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MYAGDI DISTRICT VULNERABILITY ASSESSMENT REPORT:

URBAN SETTLEMENTS AND INFRASTRUCTURE (USAI)

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Version	*B*

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I. DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Urban Settlements and Infrastructure (USAI) in Myagdi District

As discussed in the district baseline study, strategic infrastructure in urban sector in Myagdi district provides a basis for identifying the district assets/systems for vulnerability assessment. It consists of the riverside settlements as well as those settlements located in the terraced slopes, the buildings (both public and private buildings) and the other infrastructure components –the road network, water and sanitation, storm drainage system and solid waste, rain water harvesting. Those are largely confined within Beni town (district headquarter) and few other larger market centres, namely Darbang, Galeswor, Sinja Tatopani and Bhurung Tatopani.

The major components of strategic infrastructure in the USAI sector fall under the jurisdiction of: the DUDBC within Ministry of Urban Development (MoUD); the local bodies (DDC and VDCs); the district line agencies related to roads, water supply and sanitation; and the town development committees (TDCs). The district baseline study is confined to only those assets in the USAI sector created through the annual programs of DUDBC spanning a period of 3 fiscal years from 2010 to 2013. Those assets relates to: government buildings, urban amenities (e.g. temple complex, bus parks etc), and infrastructure like road and drains. (Please refer Annex F, Myagdi Baseline report).

The building sector includes the buildings for the various government offices, health related buildings, community buildings and the rain water harvesting system being established at district government hospital at Beni town (also referred to as Beni Bajaar) as reflected by the annual programs of DUDBC division office. The land use plan and zoning frame work, and the land development programs falls under the jurisdiction of the TDC responsible for planned development of Beni town.

As presented in the baseline report, the above programs are formulated and executed within a planning framework as stated in the district sector master plan which includes the DUDBC Baglung Division Offices's annual programs for Myagdi district. The priority assets based on the assets inventory, as the Table 1 and Myagdi Map (figure 1) indicates, is confined within three urban settlements areas: Beni, Sinja and Bhurung Tatopani. The field observations were limited to those three areas, as the other market centre could not be visited owing to the time constraints as well as the access difficulties due to the rainy season.

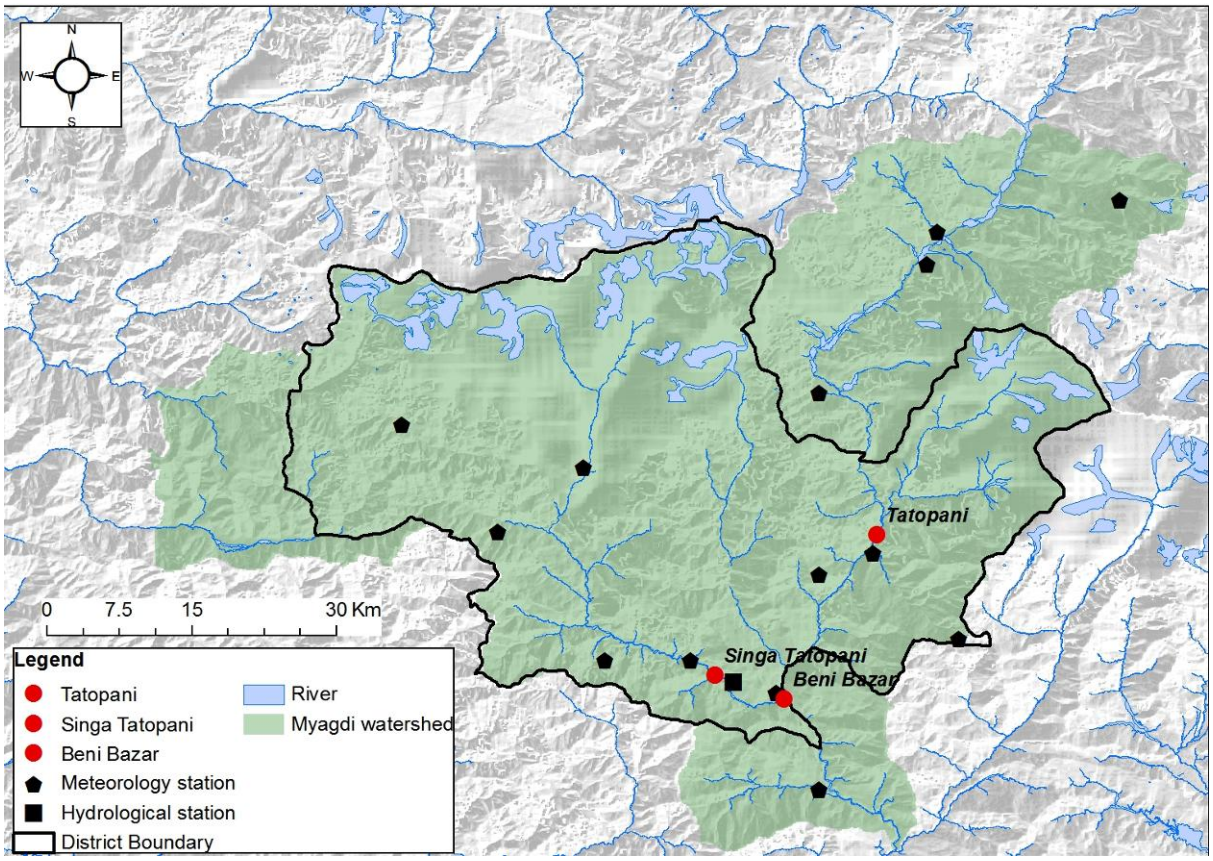

Figure 1.1: Myagdi district map and Location of the assets in the district.

The assets/systems in the urban sector within the district (total area 2297 sq.km, altitude 817 m – 8167 m) are very much influenced in terms of climate change by the following factors:

1) The characteristic geographic features of the district consisting of the river basins, mid-hills and high mountains, and northern high Himalayan region occupying 8%, 56% and 36% of the total area of the district respectively.

2) The major river systems with their tributaries (Kali Gandaki, Myagdi, and Raghu Ganga), which defines the watershed areas for the urban and rural settlements within the district (see the figure 1).

3) Climatic diversity ranging from the sub-tropical climate in the river basins below 1000 m altitude, and the temperate climate in the Mid-Hills below 2000 m up to cold temperate and alpine climatic conditions in the high mountains (2000 -5000 m) and Himalayan region (above 5000 m) respectively.

4) A wide variety of settlement typologies (agglomerated, compact, linear and dispersed settlements), responding to cultural and natural diversities, found in the district within the river basins and along the 'Tar' and terraced slopes.

1.2 The Priority Assets for Vulnerability Assessments.

1.2.1 Identifying priority assets

Identification of the priority assets were carried out on the basis of:

i. The field visits to the three areas - Beni Bazar, the seat of district headquarter; Sinja Tatopani market center at a distance of 30 km and two hours drive from Beni; and Bhurung Tatopani market center at a distance of 60 km and 3 hour drive from Beni.

ii. Due consultation with the DUDBC officials at Baglung office and with the officials of the different district level government offices including the technical and administrative staff members of Arthunge VDC where Beni, the district headquarter, is located;

iii. The concerned local persons including the business persons, and the individuals from the various walks of life at Beni Bazar, Singa and Tatopani market centres.

The key criteria for the assets prioritization were:

- 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

In addition the potential aspects contributing to vulnerability were considered. On the basis of the above criteria the following assets were short-listed:

Table 1: The Priority Assets in Myagdi district

S.No.	Assets	Infrastructure type	Reason for inclusion
1	Kaligandaki Riverside Settlements at Beni Bazar. (Kali Nadi – Myagdi Nadi 1500 meter)	Built-up urban areas	Past land slide and flooding
2	Beni Infrastructure Development (Road & Drains)	Urban infrastructure	Past flood event, as well as the adaptation measures to respond to haphazard growth and infrastructure deficiency in the town.
3	Land Fill Site	Urban facility	Past Flood Event & Inundation
4	Sinja Tatopani (Sinja VDC)	Built-up urban areas	Past flood and landslide
5	Primary health Centre, (Bhurung Tatopani)	Social Infrastructure	Past land slide, mainly falling boulders.

Two assets out of 5 short-listed USAI assets as stated in Myagdi Baseline Report (Section 2.2.1) - Kaligandaki Riverside Settlements at Beni Bazar and Beni Infrastructure Development (Road & Drains)- were selected as priority assets for vulnerability assessments and adaptation planning in Myagdi District. The detailed information on each asset is outlined in the baseline report for Myagdi district. Brief discussion on those two assets and its components are outlined below.

1.2.2 Asset I: Kaligandaki Riverside Settlement at Beni Bazar

The asset consists of a cluster of houses taking a shape of the linear urban form along with the 1500 m road along the bank of the Kali Gandaki river. A majority of the buildings are RCC structures with multi-storied construction located along the vertical cliff and sloped terrain. The asset is located at the south eastern edge of the Beni town between the suspension bridge and Kali Nadi bridge that links Beni to Parbat District. The Beni town itself is located at the confluence of Myagdi and Kali Gandaki Rivers (see Map 2), and falls within Wards 1 & 2 of Arthunge VDC.

Landslides along the vertical cliff and sloped terrain, which consists of loose conglomerates, remain the serious potential environmental hazard in the area. The whole Beni Bazar was spontaneously developed without proper planning, zoning regulations and proper building by-laws, and with non-compliance of the building code to guide the construction of buildings suitable for the hill topography of the area. This would weaken the disaster resiliency of the asset in terms of climate change.

1.2.3 Asset II: Beni Infrastructure Development (Road & Drains)

The asset- the road pavement and a network of storm drains - is located at the lower main road of the Beni town (Bazar) that links the district hospital and the stadium. The road is around 1 km long stretching from south to north where the hospital is located.

The whole Beni town is a linear settlement sloping from west to east wedged between the sloped forest and the Kali Gandaki River. The asset forms the lower eastern section of the settlement (see the map).

II. VULNERABILITY ASSESSMENT METHOD

2.1 A Brief Summary of the VA Method

The VA method followed to assess the vulnerability of urban settlements and infrastructure (USAI) assets is a widely used technique and tested in several parts of the world. **Error! Reference source not found.** outlines the process which shows that vulnerability is a function of exposure of a particular USAI asset to climatic variation, sensitivity measuring a degree of effect, and adaptive capacity indicating the ability of the asset system to adjust to climate change. In short, vulnerability = f (exposure, sensitivity, adaptive capacity). Further details follow below.

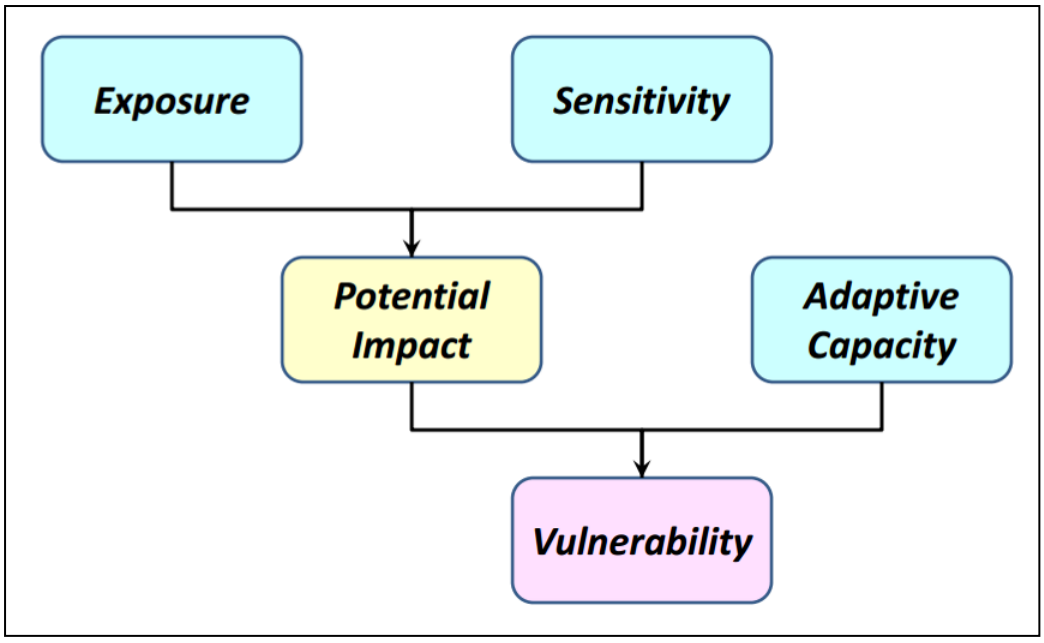

Figure 0.1 : The VA Process

1. **Exposure** refers to the extent to which an asset comes into contact to climate change (CC) threats seen in terms of change and shift in regular climate (temperature and precipitation) and in the CC events (e.g., increases in flood water levels, flash floods, localized pooling/inundation, storms, landslides, drought). The greater the exposure, the higher the sensitivity to climate change. For example, the USAI 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 threats towards the asset and the magnitude of the events.

2. **Sensitivity** is the degree to which an asset is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or by the magnitude of the

specific CC events. In other words, sensitivity refers to how the asset or system fares when exposed to the CC impacts. In the case of USAI assets, sensitivity is governed by the overall physical status of the settlements and its component structures, the materials used in the construction and its quality, levels of maintenance, the extent of planned development.

3. **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:

	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*

Figure 2.2: Determining Impact

4. **Adaptive Capacity** refers to the ability of an asset system to adjust to cope with existing climate variability or future climate impacts. This takes into account: the range of available adaptation measures, materials, technologies and funds to meet adaptation needs; local skills and knowledge base; the related institution's management capacity and responsiveness; and the relevant polices and strategies adopted by the institutions that make such adaptation to happen.

5. **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:

		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

Figure 2.3: Determining Vulnerability

2.2 Application of the VA Method to the USAI Sector

The approach used for this vulnerability assessment is consistent with other methodological guidelines prepared by UNEP as well as other international VA processes that are widely used in several projects across the globe.

Vulnerability assessment is an useful tool for the USAI assets for identifying potential risks of climate change, including climate variability and extremes. Apart from detecting threats, vulnerability assessment of the USAI assets will also identify gaps in existing information, and will also provide the appropriate indicators and management measures to reduce negative impacts. Moreover, the assessment enhances public awareness about potential threats to the USAI assets. It would also help the decision-makers with options to evaluate and modify existing policies, and to implement measures to improve urban settlements management and infrastructure services. Specifically, the VA assessment would help to:

- Assess the vulnerability of existing urban settlements (market towns/service centers) and their constituent components to CC threats, and its impact on development options, human well-being and the environment;

- Identify the potential impacts of climate change on the urban ecosystems including the USAI components, and assess the current adaptive capacity of the urban sector;
- Create a knowledge base of scientific data and information on urban sector including urban settlements and infrastructure components;
- Evaluate the impacts of environmental change in the urban system and identify management challenges;
- Examine urban sector issues and develop the policy options to respond to the CC threats;
- Identify gaps in data and research and recommend needs for further studies;

2.3 Climate Change Threat Profiles

The climate change threat profiles for Myagdi District were prepared by the Hydrological Modeling teams and the information passed on to all the experts after the field visits. The year 1980-2000 was taken as the base year, and the climate change was projected up to the year 2050. Following four point sources were used for analysis:

1) Tatopani – East of the district at low elevation and on Kali Gandaki River;
2) Mangla Ghat – Centre of the district at low elevation;
3) Central Floodplain – Centre of the district at low elevation;
4) North mountain area – North of the district at high elevation

The threat profile is annexed in Annexure 1. The climate change threat profiles for Myagdi were studied and their relevance to the USAI sector is outlined below:

(A) Increase in temperature

Looking in to the threat profile for temperature (Annex 1A) the following conclusions can be drawn:

- Increase in average maximum temperature of up to 1.7^{o} C in the summer.
- Mangla Ghat station temperature data seems more relevant for both the assets located at Beni. The data indicates, there would be an increase in average maximum temperature up to 1.6^{0} C, and the duration of such higher temperature will be longer. This means, a temperature of 25^{0} C which presently persists for 25% of days temperature exceeded, would be 38% by the year 2050, and would increase up to 27^{0} C. This implies that a higher temperature would persist during the wet season triggering a longer summer period by the year 2050.

(B) Increase in precipitation and Rainfall return periods

Precipitation vs annual recurrence interval curve (Annex 1 C: Mangla Ghat station data) shows an increase in precipitation occurs more frequently. More precipitation is being forecasted in the Beni catchment area in future. For example, 80 years event with 100 mm

of daily precipitation would occur every 5 years in 2050, and the precipitation will increase up to 170 mm implying an increase of 70% by 2050. Similarly, by 2050 in the Beni area, 30 year event which presently delivers 85 mm per day, will occur every 4 year, and by 2050 will deliver 155 mm implying increase of 82 % in the precipitation level. The corresponding data for 20 year event would be 2 years delivering daily precipitation of 80 mm and 140 mm implying an increase of 75 % by 2050. The above findings indicate that increase in precipitation frequency and volume which can be foreseen in future would trigger more landslides and flood events affecting the urban and rural settlements in the district.

(C) Increase in flows

Since the asset is situated at the confluence of Myagdi and Kali Gandaki rivers due to increasing intensity and frequency of extreme rainfall events, both the rivers would experience increased wet season flows as well as the higher water levels as a result of climate change by the year 2050. Following are the pertinent features as a result of climate change (Annex . 2C)

- Average peak monthly average flow in wet season flow during the months of July/August on the Kali Gandaki River at Tatopani Kali will increase by up to 50 %. It is being reported that the peak average flow in wet season will increase by up to 89% on the whole in the river.
- Average peak monthly average flow in wet season flow during the months of July/August on the Myagdi River at Mangla Ghat Tatopani Kali will increase by up to 6 %.
- Frequency of maximum instaneous flood return periods also would increase considerably as seen in the flooding frequency of the Myagdi river at Mangla Ghat . For example, 10 years current discharge of 760 m^3/sec would occur every 5.5 years, and would increase by 29 % by the year 2050. Similarly, 50 years discharge of 1000 m^3 would occur every 11 years, and would increase by 78 % within the same period.
- Maximum water level and average water levels could not be ascertained, although it can be assumed that there would be a considerable increase would increase in the water levels.

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 Myagdi District is outlined below.

3.1 Kaligandaki Riverside Settlement at Beni Bazar

3.1.1 Asset Situation

The asset consists of a linear urban settlement consisting of a cluster of buildings with mixed commercial and residential uses along the lower main road of Beni Bazar. A majority of the buildings are RCC frame structures with multi-storied construction situated along the vertical cliff with loose conglomerates. The asset is located at the eastern edge of the Beni town between the suspension bridge and Kali Nadi bridge, and a 1500 m earthen road just below the vertical cliff along the Kali Gandaki river links those two bridges (figure). The Beni town itself is located at the confluence of Myagdi and Kali Gandaki Rivers (figure), and falls within Wards 1 & 2 of Arthunge VDC. The photos below depict the present conditions of the asset.

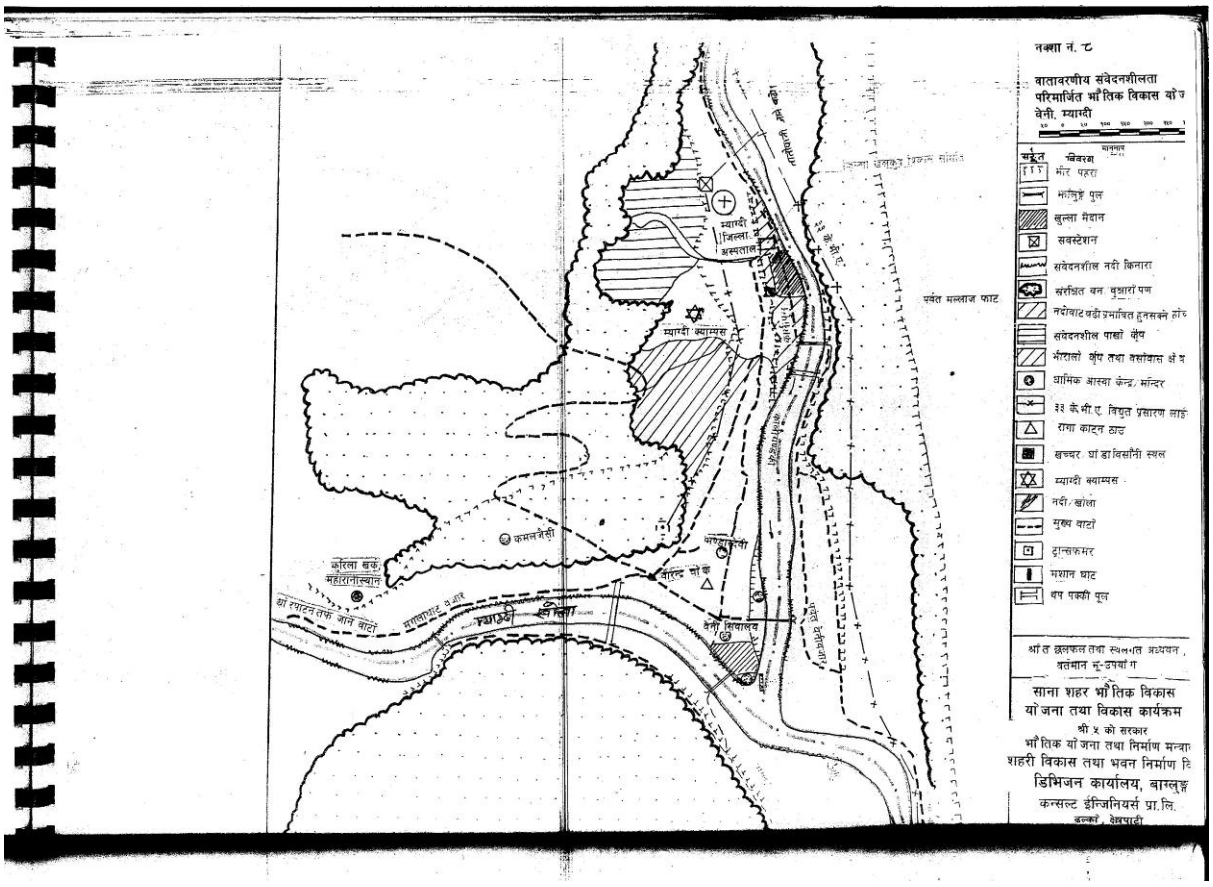

Figure 3.1: The asset along the environmentally sensitive belt along Kali Gandaki River.

Figure 2.2: A view of the linear settlement along the Kali Gandaki river.

Figure 3.3: Left - A view of the suspension bridge linking the new settlement and the traditional old market.

Figure 4.4: right - A View of the Asset with the linear cluster of buildings and the road along the Kali Gandaki river bank with the Kali bridge.

Figure 3.5: A view of the bank road along with the gabion wall with the vertical cliff.

Figure 3.6: A back view of the multi-storeyed structures along the vulnerable slope

Figure 3.7: Left - A view of the earthen road and the gabion wall along the Kali Gandaki river bank.

Figure 3.8: Right – A View of the bathing place constructed along the river bank

Figure 3.9 : Left - A view of the RCC building on the back of the vertical cliff.

Figure 3.10: Right – A front view of the buildings within the asset.

3.1.2 Vulnerability assessment

The VA matrix (Annex 2.1) takes into consideration both the aspects - Change and shift in regular climate and events – for vulnerability assessment of the asset. The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Kali Gandaki riverside settlement as a whole.

Threat: Increased Intensity of Rainfall and Risks of flood

Since the asset is situated at the confluence of Kali Gandaki and Myagdi rivers, due to increasing intensity and frequency of extreme rainfall events, the following threats have been identified as likely to impact on the asset:

- As per the threat profile (see Annexure 1), Increase in precipitation will be followed by the increase in the rainfall intensity up to 82 %, and with shorter return periods.
- The Kali Gandaki river would experience the peak average flow in wet season will increase by up to 89% with a possibility of the higher water levels.

Exposure: VERY HIGH

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

- Location: the whole settlement is located at the edge of Kali Gandaki river just separated by a vertical cliff and the sloped terrain, and an earthen road, and the

confluence of two major rivers - Kali Gandaki and Myagdi- is at the immediate downstream from the asset.

- Duration: Longer duration rainfall events occur more frequently within the asset area
- Intensity: High intensity rainfall occurs more frequently
- Aspect: Steep slopes at the edge of the settlement area could experience landslides due to more rainwater runoff.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Inadequate river bank protection structures completed few years ago;
- Modern mixed uses buildings (commercial and residential) without proper set backs from the edge of the vertical cliff, planning, design, and construction in particular, and without any compliance to the building codes in general;
- Direct rainfall and runoff could damage the vertical cliff and sloped terraces endangering the building structures;
- The sewage drains of the buildings directly flowing through the cliff and discharged to the river could endanger the stability of the sloped terraces, and pollute the river.

	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*

Impact: VERY HIGH

From the guiding matrix above, it can be seen that the impact is VERY HIGH as well. The justification for high impact in the asset area is as follows:

- There are possibilities of increased localized landslides along the vertical cliff and the sloped terraces whee the building structures are located. Field observations indicate, there are no adequate setbacks provided to the buildings from the edge of the cliff and sloped terraces.
- High intensity of rainfall with shorter return periods could trigger such landslides with substantial damages to the building structures resulting into a loss of lives and property.
- Increasing trend towards river bank erosion due to flooding in Kali Gandaki River was observed in past. In the future, increase in the high intensity rainfall in the catchment area and reductions in the return periods of peak flow events will intensify the river bank erosion.
- Multiple events of river bank erosion and localised landslides, which can occur concurrently in the future in the asset area, cannot be ruled out resulting into a loss of lives and property followed by a substantial economic loss and livelihood opportunities.

Adaptive Capacity: Medium

The adaptive capacity was ranked as medium due to the presence of district level government institutions and the local bodies (DDC and VDC) for dealing with the disaster events which did occur in the past. Hence, it seems, some technical / financial resources can be made available to deal with the adverse situations.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the Kali Gandaki riverside settlement 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 Beni Infrastructure Development (Road & Drains)

3.2.1 ASSET DESCRIPTION

The asset- the road pavement and a network of storm drains - is located at the lower main road of the Beni town (Bazar) that links the district hospital and the stadium. The road is around 1 km long stretching from south to north where the hospital is located.

The whole Beni town is a linear settlement sloping from west to east wedged between the forest and the Kali Gandaki River. The asset forms the lower eastern section of the settlement (see the map).

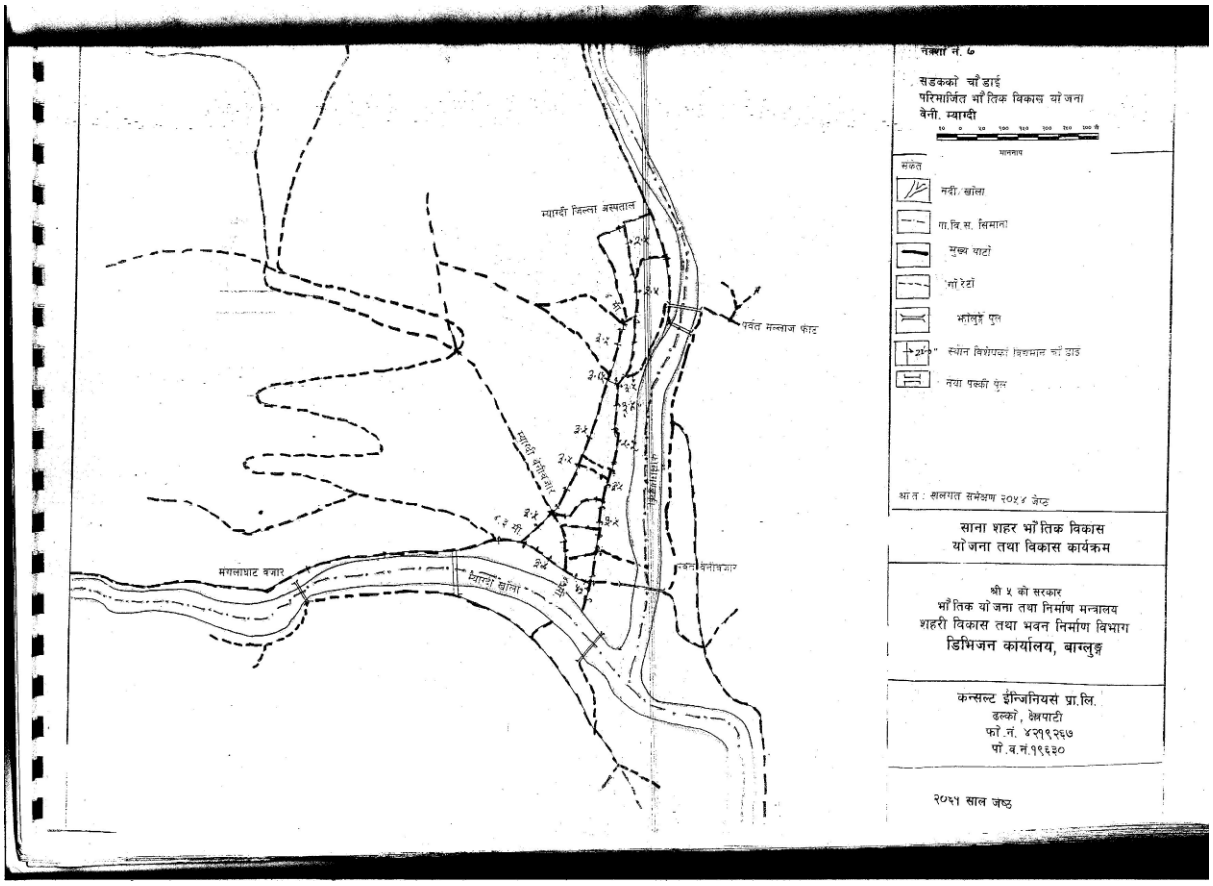

Figure 3.11: Map of the road network of Beni town indicating the location of asset

Figure 3.12: Road and drain along the lower main road, Beni Bazar

Figure 3.13: District Hospital – the northern point of Asset.

Fig. 3.14: Stadium gate – the southern point of the asset.

Figure 3.14: View of watershed area of the asset

Fig. 3.15: ***Left - Typical central drain along the link road serving the houses on both sides.***

Fig. 3.16: Right - A general view of the lower main road with completed road pavement and drains

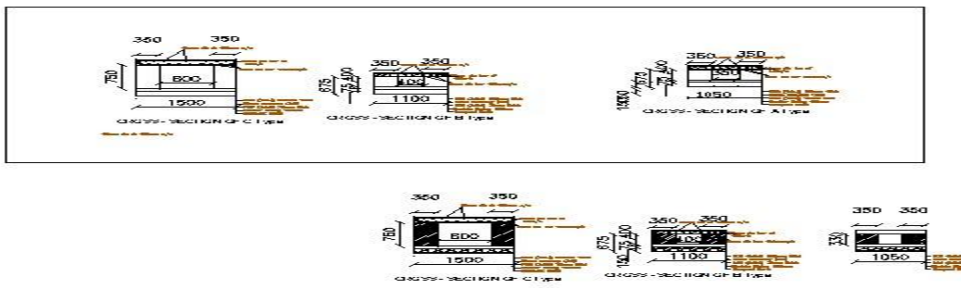

Figure 3.17: 3 Type designs of the drains.

Fig. 3.18: Left - *Type* A drain construction under process along the lower main road

Fig. 3.19: Right - Drainage construction in a narrow link road.

3.2.2 Vulnerability assessment

The VA matrix (Annex 2.1) takes into consideration both the aspects - Change and shift in regular climate and events – for vulnerability assessment of the asset. The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the Beni Infrastructure Development (Road & Drains).

Threat: Increased intensity of rainfall and Extreme localized pooling/flooding

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

- As per the threat profile (see Annexure 1), Increase in precipitation will be followed by the increase in the rainfall intensity up to 82 %, and with shorter return periods.
- Increased risk of localized pooling and flooding within the asset area affecting the building structures, road and drains, and other infrastructure components.

Exposure: VERY HIGH

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

- Location: The whole asset is located at the lower eastern section of the Beni town which is wedged between the sloped forest area and the Kali Gandaki River, and is also exposed to high intensity rainfall zone.
- Duration: Longer duration rainfall events occur more frequently within the asset area
- Intensity: High intensity rainfall occurs more frequently

- Aspect: Past flash flood events from the hilly terrain upslope of Beni Bazar caused more rainfall runoff to the site resulting into more localized pooling and flooding.

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Road and drainage net work was constructed three years back.
- Drains were constructed more for household waste water and rain water outlets with inadequate pro vision for surface water run-offs.
- Storm drains were not properly designed and constructed within the asset site. Three types of storm drains were applied on an ad-hoc basis without proper considerations of catchment area and rainfall intensity.
- The pavement conditions of the road network need improvement to withstand the intense rainfall conditions.

	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*

Impact: VERY HIGH

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

- Increase in pluvial flooding, sheet flow and erosion from run-off will result in pot holes and blocking of drains.

- The road pavements are particularly vulnerable to these impacts because of construction techniques and pavement materials used for the road surface.
- Secondary impacts, particularly due to flash floods, include the roads becoming impassable affecting free movement of people and transport within the town area, and resulting into possible damages to the buildings and civil structures.
- Such events could affect free movements of people and goods, and impede services delivery causing adverse impacts on Beni town's economy.

Adaptive Capacity: Medium

Medium institutional capacity because of presence of district level government institutions for dealing with the potential disaster events, and, hence, has access to technical / financial resources to adapt.

Vulnerability Scoring: VERY HIGH

As per the below guiding matrix, the vulnerability for the asset 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
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	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

MYAGDI DISTRICT VULNERABILITY SUMMARY

4.1 SUMMARY OF VA RESULTS

4.1.1 Kaligandaki Riverside Settlement at Beni Bazar

The table below summarizes the vulnerability assessment of the Kaligandaki Riverside Settlement at Beni Bazar. The analysis shows that the asset is vulnerable to both the intense rainfall and riverine flooding events, and the most vulnerable components of the urban system are the building structures along the steep slopes, and the river bank road along the Kali Gandaki river. The table below summarizes the vulnerability assessment of the asset. The analysis shows that the asset is ranked as highly vulnerable.

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADPTATIVE CAPACITY	VULNERABILITY SCORE
INCREASED RAIN FALL	VERY HIGH	HIGH	VERY HIGH	MEDIUM	VERY HIGH
RIVERINE FLOODING	VERY HIGH	HIGH	VERY HIGH	MEDIUM	VERY HIGH

4.1.2 Beni Infrastructure Development (Road & Drains)

The table below summarizes the vulnerability assessment of the Beni Infrastructure Development (Road & Drains). The analysis shows that the asset is vulnerable to intense rainfall and extreme localized pooling/flooding, and the most vulnerable components of the settlement system are the infrastructure components namely, road and storm drains. The table below summarizes the vulnerability assessment of the asset. The analysis shows that the asset is ranked as highly vulnerable.

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADPTATIVE CAPACITY	VULNERABILITY SCORE
INCREASED RAIN FALL	VERY HIGH	HIGH	VERY HIGH	MEDIUM	VERY HIGH
EXTREME LOCALISED POOLING/FLOODING	VERY HIGH	HIGH	VERY HIGH	MEDIUM	VERY HIGH

1.3 Most Vulnerable Assets and Components

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

4.2.1 Kaligandaki Riverside Settlement at Beni Bazar

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increase in precipitation	On an average rainfall intensity will increase up to 82 %;	Possibilities of Increased localized landslides along the vertical cliff and the sloped terraces.	Cause damages to the building structures, loss of lives and property.
Increasing wet season flow	Peak average flow will increase by up to 89 %.	High intensity rainfall in the catchment area and reductions in the return periods of peak flow events will intensify the river bank erosion.	The river bank erosion would cause damage to the buildings. drainage and other urban structures.
Riverine flooding	Increasing trend towards river bank erosion due to flooding in Kali Gandaki River.	Damage to the buildings. drainage and other urban structures.	Impeding of services delivery causing adverse impacts on Beni town's economy

4.2.2 Beni Infrastructure Development (Road & Drains)

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increase in precipitation	On an average rainfall intensity will increase up to 82 %. Occurrence of flash floods because of hilly terrain towards upslope of the asset.	Increase in pluvial flooding, sheet flow and erosion from run-off will result in pot holes and blocking of drains, and damages to the road pavement.	Roads becoming impassable affecting free movement of people and transport within the town area, and resulting into possible damages to the buildings and civil structures
Extreme Localized pooling/flooding	Inadequate provision of drainage for surface water run-offs.		Affect free movements of people and goods, and impede services delivery causing adverse impacts..

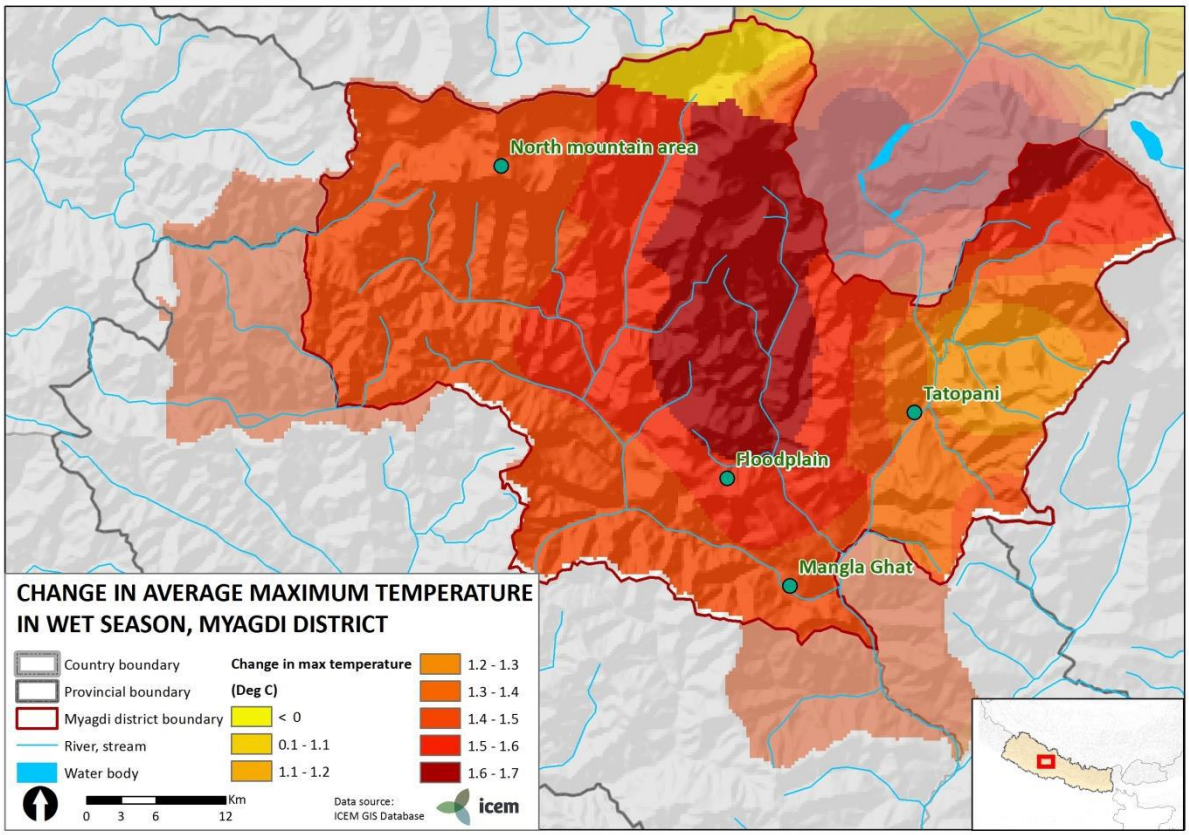
1.4 Lessons and Application to Other Assets

- The VA assessment aims to address the main issue – achieving increased resilience of Myagdi district's urban assets to climate variability and climate change.
- A large majority of urban and rural settlements in the mid-hill regions of Nepal are in the similar situation as illustrated by the two short-listed assets. The lessons can be applied to a majority of similar located at the hilly terrains and the river banks within the district, and in the mid-hill regions of the country.
- The VA of the two selected urban assets highlight a need for linking with other sectors – particularly, road & bridge, water supply and sanitation (WATSAN) sectors, and coming out with an integrated strategy, plans and programs to achieve the goals of climate resiliency.

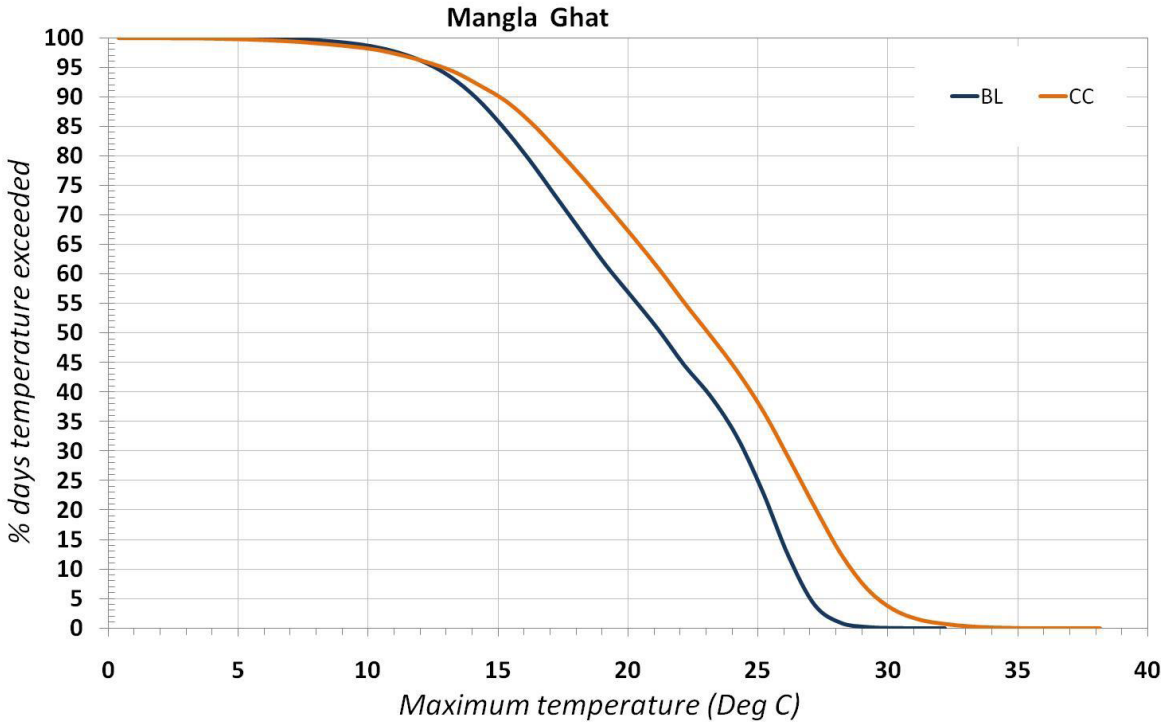
ANNEXURE 1

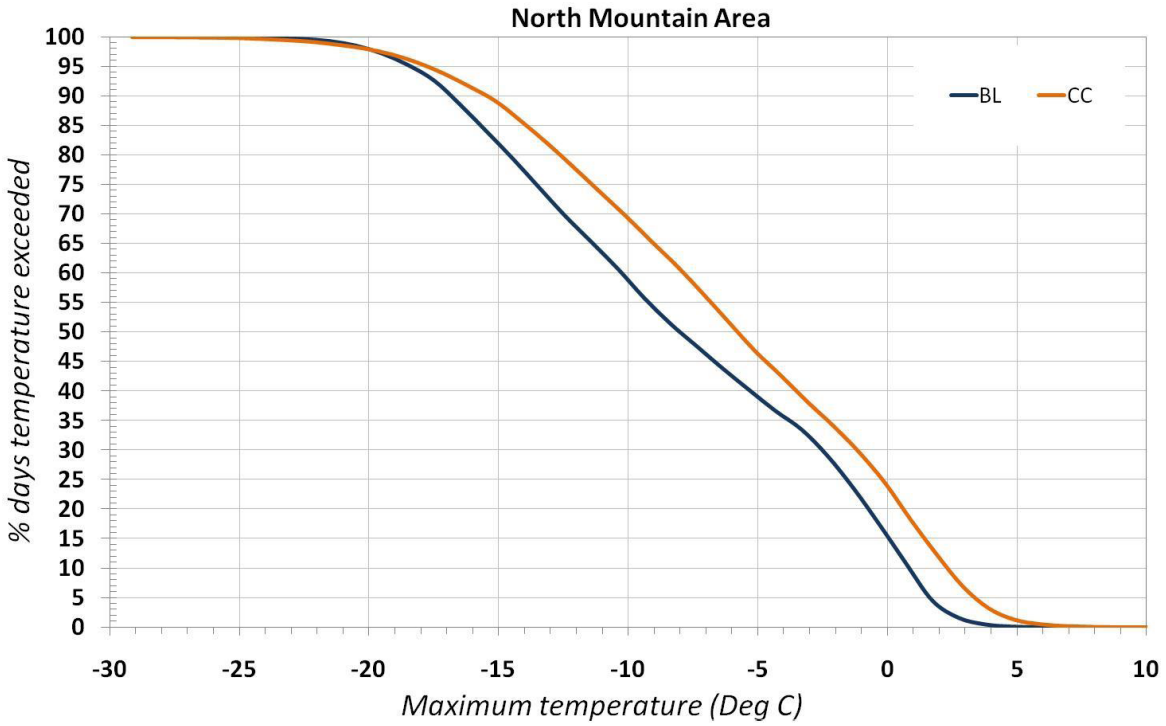
TA 7984 MYAGDI DISTRICT – KEY CLIMATE CHANGE THREATS PROFILE

A. INCREASING MAXIMUM TEMPERATURES
Wet season[1] average maximum temperatures



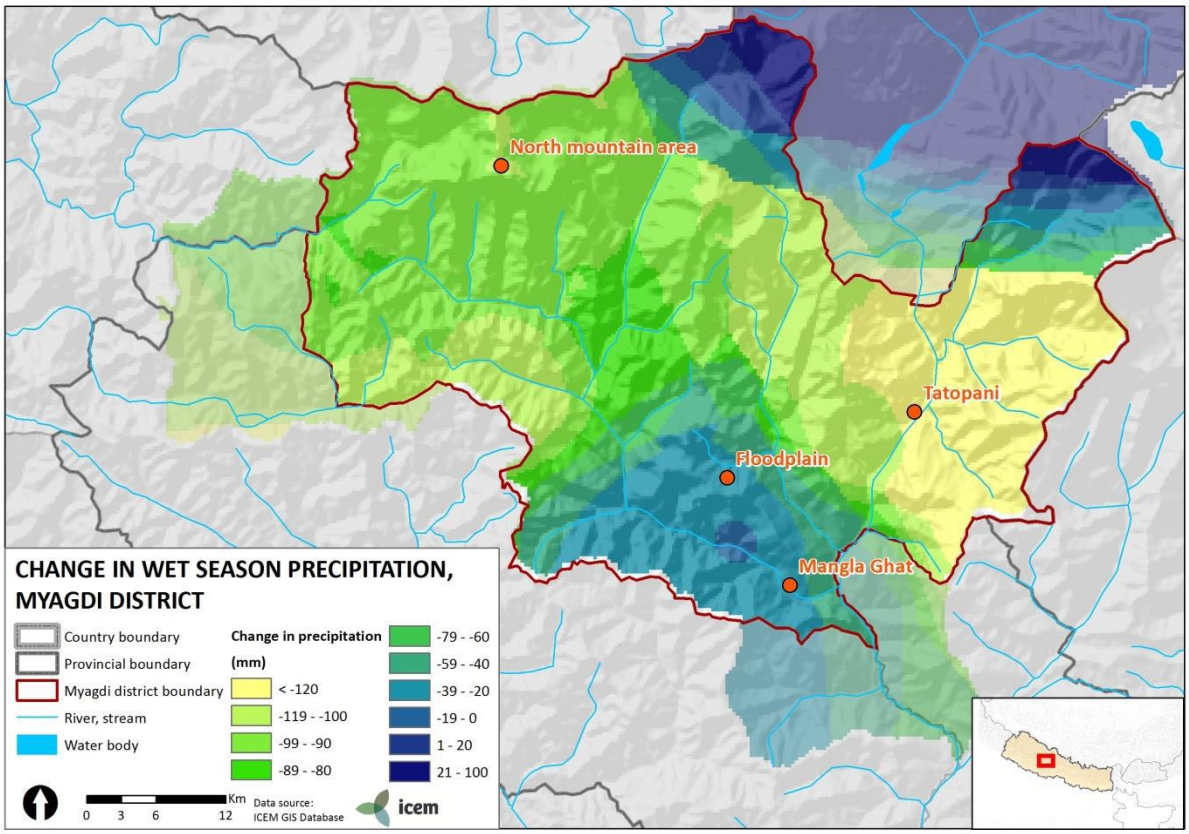
[1] *Wet season*: 15 May to 30 September



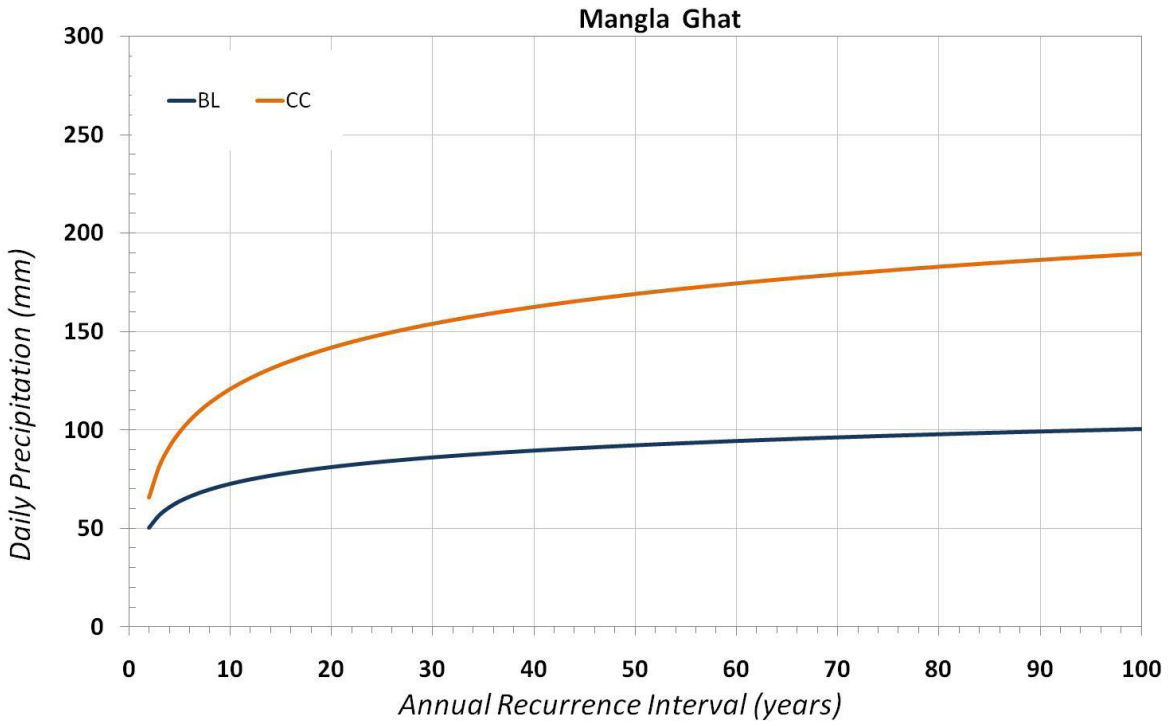


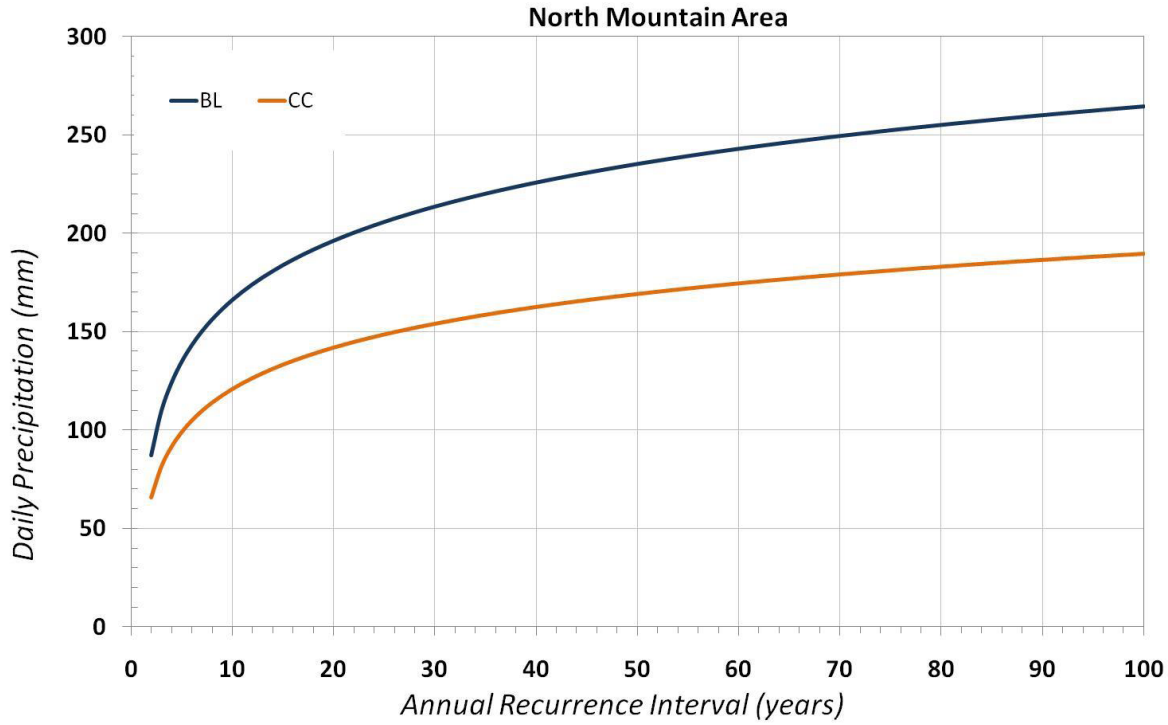
B. INCREASING INTENSITY OF RAINFALL EVENTS

Change in total wet season precipitation

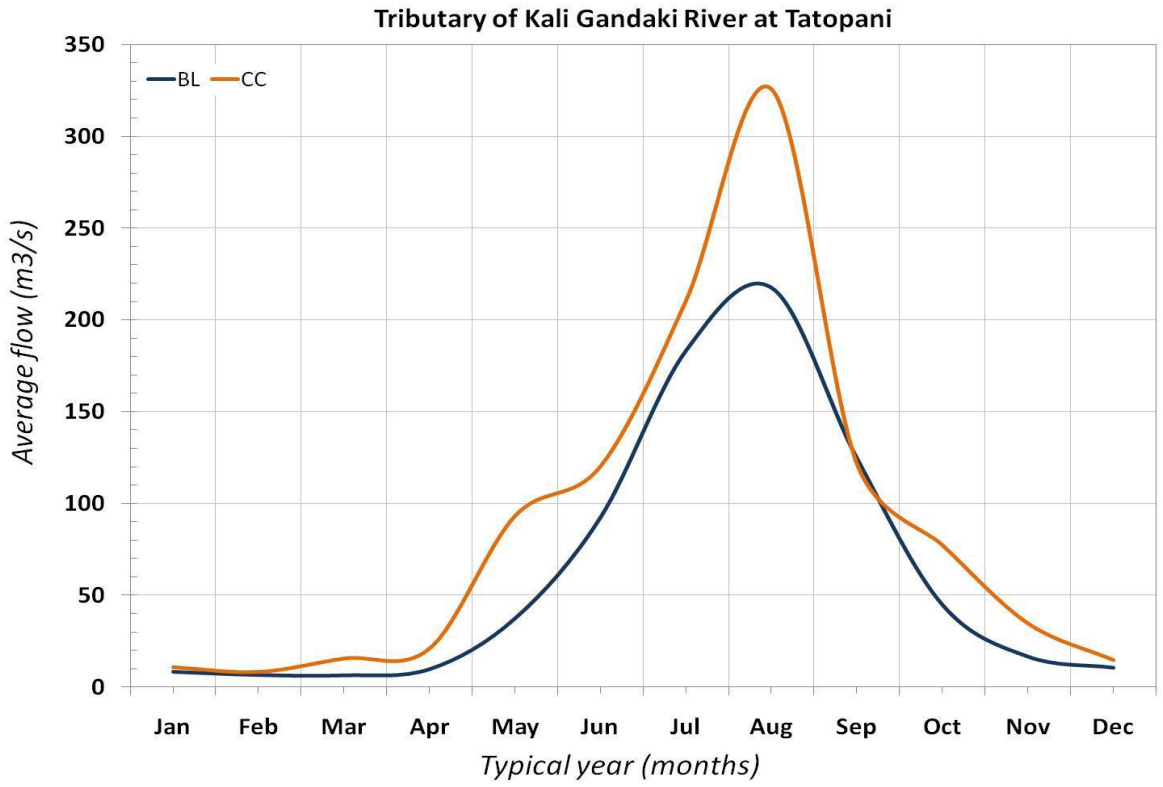


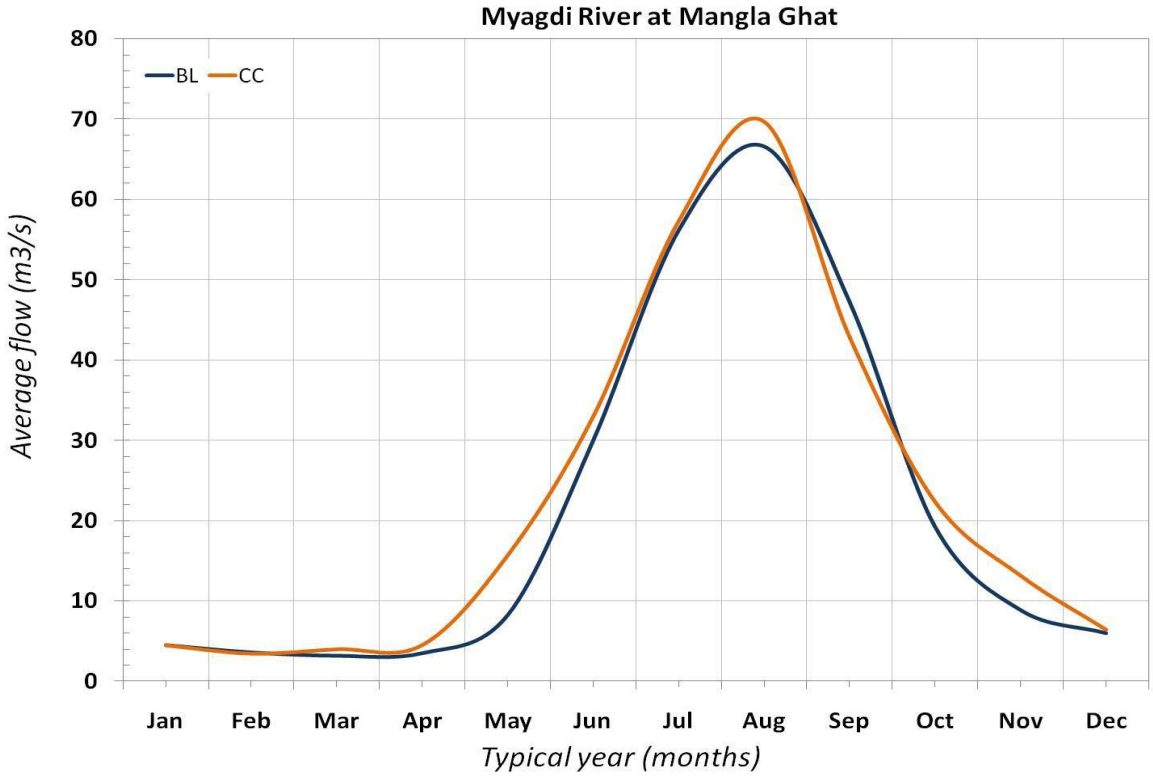
C. INCREASING NUMBER OF EXTREME RAINFALL EVENTS



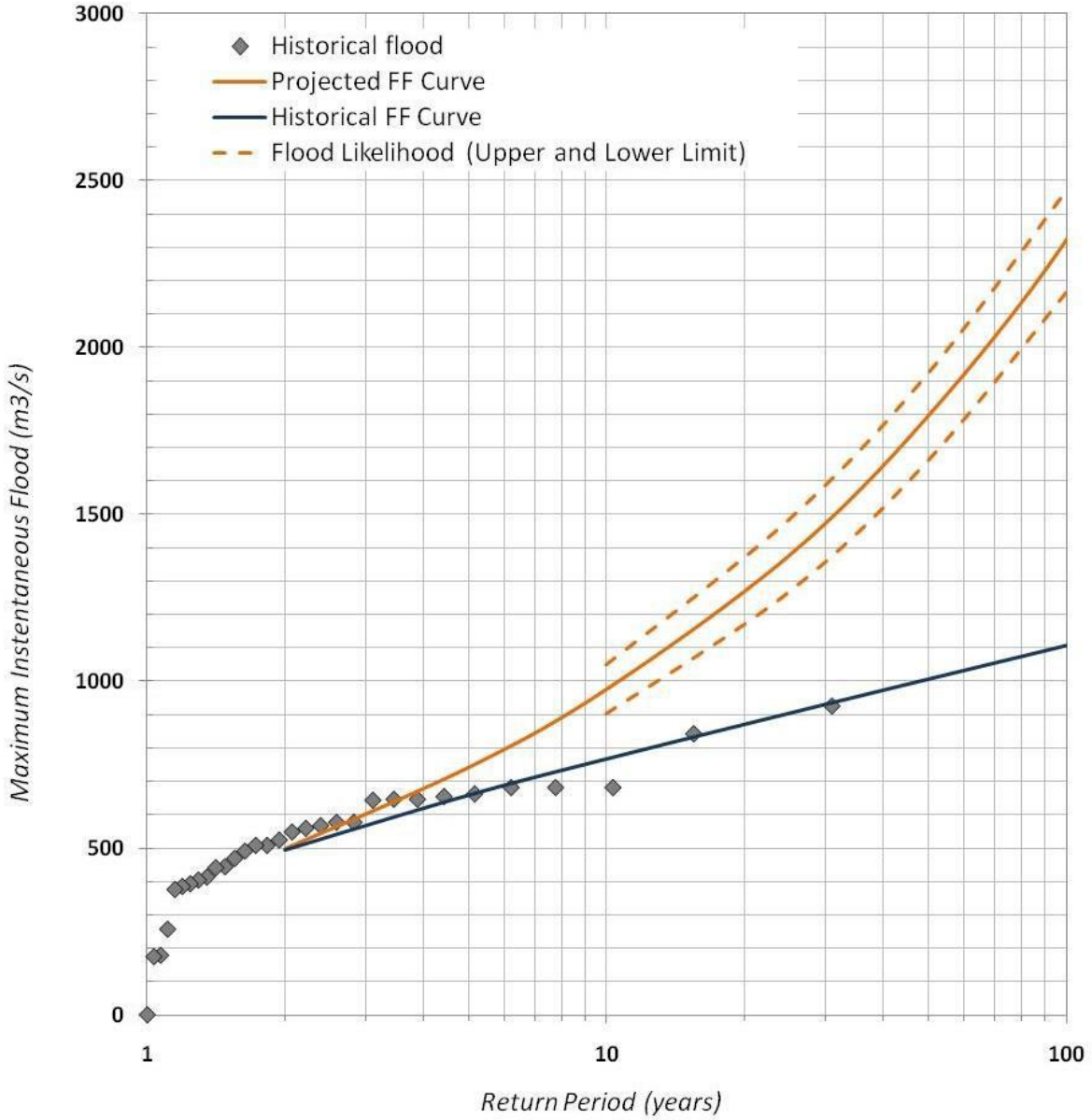


D. INCREASING FLOW: HYDROGRAPHS





E. FLOOD FREQUENCY ANALYSIS -MYAGDI RIVER AT MANGLA GHAT


Historical flood
Projected FF Curve
Historical FF Curve
Flood Likelihood (Upper and Lower Limit)
Maximum Instentaneous Flood (m3/s)
3000
2500
2000
1500
1000
500
0
1
10
100
Return Period (years)

Annexure 2

Annexure 2.1

VA Matrix of Kaligandaki Riverside Settlement at Beni Bazar

Threat	*Interpretation of threat*	*Exposure*	*Sensitivity*	*Impact Level*	*Impact Summary*	*Adaptive capacity*	*Vulnerability*
Change and shift in regular climate							
Increase in precipitation *(1) 30 year and 80 year extreme events will in future occur every 4 and 5 years.* *(2) Rainfall intensity will increase up to 82 %;* ***Increasing wet season flow on the Kali Gandaki River*** *Peak average flow will increase by up to 89 %.*	. *(1) High intensity of rainfall in terms of peak daily precipitation exceeding149 mm likely to cause landslides.* *(2) Shorter return periods could further worsen the situation.* *(3) Possibility of high flood in the river endangering the buildings and river bank*	*Very high*[1]	*high*[2]	*Very high*	▪ *High intensity of rainfall with shorter return periods, and the landslide events, which can occur concurrently, will result in substantial damages to the building structures, loss of lives and property.* ▪ *Possibilities of Increased localized landslides along the vertical cliff and the sloped terraces.* ▪ *Possibilities of high impact from the landslides because of non-cohesive soil, lack of protective systems(e.g. vegetation cover, sub-soil drains, steep and unstable slopes etc)* ▪ *In the future, increase in the high intensity rainfall in the catchment area and reductions in the return periods of peak flow events will intensify the river bank erosion.*	*Medium*[3]	*Very high*

	road.				.		
Change and shift in events							
Riverine flooding	*Increasing trend towards river bank erosion due to flooding in Kali Gandaki River.*				▪ *The river bank erosion would cause damage to the buildings. drainage and other urban structures.* ▪ *Impeding of services delivery causing adverse impacts on Beni town's economy..*		

1. *High exposure because of location of the buildings at the vertical cliff which forms an edge of Kali Gandaki river just separated by an earthen road; The confluence of two major rivers - Kali Gandaki and Myagdi- is at the immediate downstream of the asset; The vertical cliff is a fragile landslide prone area; the earthen river bank road in a very bad condition.*

2. *Minimum river bank protection in the form of gabion walls in place; The overflow during the peak wet season could damage the vertical cliff endangering the building structures; The sewage drains of the buildings directly flowing through the cliff and discharged to the river, and rain water runoff could loosen the soil structures of the vertical cliff.*

3. *Medium institutional capacity because of presence of district level government institutions for dealing with the potential disaster events, and, hence, has access to technical / financial resources to adapt.*

ANNEXURE 2.2

VA Matrix of Beni Infrastructure Development (Road & Drains)

Threat	*Interpretation of threat*	*Exposure*	*Sensitivity*	*Impact Level*	*Impact Summary*	*Adaptive capacity*	*Vulnerability*
Change and shift in regular climate							
Increase in precipitation *(1) Rainfall intensity will increase up to 82 %;* *(2) 30 year and 80 year extreme events will in future occur every 4 and 5 years.*	*(1) Direct rainfall and run-off leading to ponded areas and sheet flow across road.* *(2) Intense rainfall of short duration.* *(3) Occurrence of flash floods because of hilly terrain towards upslope of the asset.* *(3) Shorter return periods could further worsen the situation*	*Very high*[1 2]	*High*[34]	*Very high*[5]	*(1) Increase in pluvial flooding, sheet flow and erosion from run-off will result in pot holes and blocking of drains.* *(2) The road pavements are particularly vulnerable to these impacts because of construction techniques and pavement materials used for the road surface.* *(3) Secondary impacts, particularly due to flash floods, include the roads becoming impassable affecting free movement of people and transport within the town area, and resulting into possible damages to the buildings and civil structures.*	*Medium* [3]	*Very high*
Change and shift in events							
Extreme Localized pooling/flooding	*(4) The drains not functioning properly, or*	*Very*	*high*[3]	*Very high*[5]	*(4) Such events could affect free movements of people and goods, and impede services delivery causing adverse impacts*	*Medium*[3]	

	inadequate provision for surface water run-offs.	*high*[12]			*on Beni town's economy..*		

1.

Located in the lower eastern section of the Beni town which is wedged between the sloped forest area and the Kali Gandaki River.

2. Past flash flood events from the hilly terrain upstream of Beni Bazar.

3. Road and drainage net work constructed one year back, and of fairly good quality construction and maintenance.

4. Drains designed more for household waste water and rain water outlets with inadequate provision for surface water run-offs.

5. Medium institutional capacity because of presence of district level government institutions for dealing with the potential disaster events, and, hence, has access to technical / financial resources to adapt.