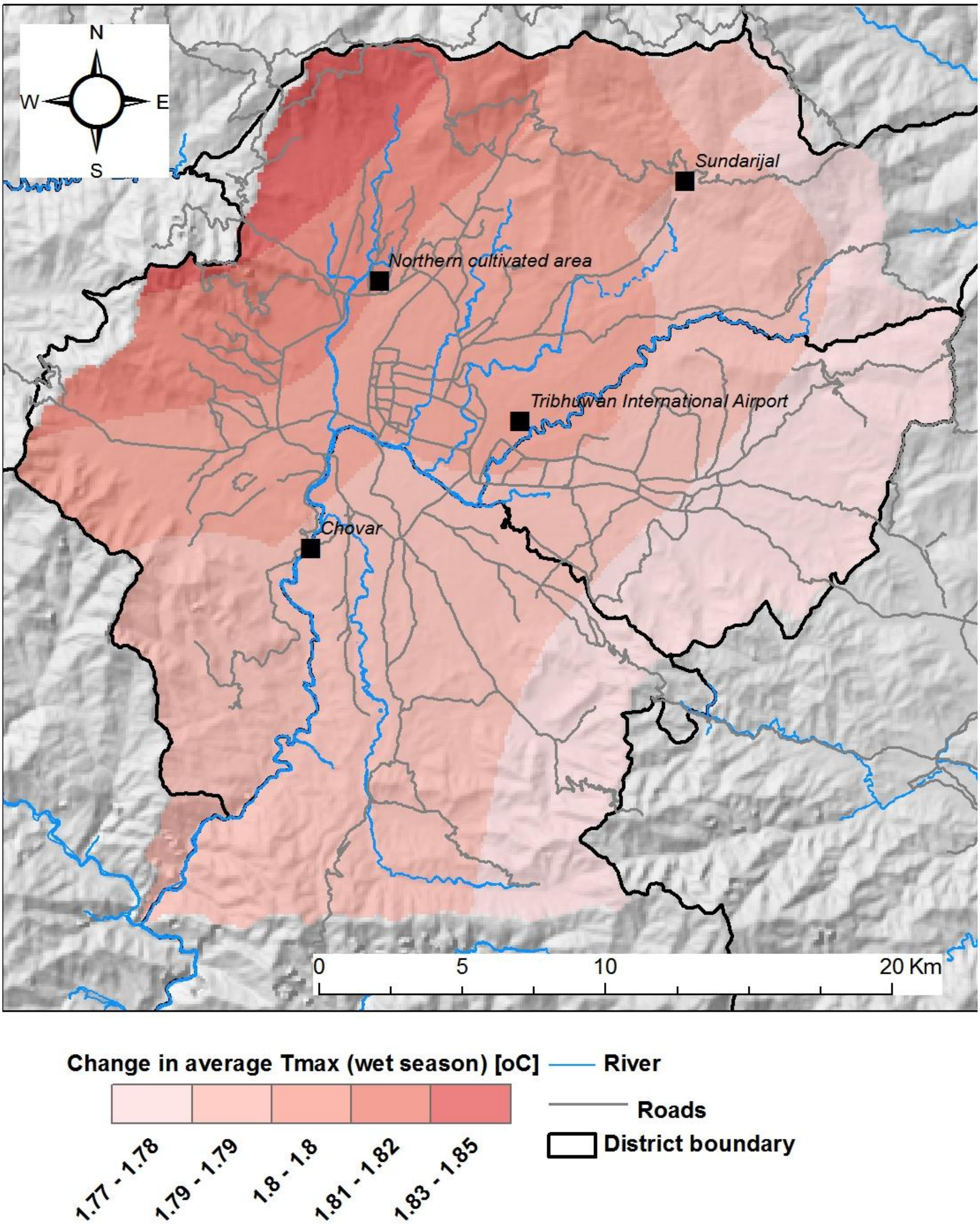
E. **Greater likelihood of pooling**

F. **Increase in irrigation demand** – irrigation demand will increase by up to 980mm

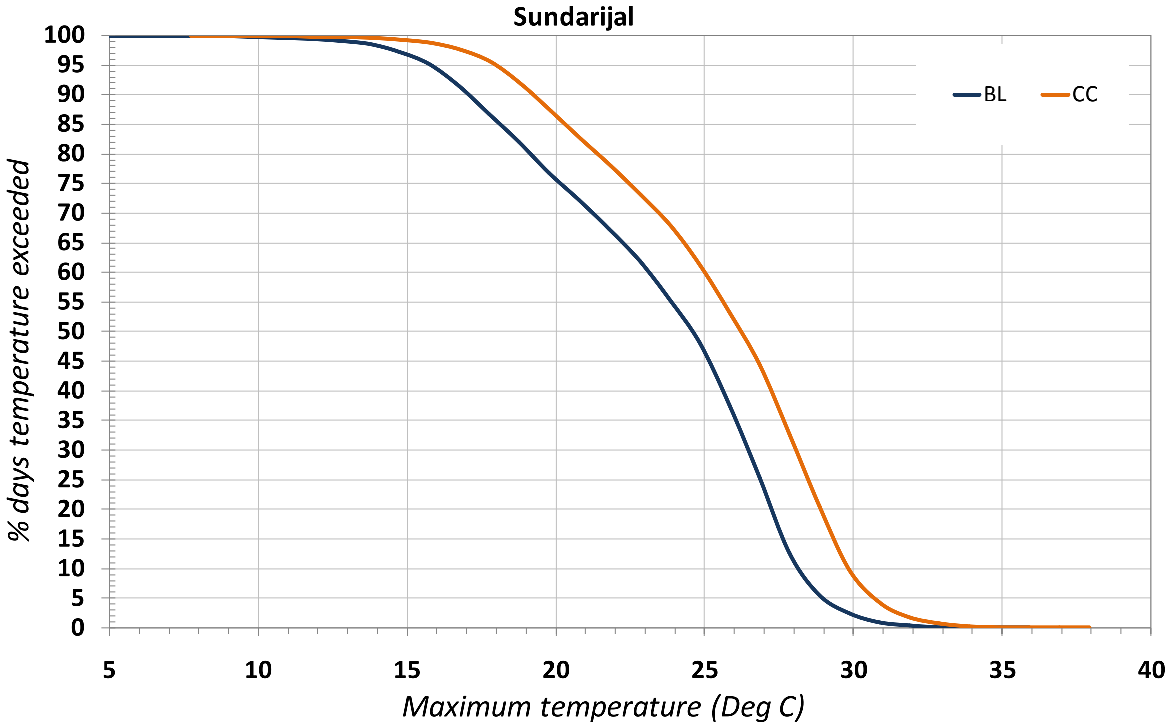
G. Increasing risk and severity of flash floods during wet season

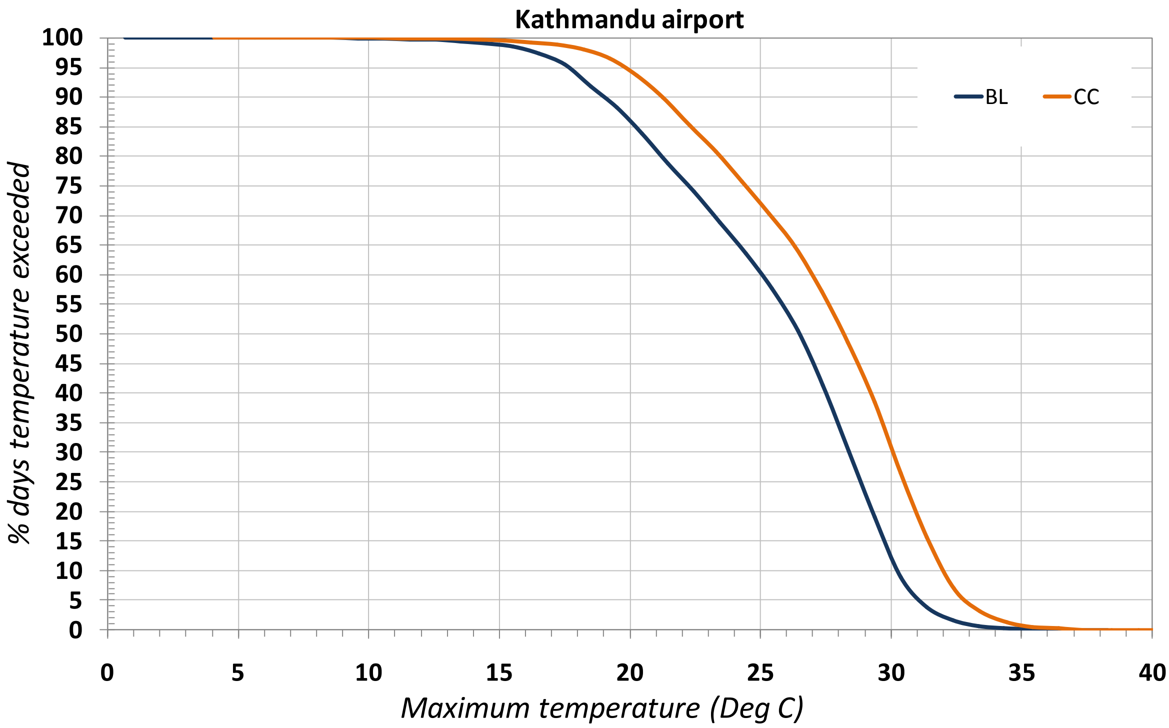
A. INCREASING MAXIMUM TEMPERATURES

Wet season average maximum temperatures



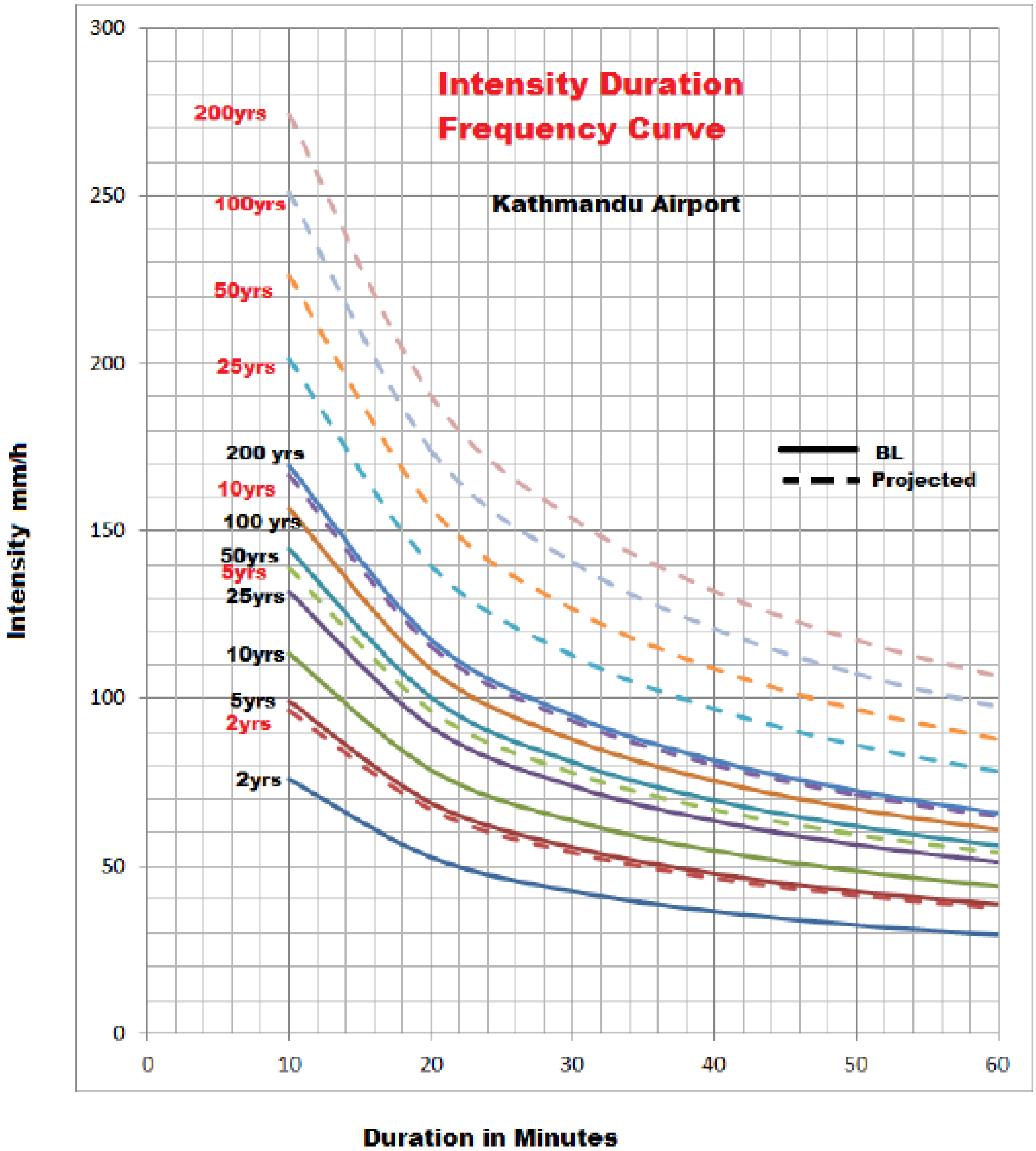
Daily maximum temperature exceedance curves





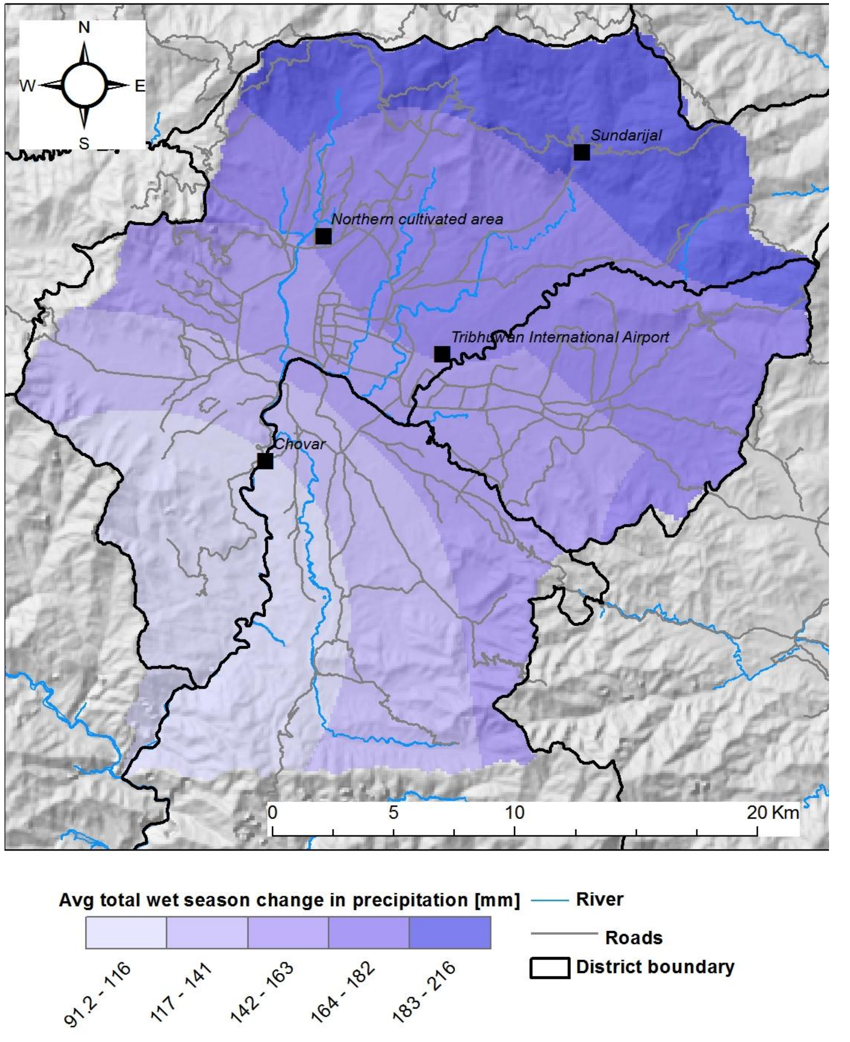
B. INCREASING INTENSITY OF RAINFALL

Intensity Duration Frequency (IDF) curves



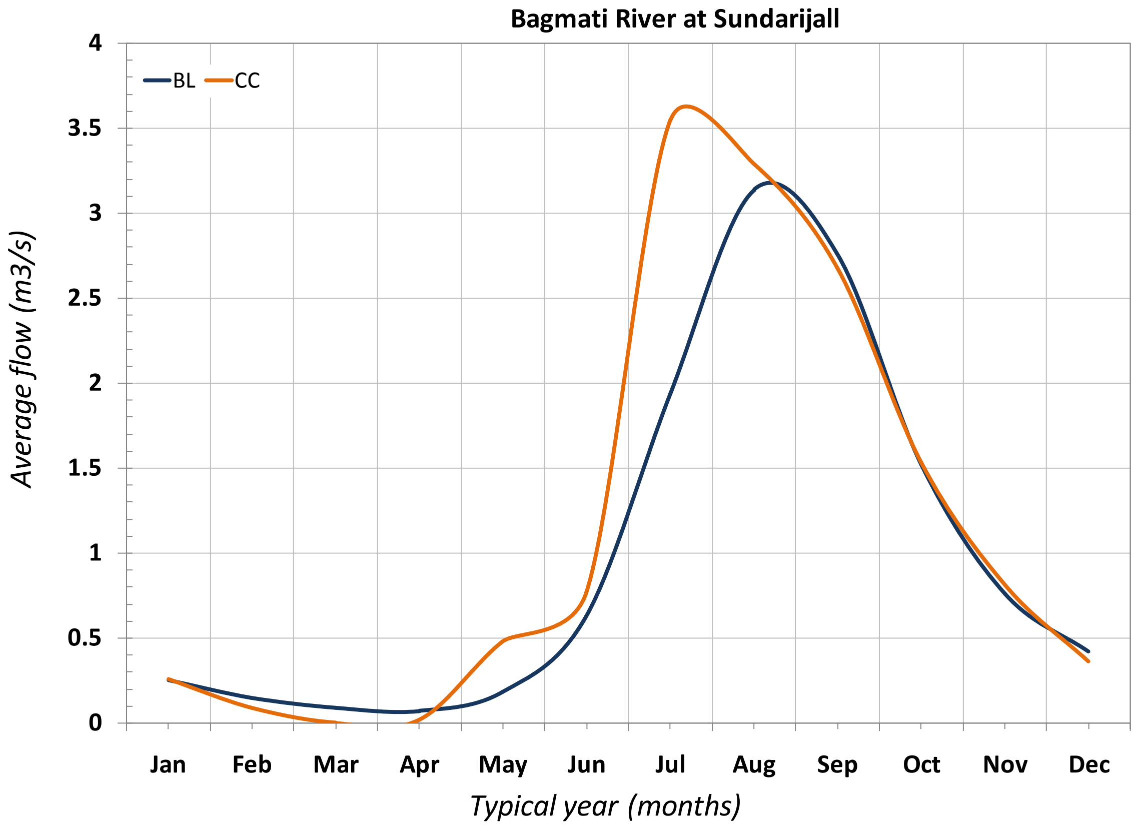
C. INCREASING NUMBER OF EXTREME RAINFALL EVENTS

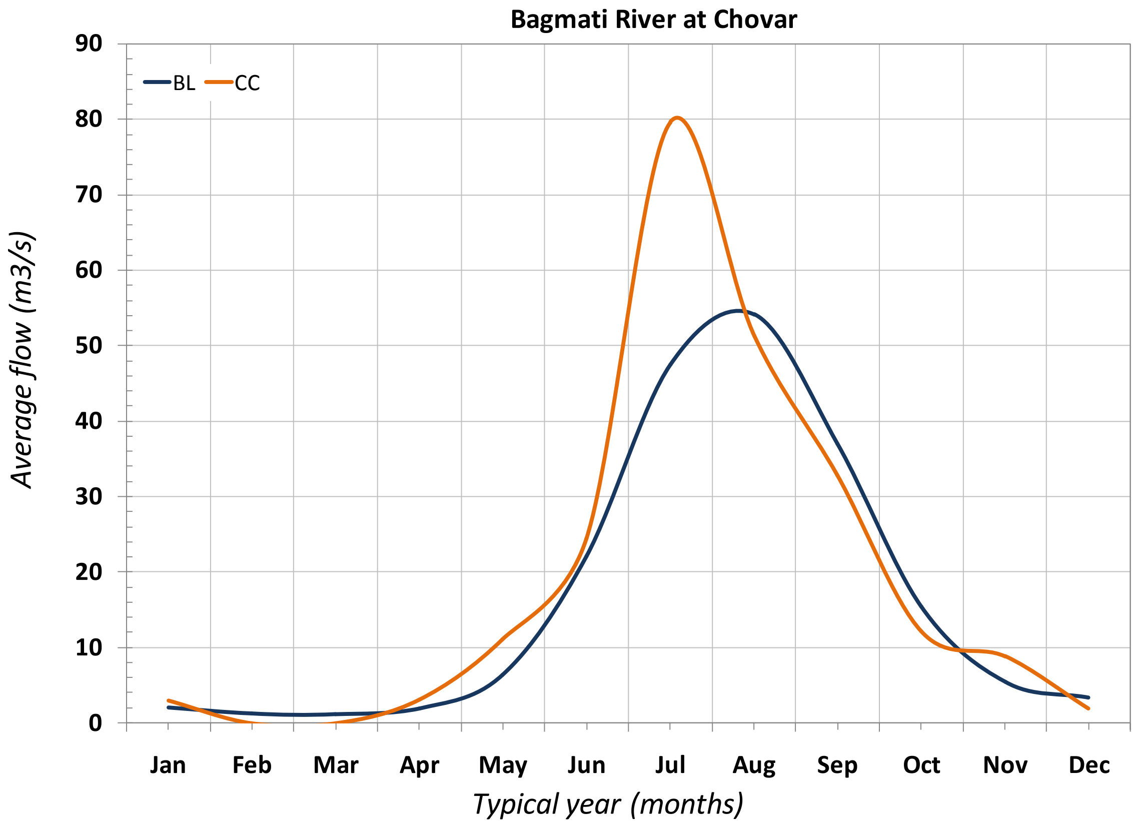
Change in total wet season precipitation



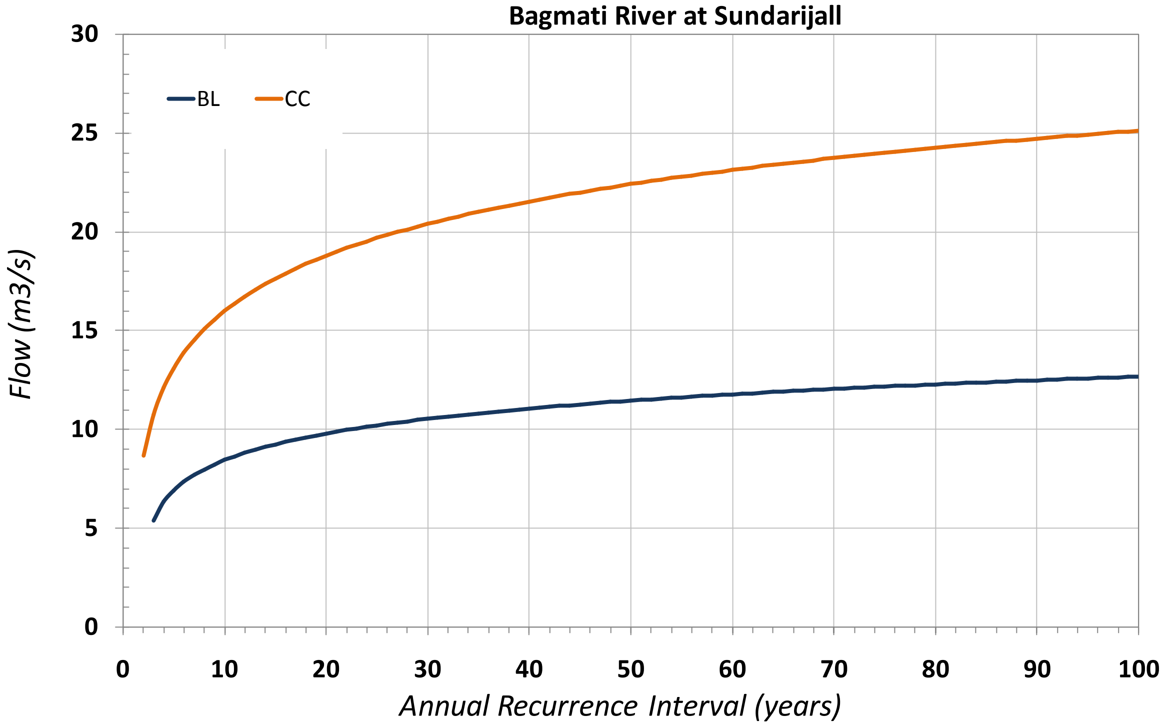
D. INCREASING FLOW AND WATER LEVELS

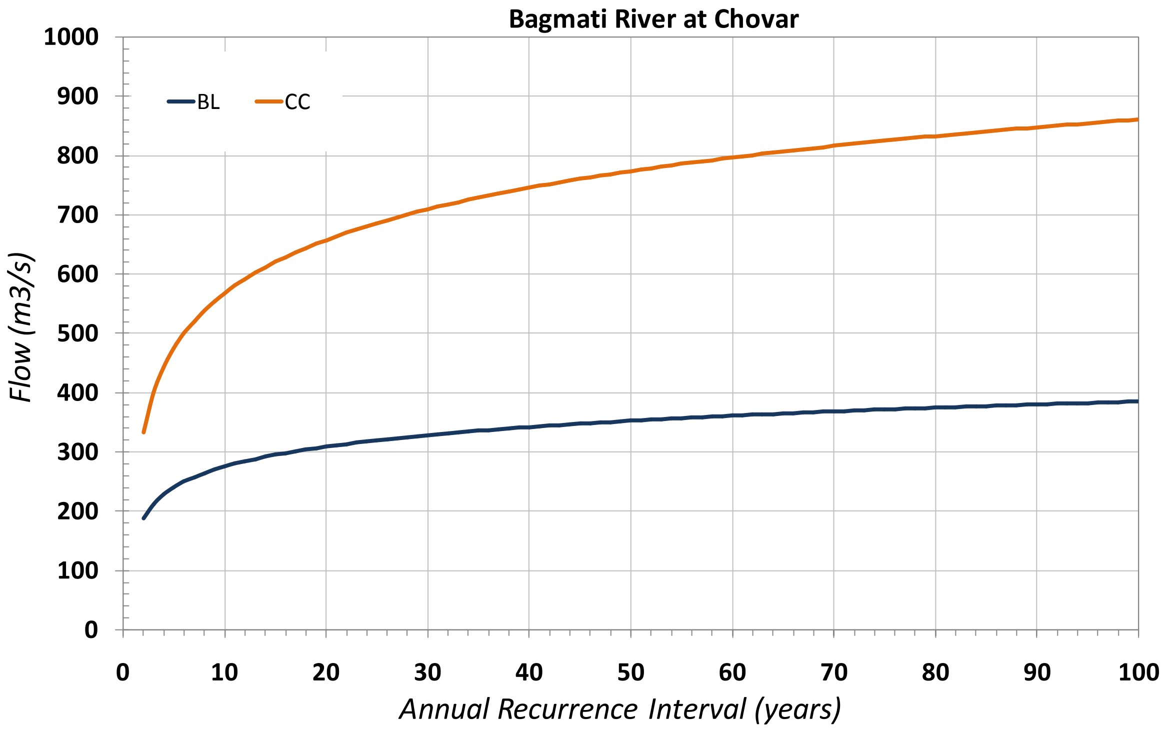
Hydrographs



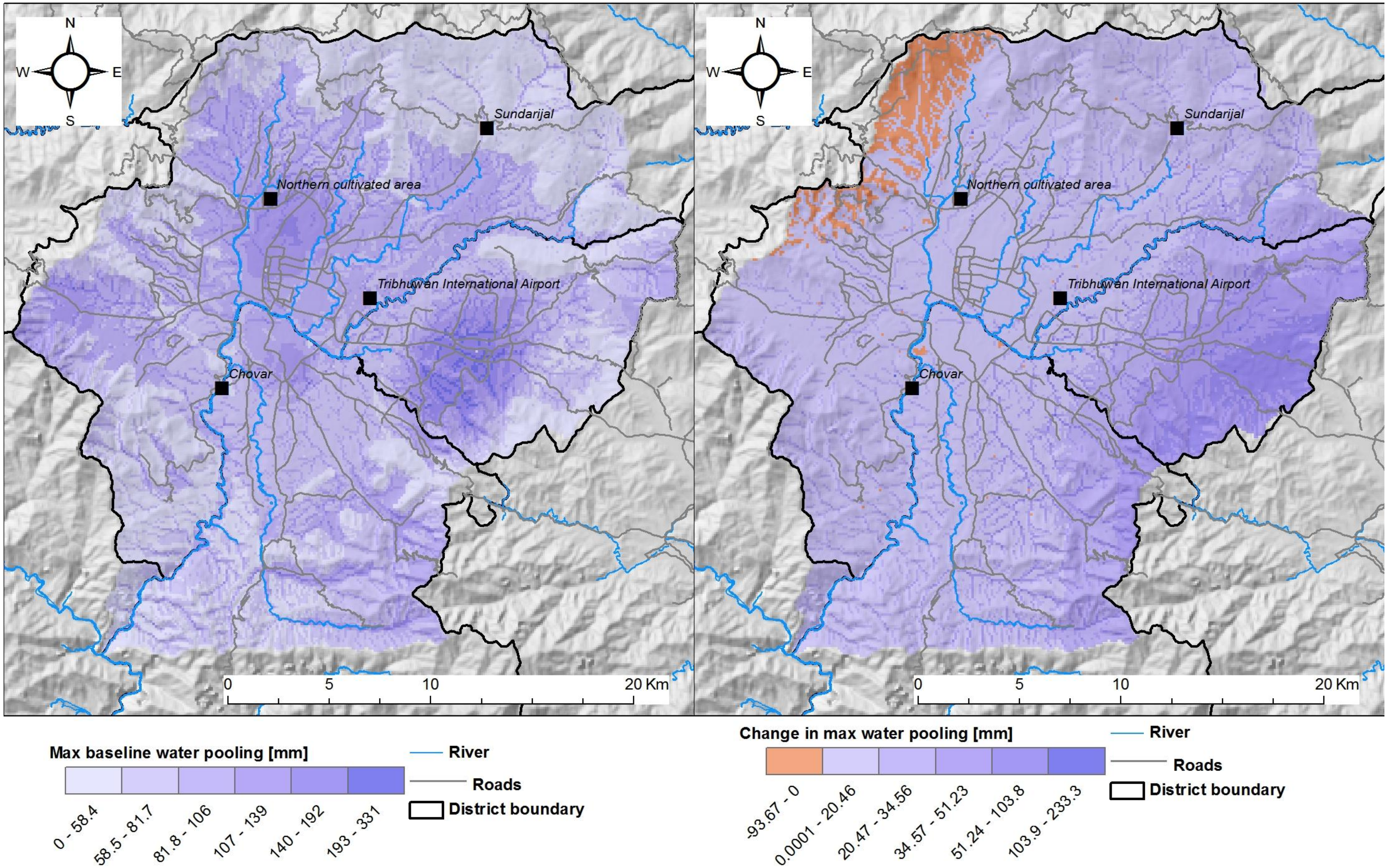


Discharge return periods



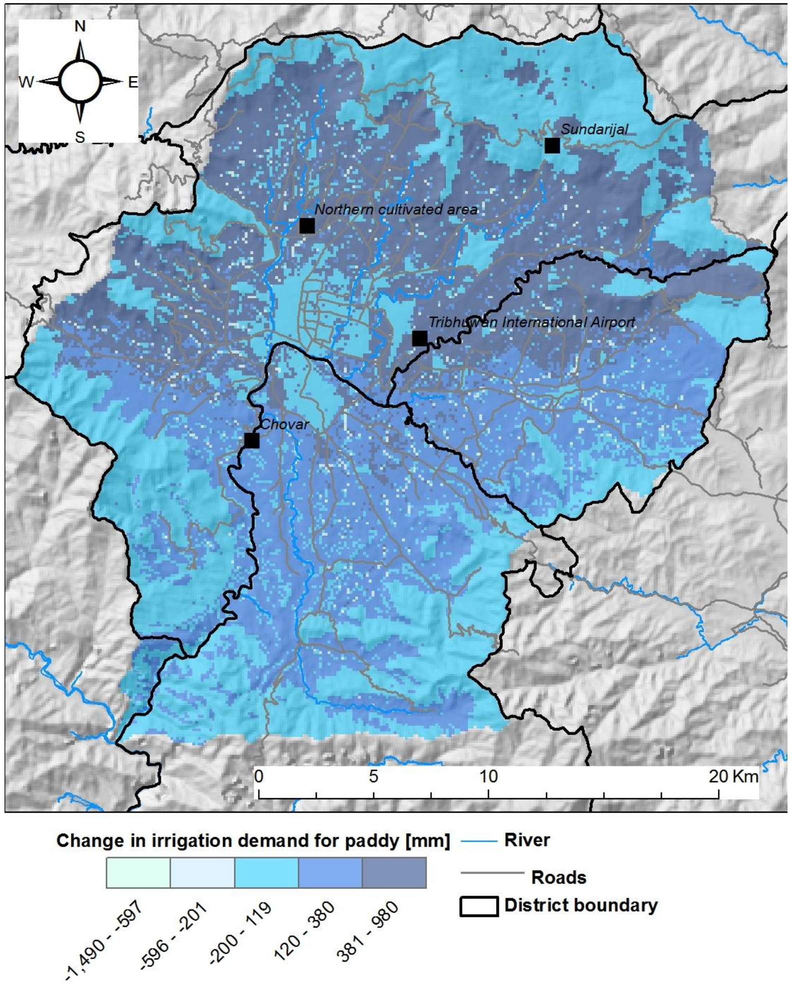


E. GREATER LIKELIHOOD OF PONDING



F. INCREASE IN IRRIGATION DEMAND

Increasing irrigation demand for rice



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 intensity of rainfall	On an average intensities will increase	VH[1,2,3]	H[4,5,6,7]	VH	▪ More rain will lead to more untreated sewer overflows to the Bagmati River adjacent to the Holy Pasupathinath Temple. ▪ More rain means, more rubbish arrive at STP that may block the inlet chamber and also more sediments in sewage means more load on the current treatment process. ▪ Decreased precipitation means, more concentrated sewage reaches STP that attracts more energy and complex processing techniques, adds more burden on STP budget.	VL[8,9,10]	VH

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently.
[2] Location: Asset (Guheshwori STP) is located behind the Holy Pasupathinath Temple. The location of the asset is not only exposed to increase in temperature, rainfall and flow in the river but also any failure to the STP will have a huge impact on the National Heritage site.
[3] Intensity: Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently.More precipitation can be seen in the catchment thanthat was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.
[4] Materials used in the construction of STP are above acceptable level.
[5] The design and construction is safe, adequate and fit for the purpose.
[6] Increased O&M costs are foreseen due to more sediment through increased rainfall.
[7] No good protective measures against increased flow (emergency pumping arrangement) and flat gates at the discharge point to Bagmati River.

Threat		Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increase inBagmati River flow	On an average temperature will increase	VH[11][12][13]	H[14][15][16][17]	VH	▪ Higher water level in the river means, effluent cannot be discharged under gravity, need pumping arrangements (increased energy needs) or else, backup flows in the system that may trigger manhole flooding and pipe surcharges. ▪ Danger of flood waters entering into the STP site and cause serious damage to the STP. ▪ Danger of STP site washed away.	VL[18][19][20]	VH

[8]Limited funds are available with the authority.
[9]Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas.
[10]Technical capabilities are not readily available within the authorities, need more trained staff.
[11]Duration: Increased water level in Bagmati Riveris throughout the year this means longer durations.
[12] Location: Asset is located behind the Holy Pasupathinath Temple. The location of the asset is exposed to extreme flood levels.
[13] Intensity: High flood levels will occur more frequently than before.
[14] Material: Good quality and acceptable standards.
[15] The design and construction is safe and adequate.
[16] Increased O&M costs are foreseen.
[17] No good protective measures against increased flow (emergency pumping arrangement) and no flat gates are provided at the discharge point to Bagmati River.
[18]Limited funds are available.
[19] Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas.
[20]Technical capabilities are not readily available, need more trained staff.

Threat		Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increase intemperature	On an average temperature will increase	H[21][22][23]	H[24][25][26][27]	H	▪ Bagmati River has delicate ecosystems that will be negatively affected if the added water is much warmer. Effluent will likely need to be cooled before discharging, adding cost and energy needs to the process. ▪ Rate of biological reactions is temperature dependant so increased temperature will have huge impact on the treatment process as well as on corrosion of collection system pipes. ▪ Major greenhouse gases evolved from STP are CO2, CH4 & N20, this means STP will contribute to climate change	VL[28][29][30]	VH

[21] Duration: Increased temperatures will be throughout the year this means longer durations.
[22] Location: The location of the asset is not only is exposed to high temperature risks.
[23] Intensity: High temperatures will occur more frequently than before.
[24] Material: Good material and acceptable levels.
[25] The design and construction is safe and adequate.
[26] Increased O&M costs are foreseen due to replacement of corroded pipe lines.
[27] No good protective measures against increased temperature (no corrosion protection measures to the pipe system and also to the equipment within STP).
[28] Limited funds are available.
[29] Material, equipment and spare-parts are not readily available in Nepal, need to import from overseas
[30] Technical capabilities are not readily available, need more trained staff.

Threat		Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in events							
Increasing number of extreme rainfall events	events that used to occur every 50 years will now occur every 15 years						

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 intemperature	Increase in Tmax up to 1.85°C	H[1][2]	M[3]	M	The increase in temperature has affected the sources to run dry. This has the following consequences: - There is less water in the WS system available for daily domestic purposes. Less water means reduced consumption with negative impacts on hygiene and sanitation services as well. - There is need to run the pumping system in the boring site which has economic and technical implications for the users. - There is need to search additional water source as alternative to the seasonal sources. This means more capital investment and operational expenses are required for inclusion of the new sources.	H[4][5]	M

[1]Duration: Long duration of increased temperature will occur more frequently which result in increased evapo-transpiration from the catchments and there will be less water retained in the sub-soil.

[2] Location: The spring sources as assets are appropriately located for connection with the whole WS system. In the past years there was some regularity of the yield in the mid of the rainy season.Therefore the location doesn't play significant role in terms of exposure to the threat.

[3]There is no observed role of the material, design or construction quality of the intakes with regards to the drying up of the sources. The only factor of sensitivity in this case is likely to be the function of the underground recharge system which is greatly affected by the level of holding run-off water in and around the roots of the plants in the catchment area.

[4]The user group has good practice, HR skills and experience of working over the period of several years to address and solve the water shortage issues. The institution is in good capacity to manage the funds and resources for improvement of WS system even in the case of the drying up spring sources.

[5]The user group (committee) has good relation with DWSS and other government agencies to avail technical supports and funds for improvement of the WS system.

Linkages with other sectors

1. Besides of the direct impacts on WATSAN sector, there are other consequences of the drying of the springs and performance of WS system. The obvious and potential effects are: i) difficulty in proper maintaining of environmental health and hygiene at personal/household/community levels; ii) lack of water for kitchen gardening; iii) increased expenses for buying tanker and bottled water.

Note for futurevulnerability assessments

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.

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 intensity of rainfall	On an average intensities will increase	VH[1][2][3]	H[4][5][6][7]	VH	▪ More rain will lead to more flows means the soil and the land around the structure may erode and the structure may collapse within no time. ▪ More rain means, the land around the intake and transmission line are more subjected to severe landslides which would damage the assets and cause disruption of water supplies to the residents.	M[8][9][10]	VH

[1]Duration: Long duration of rainfall events with high intensity will occur more frequently.
[2] Location: Asset is located on the historic landslide area which is highly vulnerable to medium – high intensity rainfall.
[3] Intensity: Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently.More precipitation can be seen in the catchment thanthat was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.
[4]Material used in the construction is concrete and is of international standard.
[5]The design and construction of intake is appropriate but location is in-appropriate.
[6]Increased O&M costs are foreseen due to more sediment through increased rainfall.
[7]No good protective measures against any landslides.
[8]Limited funds are available with the authority.
[9]Material, equipment and spare-parts are readily available in Nepal.
[10]Technical capabilities are readily available within the KUKL authorities.