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WATSAN – CHITWAN DISTRICT VULNERABILITY ASSESSMENT REPORT

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TABLE OF CONTENTS

1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Chitwan District WATSAN Infrastructure

Chitwan district is one of the seventy five districts in Nepal that are located in the inner Tarai areas of Narayani Zone in the Central Development Region. The district takes its name from the Chitwan valley one of Nepal's Inner Tarai Valleys between the Mahabharat and Siwalik ranges, both considered as foothills of the Himalayas. It covers an area of about 2,218 sq. km.

Bharatpur Municipality (BM) is its district headquarters. Chitwan district is centrally located in the country and is made of 40 VDCs and two urban centers such as Bharatpur Municipality (BM) and Ratnanagar Municipality (RM). As per the recent National Census of 2012, the population of the district is 579,984 out of which 279,087 are male and 300,897 are female.

Chitwan district has a very distinct terrain which hosts both plain and mountainous terrain. Due to this unique feature, it is highly challenging to provide both water and sanitation services under one roof. Supply sources and techniques are different for plain and hilly terrain. In order to cater for both terrains, a range of water supply sources with both gravity and pumping or combination of both systems can be seen in Chitwan. The following are the typical water supply and sanitation systems in Chitwan:

- Spring intakes of different types
- Transmission pipes: Mainly HDPE pipes with GI pipes in some places
- Overhead tanks made up of steel and RCC of various capacities
- Reservoirs are mostly semi underground with Corrugated Galvanized Iron (CGI) roofing.
- Break pressure tanks: They are made of Steel and RR masonry
- Water treatment plants of varied capacity
- Distribution pipes: mainly HDPE pipes
- Septic tank system and partially covered sewerage system
- Sewage treatment plant

1.2 Vulnerability Assessments

1.2.1 *Identifying priority assets*

Important criteria for identifying priority assets include:

- Infrastructure of national strategic importance;
- Infrastructure of district strategic importance;
- Infrastructure that has been impacted by past extreme events;
- Infrastructure located in areas prone to past extreme events.

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 the entire 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 system and the operating institutes ability to adjust to cope with existing climate variability or future climate impacts

Based on the above sets of criteria, 2 water supply systems and 1 sanitation facility has been selected as priority assets in Chitwan District. The detailed information on each asset is outlined in the baseline report for Chitwan district. Brief discussion on the asset and its components are outlined below.

1.2.2 Bharatpur Water Supply System- Urban Water System

The Bharatpur WS System is operated by Bharatpur Municipality. Details of the water supply system include:

- Source: Groundwater through tubewells, 18 in total but 16 in operation
- Yield: average yield of each tube well is 25 LPS
- No. of Reservoirs: 5 (2 Overhead tanks and 3 Ground tanks)
- Capacity of OHTs : 400 cu-m and 450 cu-m
- Capacity of Ground Tanks: 1200 cu-m, 900 cum and 1000 cu-m
- Total length of Pipelines: Approximately 360 Km.
- Material of Pipes: DI, GI and HDPE
- No. of existing household connections: About 15,000
- Average demand of new connections: 1200-1500 per year.
- Average water supply duration: 9-10 hours/day
- Expected total connections in next 5 years' time: 28,000

1.2.3 Jutpani Pithuwa WS System – Rural Water System

The Jutpani Pithuwa WS System is operated by Water Users Committee. Details of the system include:

- Source: Karwa River and a RCC collection chamber
- No. of reservoirs - 2 RR masonry type of semi-underground type
- 100 public stand-posts and above 1,200 metered connections
- Pipe line system: from collection chamber hume-pipe of 50cm diameter transmits the raw water to the treatment plant
- Distribution Pipeline: Mostly old GI pipes
- Coverage : 25,000 people and has above 75 km long pipelines

1.2.4 Bharatpur Sewerage System (BSS) – Urban System

The existing sewerage system was built under the ADB funded UEIP project in 2010/11. The current system covers only Wards 1, 2 and 3 of Bharatpur Municipality (designated as C1, C2, and C3 during the project implementation) which is most densely populated areas in the whole city and is considered to be within Narayanghat town.

The each system is designed for 1,200 -1,300 households' however; only 450 households are connected to the system. It is proposed to raise the household connections to 2,800 in next five years.

During the first phase of the project, it was planned to lay the sewer lines in Wards 1, 2, 3 and 4, however they have not been able to complete the sewer laying activities in Ward 4 due to variety of reasons. There are 3 individual sewage treatment plants located adjacent to each other along the Narayani River bank and they provide treatment facilities for C1, C2, and C3. The treatment plants are of reed bed type which is most widely used in developing countries that have proved to be the best treatment technique and falls under World Bank designated DEWATS. The sewage from the designated areas within the covered zone is conveyed through the collection system through the existing trunk sewer and conveyed to the sump well under gravity from where the sewage is passed on to the large collection chamber which is just upstream of the sewage treatment plant. The entire sewerage system is designed as gravity system with no pumping stations or lift stations.

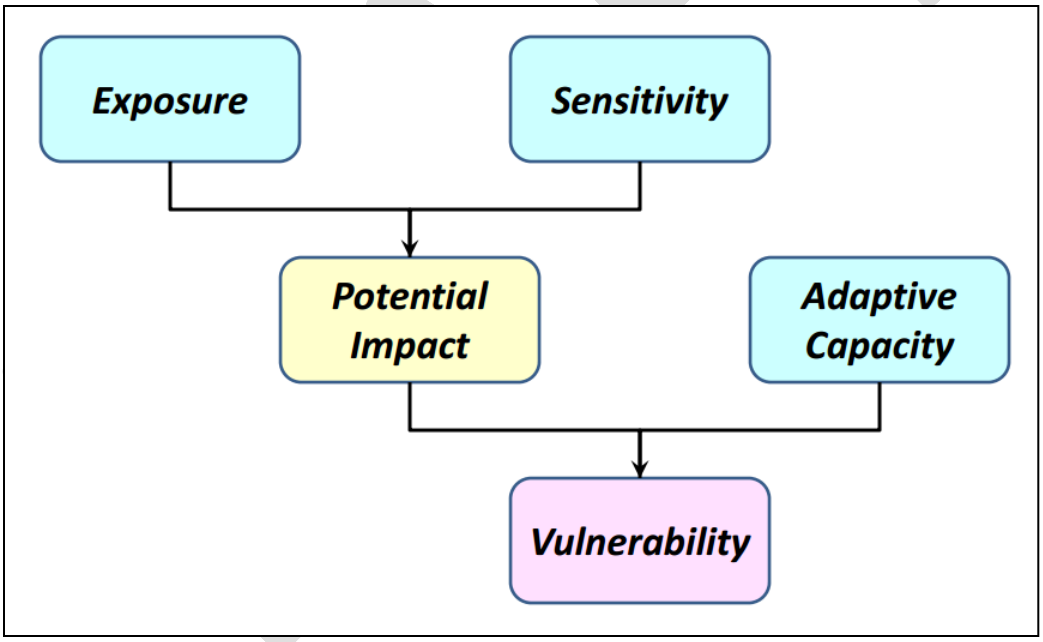
The solid particles are allowed to settle at the bottom of the sump well. The initial anaerobic digestion process takes place within the collection chamber before it is conveyed to the next treatment process. The supernatant from the collection chamber is allowed to flow under gravity into the reed-bed chambers where the main biological action takes place in a semi-aerobic condition. It has been confirmed from the local operator that the effluent from this process is of good quality, meets the local discharge standards; hence, it is finally discharged into the Narayani River.

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 outlines the process.

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, 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				
		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 consistent with other methodological guidelines prepared by UNEP and Peking University (UNEP, 2009) as well as other 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 Chitwan District were prepared by the Hydrological Modeling teams and the information 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 Chitwan 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.
- Increase in precipitation frequency and volume can be foreseen in future, this may trigger more landslides. Precipitation that used to occur at every 30 years, now occur at every 10 years.

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 2^0C.
- 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

Increased flows due to increase in rainfall is expected. Increase in flood water levels in Narayani River has huge impact on WATSAN sector for Chitwan District and peak monthly average flow in wet season will increase by up to 20%

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 Chitwan District is outlined below.

3.1 Bharatpur Water Supply System (BWSS)

3.1.1 Asset Description

Asset Age	**3 years**
Operator	Bharatpur Municipality
Source	Groundwater through tube-wells
Transmission Pipeline	Total length of pipeline system is approximately 360km
Reservoirs	2 overhead tanks (steel type) with each 400 and 450 cu.m. Capacity and 3 ground tanks with each 1,200, 900 and 1,000 cu.m. capacity

Supply Hours	9-10 hrs. per day
Total Connections	Approximately 15,000
Water Treatment Plant	Exists
Distribution Pipeline	Approx. 360 Km including transmission pipeline
Coverage	Bharatpur Municipality area

The following table describes the important aspects of Bharatpur water supply system. **Error! Not a valid bookmark self-reference.**,

Figure **3-2** and

Figure 3-3 show a typical view of the BWS system.

Figure 3-1: Steel overhead tank in BWSS

Figure 3-2: Ratna Nagar WSS

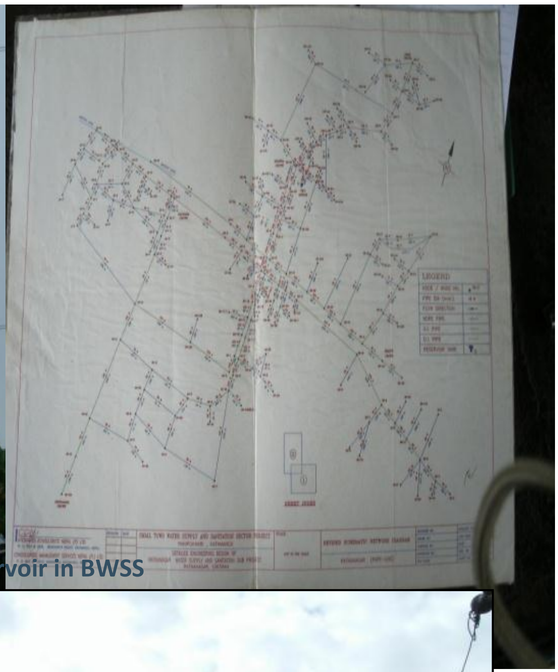


Figure 3-3: RCC reservoir in BWSS

3.1.2 Vulnerability assessment on BWS groundwater system

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

Threat: Increased Intensity of Rainfall

The following threats have been identified as likely to positively impact the entire water supply source system:

- As per the threat profile (see Annexure 1), on an average rainfall intensities will increase by 80%.
- Rainfall events occur more frequently than before

Exposure: LOW

The exposure was ranked as low for the following reasons:

- Location: The existing groundwater sources across the catchment are partially 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 groundwater sources and are not made of any physical material
- 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.

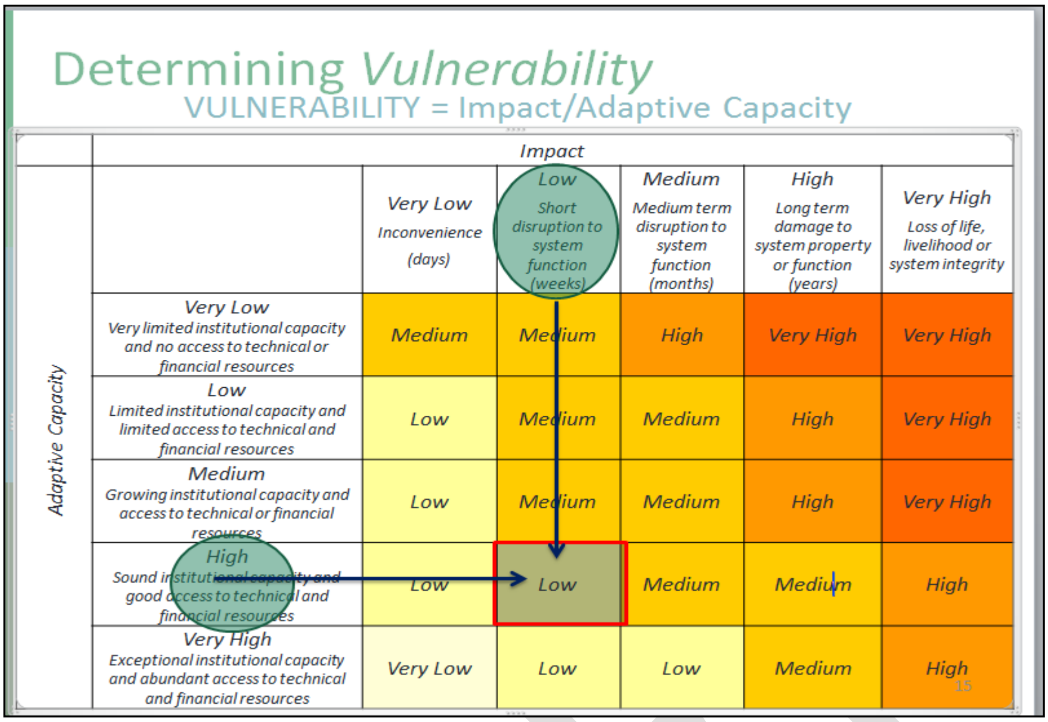
Adaptive Capacity: HIGH

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 within the municipality and through local consulting firms

Vulnerability Scoring: LOW

As per the below guiding matrix, the positive vulnerability for the BWSS is LOW.



	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

<u>Threat: Increased temperature</u>

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 Narayani 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 affects 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 or saturation state. This means, less water percolates through the soil and retards the groundwater recharge.

<u>Exposure: HIGH</u>

The exposure was ranked as high for the following reasons:

- Duration: Increased temperature (up to 2^0C) with longer duration and more frequency is a threat to the reduced water levels in the Narayani River.
- 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 groundwater source.

<u>Sensitivity: LOW</u>

The sensitivity was ranked as low for the following reasons:

- The material, design and construction (in all sources) have no impact.
- 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: MEDIUM

From the guiding matrix, it can be seen that the impact is MEDIUM. The justification for medium 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.

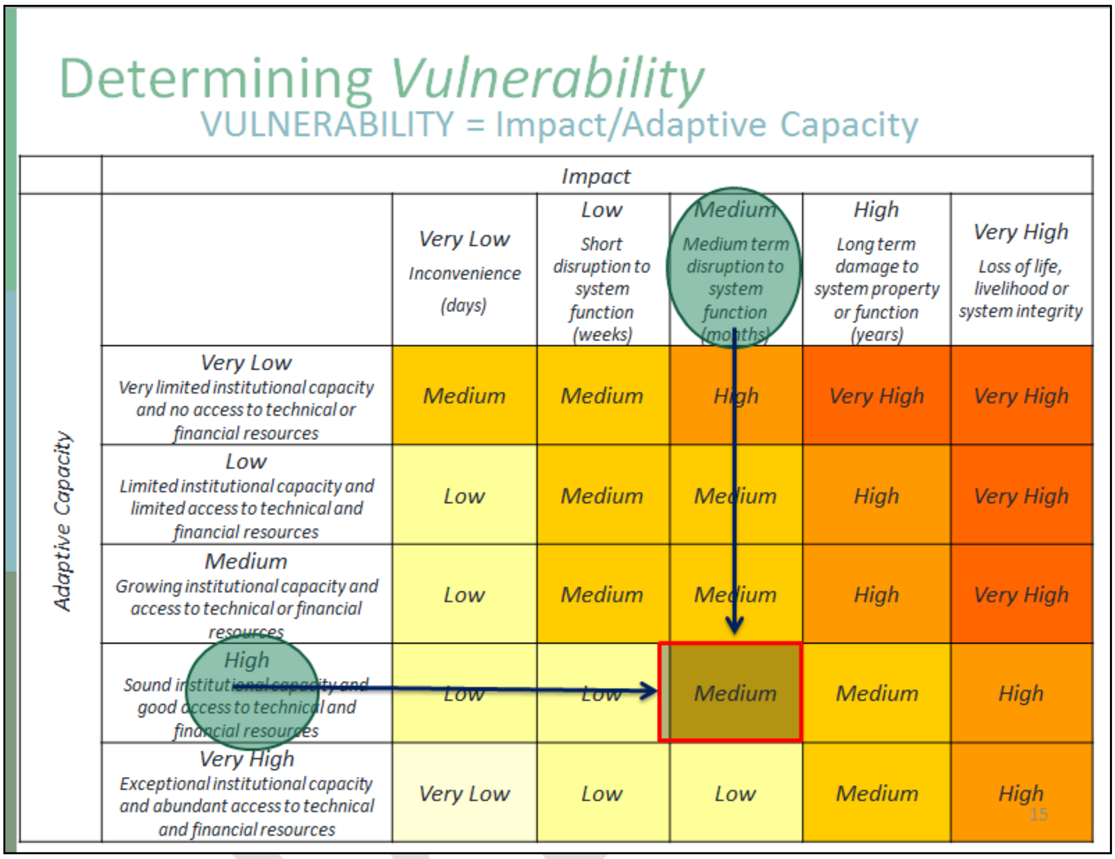
Adaptive Capacity: HIGH

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

- The local authority is supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
- Advanced technical capabilities are readily available through local consulting firms to design more sustainable assets with climate resilient approach.

Vulnerability Scoring: MEDIUM

As per the below guiding matrix, the vulnerability due to the increased temperature for the BWSS is MEDIUM.



Determining *Vulnerability*

VULNERABILITY = Impact/Adaptive Capacity

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

3.2 Jutpani Pithuwa WS System – Rural Water System

3.2.1 Asset Description

The following table describes the important aspects of the Jutpani Pithuwa WS system. Figure 3-4 and Figure 3-5 show a typical view of the intake and surrounding areas.

Area	**Intake structure adjacent to Karwa River**
Type of intake	Concrete structure in a very bad condition
Type of screening facilities	Perforated pipe as screen system
Issues with the system	Frequent overflows from the Karwa River into the intake and frequent damages to the intake structure Could be a major contributor to the increased sediments and organic matter into the system (further research required to confirm) Downstream water treatment plant is not in good working condition and is failed to perform treatment efficiently
Operator	Operated by the local water users committee

Figure 3-4: Intake structure

Figure 3-5: Another view of intake structure

3.2.2 Vulnerability assessment on Jutpani Pithuwa WS system

Threat: Increased Flow in Karwa River

The following threats have been identified as important for the Jutpani Pithuwa WS System:

- Peak monthly average flow in wet season will increase by up to 20%.
- The water levels will go higher

Exposure: VERY HIGH

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

- Location: Asset is located adjacent to the Karwa River and no protection is provided. The location of the asset is exposed to extreme flood levels.
- Duration: Increased water level in Karwa River is throughout the year this means asset is exposed for longer durations.
- Intensity: High flood levels will occur more frequently than before.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Materials used in the construction of intake are of acceptable level.
- The design and construction is inadequate and not fit for the purpose.
- Increased O&M costs are foreseen due to the intrusion of flood water into the intake.
- No good protective measures against increased flows that overflow in to the intake and in majority of the cases chances are that the intake might get washed away by the peak flows from Karwa River.

Impact: VERY HIGH

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

- Danger of flood waters entering into the intake and cause serious damage to the structure.

- Danger of intake structure washed away.
- Public health issues will arise due to the increased sediments and organic matter reaching the intake and very little screening protection available onsite.

Adaptive Capacity: VERY LOW

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

- Limited funds available.
- Technical capabilities are not readily available, need more trained staff.
- No emergency system in place for any sudden collapse of the system.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Jutpani Pathuwa 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 Bharatpur Sewage Treatment Plant – Urban System

3.3.1 Asset Description

The following table describes the important aspects of the Bharatpur STP system. Figure 3-4 and Figure 3-5 show a typical view of the STP.

Area	**3 STP's adjacent and along the banks of Narayani River**
Type of STP	Reed Bed STP
Type of treatment facilities	Both anaerobic and aerobic treatment facilities
Issues with the system	Frequent rise in water level in the Narayani River may cause frequent damages to the treatment plant and associated structures During the complete shut-down of the STP system due to flood damage, may trigger, health and hygiene issues to all the customers that are connected to the STP

	Full restoration of system may take several months, this may lead to serious public health issues to the public of Bharatpur
Operator	Operated by the Bharatpur Municipality

Figure 3-6: STP site adjacent to Narayani River

Figure 3-7: Water level in River under floods

3.3.2 Vulnerability assessment on Bharatpur STP's

Threat: Increased Flow in Narayani River

The following threats have been identified as important for the Bharatpur STP:

- Peak monthly average flow in wet season will increase by up to 20%
- The water levels will go higher

Exposure: VERY HIGH

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

- Location: Assets are located adjacent to the Narayani River and no protection is provided. The location of the asset is exposed to extreme flood levels.
- Duration: Increased water level in Narayani River is throughout the year this means the assets are exposed for longer durations.
- Intensity: High flood levels will occur more frequently than before.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Materials used in the construction of intake are of acceptable level.
- The design and construction is adequate and fit for the purpose but not a SAFE location.
- Increased O&M costs are foreseen due to the intrusion of flood water into the STP.

- No good protective measures against increased flow (emergency pumping arrangement) and flap gates at the discharge point to Narayani River.

Impact: VERY HIGH

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

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 Bharatpur STP 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 CHITWAN DISTRICT VULNERABILITY SUMMARY

4.1 Summary of VA Results

4.1.1 Bharatpur WS System

The table below summarizes the vulnerability assessment of the Bharatpur water supply system. The analysis shows that the assets are not vulnerable to increased rainfall events; in fact, they produce positive results such as increased groundwater recharge. In contrast, the increased temperature would result in decreased groundwater levels.

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

4.1.2 Jutpani Pathuwa WS System

The table below summarizes the vulnerability assessment of the Jutpani Pithuwa WS system. The analysis shows that the intake system is ranked as highly vulnerable.

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED FLOW IN RIVER	VERY HIGH	HIGH	VERY HIGH	VERY LOW	**VERY HIGH**

4.1.3 Bharatpur STP

The table below summarizes the vulnerability assessment of the Bharatpur STP system. The analysis shows that the system is ranked as highly vulnerable.

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED FLOW IN RIVER	VERY HIGH	HIGH	VERY HIGH	VERY LOW	**VERY HIGH**

4.2 Most Vulnerable Assets and its Components

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

Bharatpur WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Groundwater Sources			
Increased Temperature	Increased temperature events occur more frequently and in higher degree	Water level in the Narayani River goes down and thus impacts the groundwater aquifers	The groundwater aquifers are controlled by the water level in the River. Reduced water levels cause, less water supplies to the public.
Increased Rainfall	On an average rainfall intensities will increase by 70%. Rainfall events occur more frequently	Positive impact due to increased groundwater recharge	Provides more reliable water supplies with uninterrupted supply

Jutpani Pithuwa WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased water level in the Karwa River	On an average the water levels in the River will increase by 1m.	Impacts the operation of intake and damages to the screening system happens more frequently. Increased water level in Karwa River will induce overflow in to the intake and in some cases the intake may get washed away.	Failure of intake causes serious damages to the water supplies to the public and no water scenario causes health & hygiene issues to the residents that are connected to the system.

Bharatpur STP

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
increased flow in Narayani River	More rainfall and frequent Increased flow for longer durations may happen more frequently	Impacts the operation of STP and damages to the equipment happens more frequently. Increased water level in Narayani 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.	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.

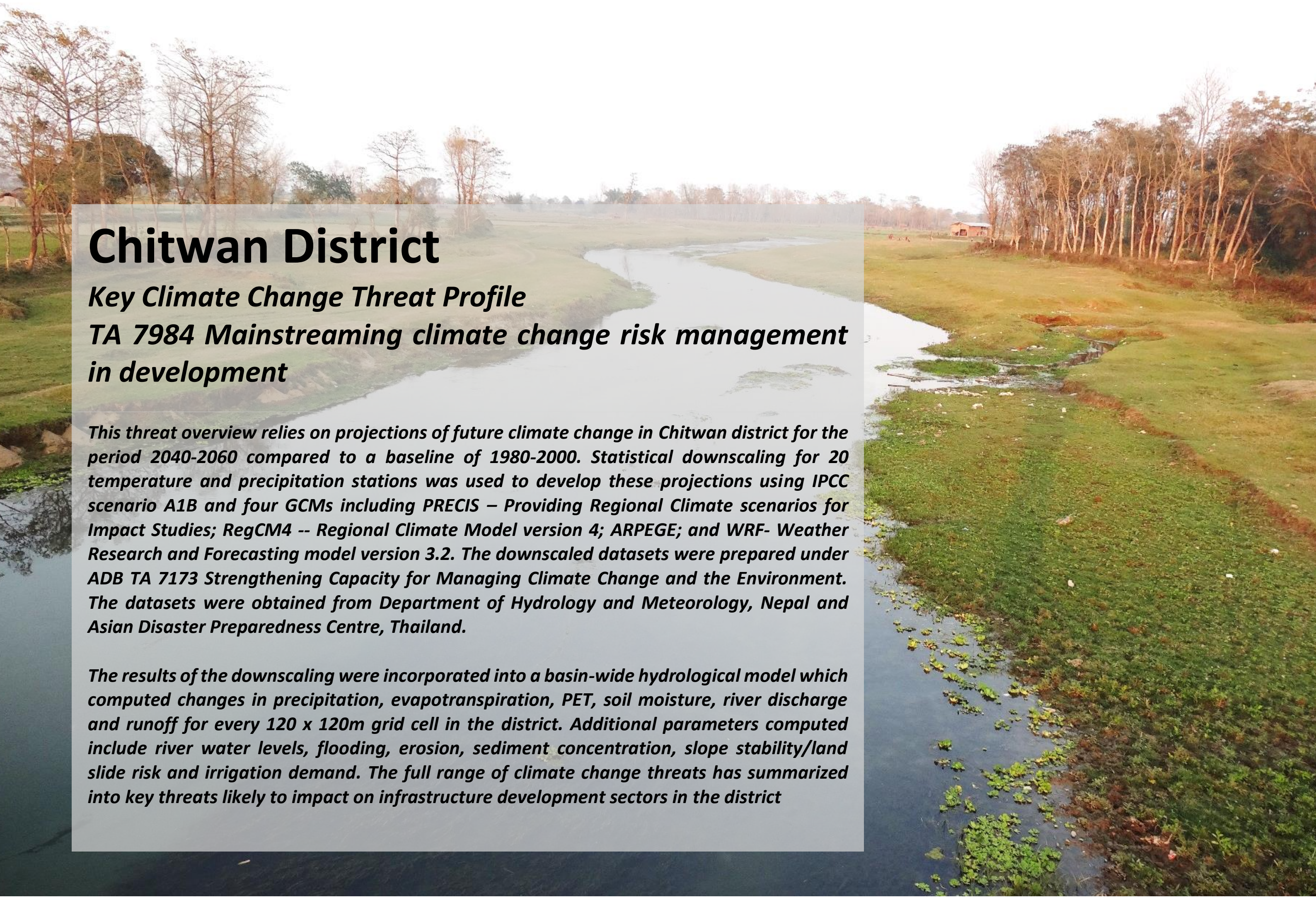
4.3 Lessons and Application to Other Assets

Chitwan 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 same impacts, vulnerability and adaptation plans can be applied to wider urban and rural areas within the district. Majority of the water supply and sanitation assets 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 protecting the rural intake points, sediments that are arriving at the intake and reservoir system. This can be achieved through simple construction of intake structure with proper screening facilities. 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, in the sanitation sector within Chitwan, the Bharatpur STP is constructed along the banks of Narayani River and the system is extremely vulnerable to the increased water level in the River and also flash floods. The STP's either shall be protected from the impact of increased water levels by constructing a bund along the STP's or completely relocate them to a more safe location. The same approach and adaptation plans can be applied across Chitwan.

ANNEXES

ANNEXURE 1: THREAT PROFILE



Chitwan 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 Chitwan 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

CHITWAN DISTRICT – KEY CLIMATE CHANGE THREATS

A. **Increasing maximum temperatures** - increase in average maximum wet season daily temperature 2 °C

B. **Increasing number of extreme rainfall events** – events that now occur every 30 years are projected to occur every 10 years

C. **Increasing wet season flow in the Rapti River** – peak monthly average flow in wet season will increase by up to 20%

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

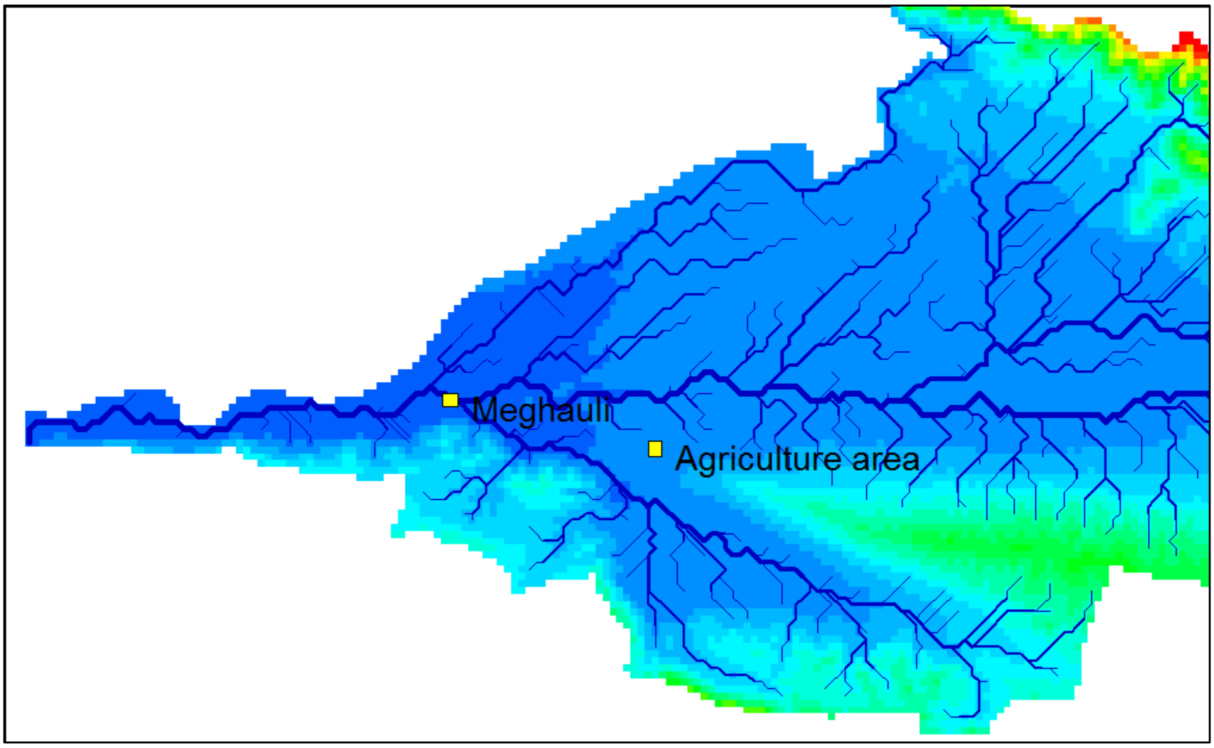
Climate change: 2040 - 2060 (**"2050"**)

Wet season: 15 May to 30 September

Dry season: 1st January to 14th May and 1st October to 31st December

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

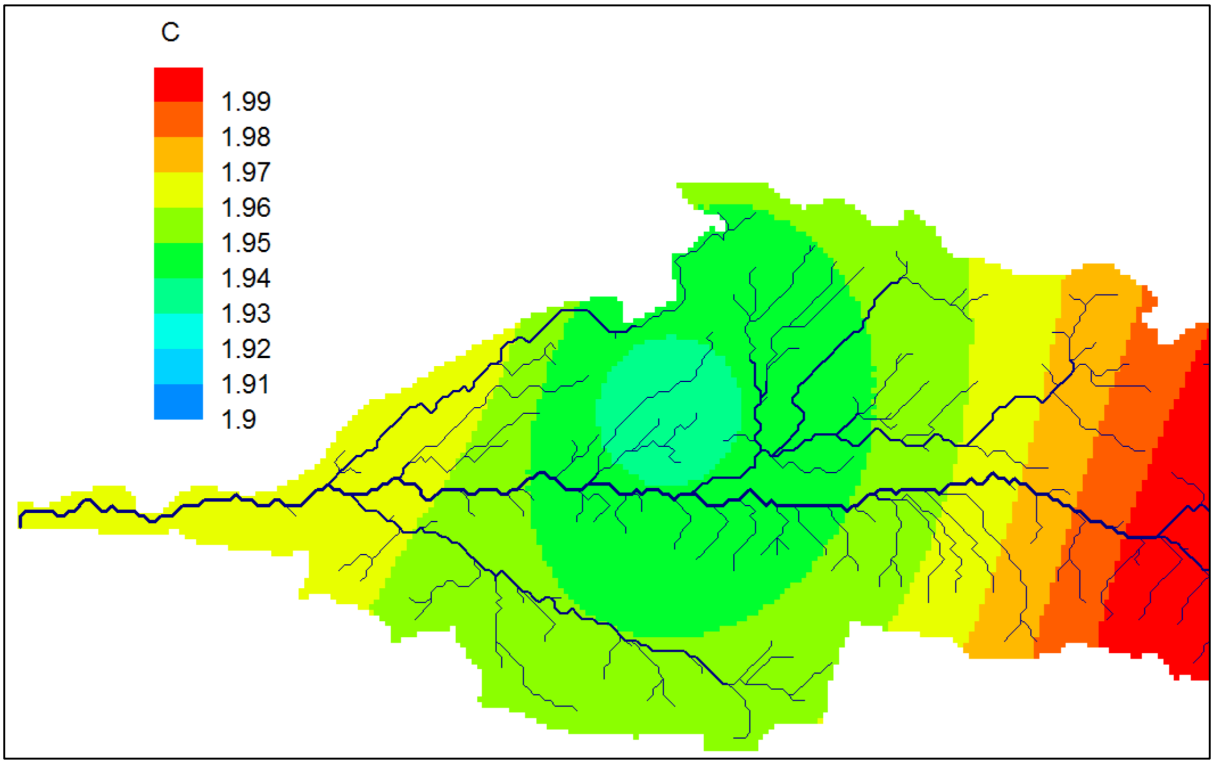
- Meghauli – West of the district at low elevation
- Agrriculture area – west of the district at low elevation



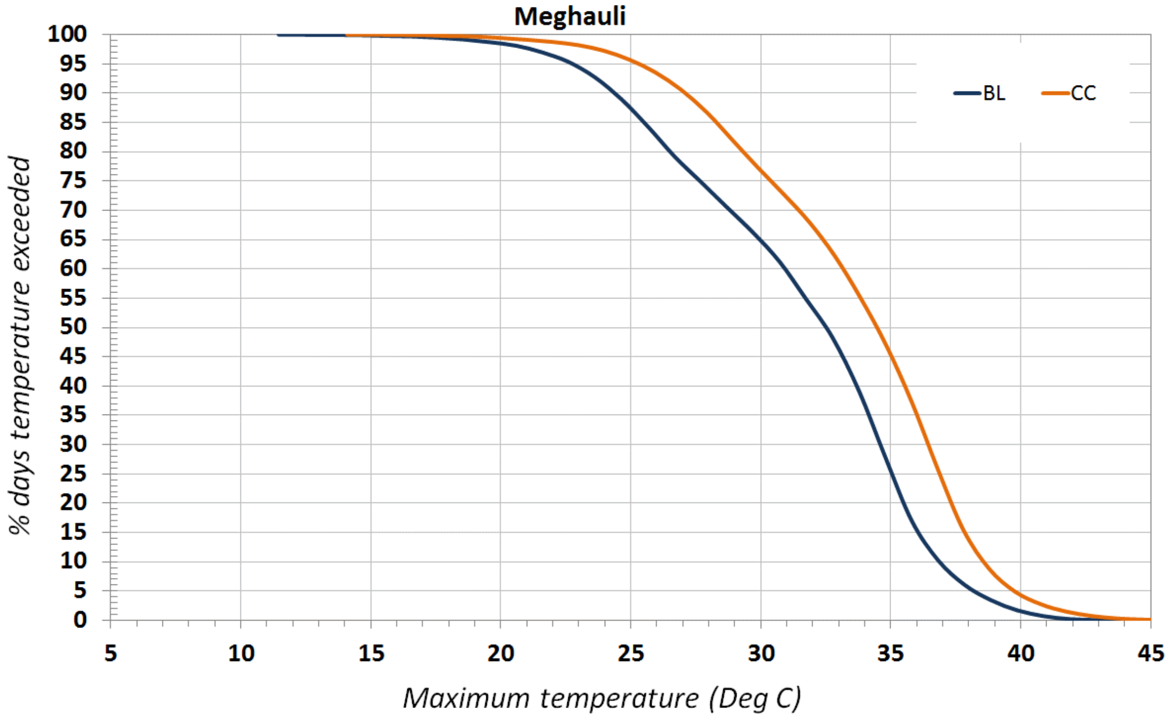
SUPPORTING ANALYSIS

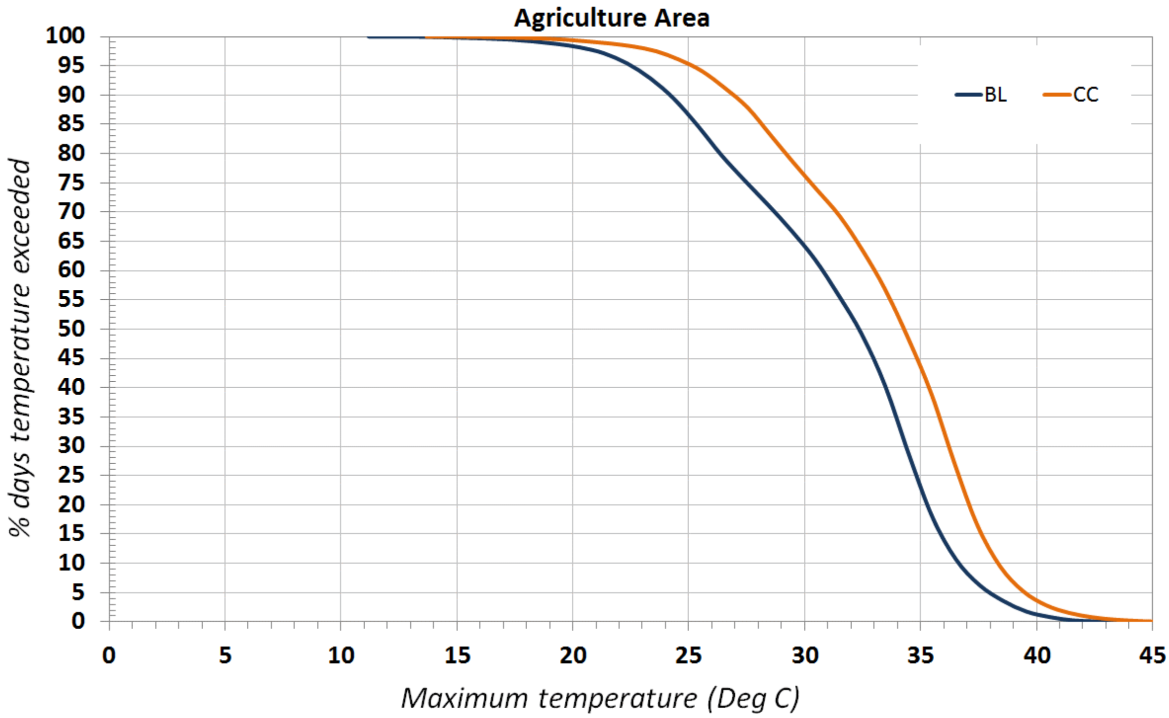
A. INCREASING MAXIMUM TEMPERATURES

Wet season average maximum temperature change



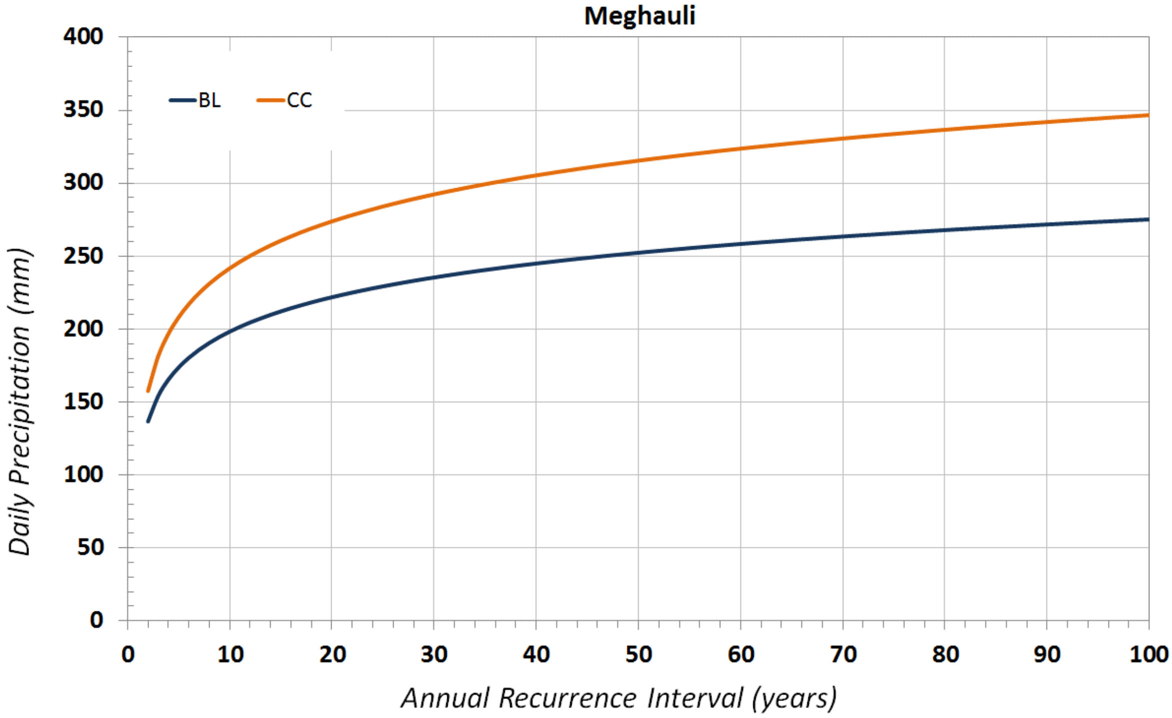
Daily maximum temperature exceedance curves

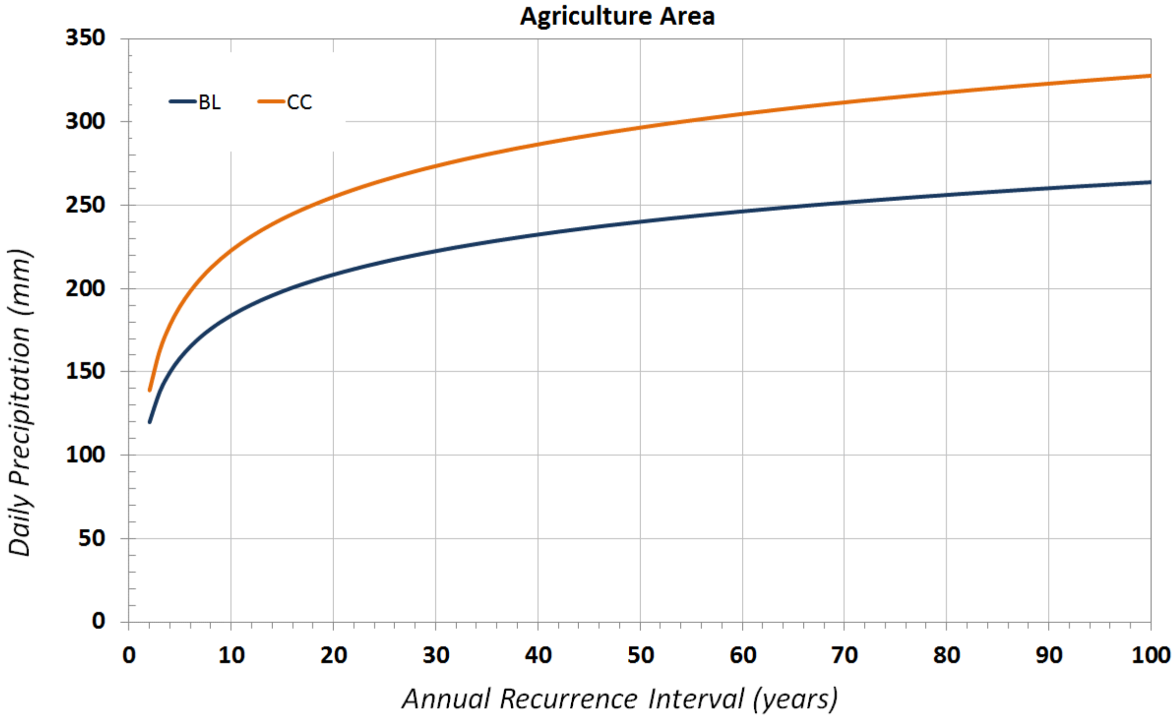




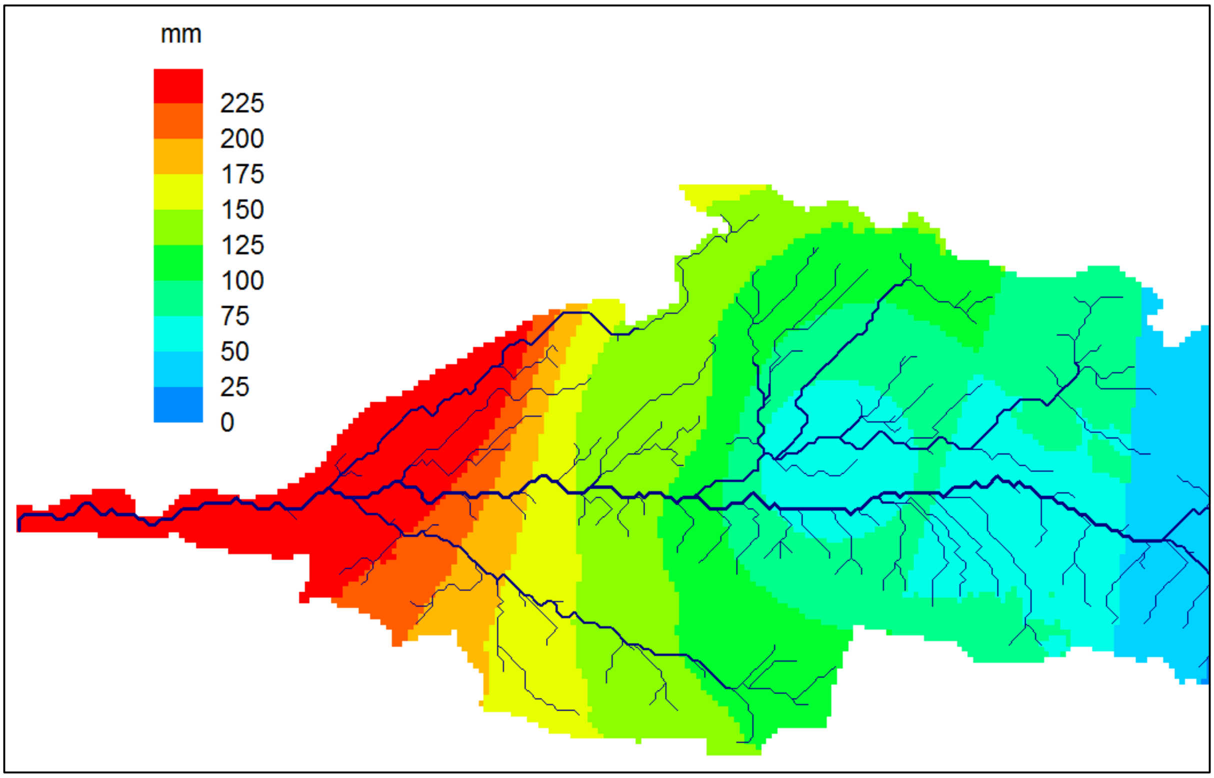
B. INCREASING NUMBER OF EXTREME RAINFALL EVENTS

Change in annual recurrence interval



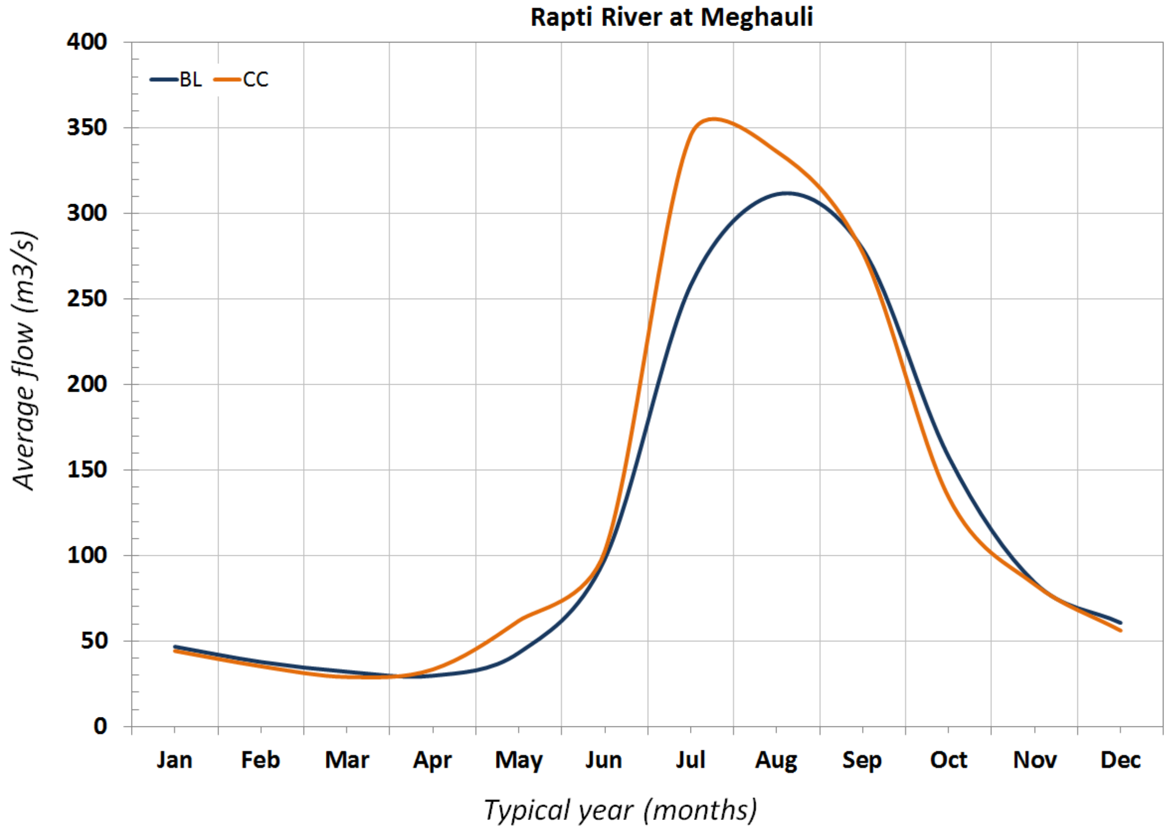


Change in total wet season precipitation

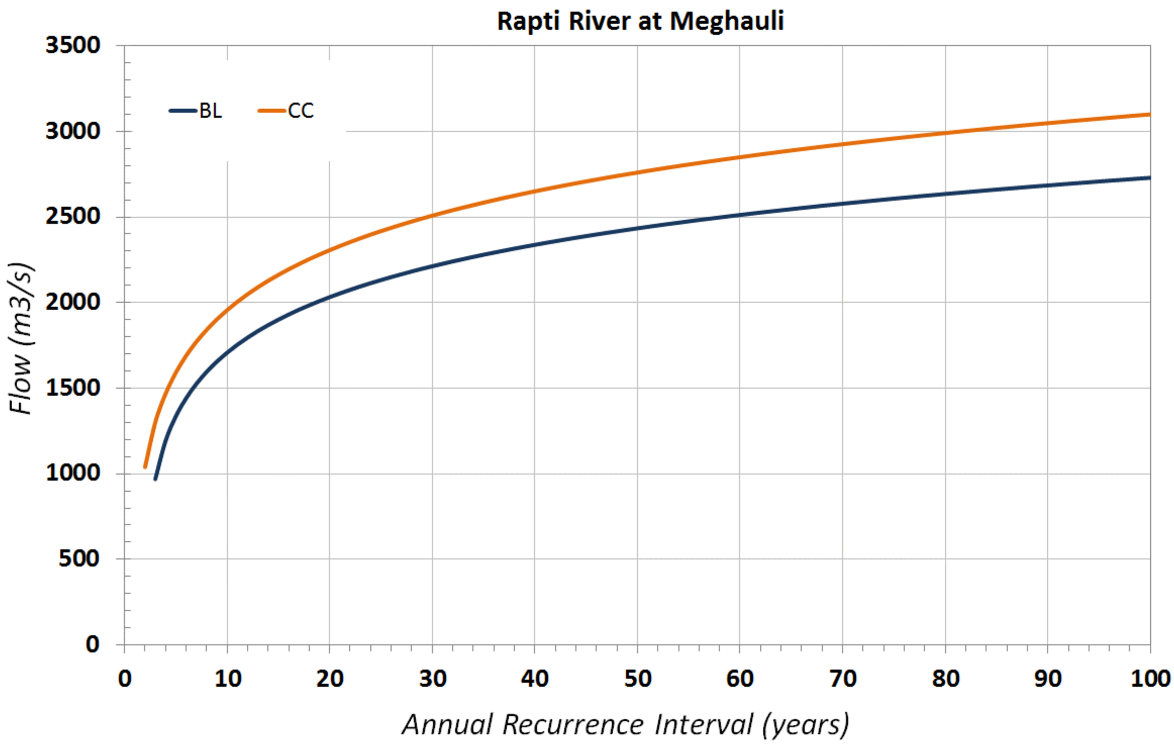


C. INCREASING WET SEASON FLOW IN THE RAPTI RIVER

Hydrographs



Discharge return periods



ANNEXURE 2: VA MATRIX

Asset: Bharatpur STP

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							
Increased flow in Narayani River	On an average increase in flow is estimated to be70% and an average WL increase of 1 m.	VH[1 2 3]	H [4 5 6 7]	VH	• 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.	VL[8 9]	VH

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently that brings more flows to the identified site.
[2] Location: The STP is located adjacent to Narayani River that could bring flash flows due to increased high-intensity rainfall.
[3] Intensity: Increase in precipitation frequency and volume would make the location more vulnerable for flash flows that would trigger shock-loads at the STP.
[4] Materials used in the construction of STP are of above adequate level.
[5] The design and construction of STP is not SAFE.
[6] Regular maintenance at the STP is performed by the authorities.
[7] There were no protective measures for STP.
[8] The local authority is not supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
[9] Advanced technical capabilities are not readily available through local consulting firms to design more sustainable assets with climate resilient approach.

Asset: Bharatpur Water Supply System

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate							
Increase in precipitation	On an average intensity of rainfall increases by 80%.	L[1] [2] [3] [4]	L[5] [6]	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[7] [8]	L
Increase in temperature	Increased temperature (up to 2^0C) with longer duration	H	L	M	Less water available in the WS system. Less water means reduced consumption with negative impacts on hygiene and sanitation services as well.	H	M

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently.
[2] Location: Located in the high-intensity rainfall zone
[3] Intensity: 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.
[4] Located on SSW facing slope this means more susceptible to longer duration precipitation.
[5] No materials used in the construction of groundwater sources.
[6] The municipality are maintaining the assets at the moment and the condition of assets is good.
[7] The assets are under the control of municipality and have adequate funds to enhance the assets that are/will affected by climate change events.
[8] Advanced technical capabilities are readily available within the municipality to design more sustainable assets with climate resilient approach.

Asset: Jutpani Pithuwa WS System

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							
Increased flow in Karwa River	On an average increase in flow is estimated to be70%.	VH[1 2 3]	H [4 5 6 7]	VH	• Danger of flood waters entering into the intake and cause serious damage to the structure. • Danger of intake structure washed away. • Public health issues will arise due to the increased sediments and organic matter reaching the intake and very little screening protection available onsite.	VL[8 9]	VH

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently that brings more flows to the identified site.
[2] Location: The intake and the storage reservoir are located just u/s of the wide catchment basin that could bring flash flows due to increased high-intensity rainfall.
[3] Intensity: Increase in precipitation frequency and volume would make the location more vulnerable for flash flows that would trigger shock-loads at the source point
[4] Materials used in the construction of intake, reservoirs, transmission and distribution lines are of above adequate level.
[5] The design and construction of intake point is not SAFE.
[6] Regular maintenance at the intake is performed by the authorities.
[7] There were no protective measures for intake.
[8] The local authority is not supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
[9] Advanced technical capabilities are not readily available through local consulting firms to design more sustainable assets with climate resilient approach.