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ROADS AND BRIDGES SECTOR

DoR

BANKE VULNERABILITY ASSESSMENT REPORT

Prepared by	ICEM – International Centre for Environmental Management
	METCON Consultants
	APTEC Consulting
Prepared for	Ministry of Science, Technology and Environment, Government of Nepal
	Environment Natural Resources and Agriculture Department, South Asia Department, Asian Development Bank
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1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Briefing on Sector in Banke District

1.1.1 Overall View of the District

Banke District is located in the Mid-Western Region with Nepalgunj as its district headquarters. It covers an area of 2,337 km² and has a population of 493,017 as per 2011 census. The major part of the district lies in the terai. There are 46 VDCs and one municipality.

The major rivers in the district are Rapti, Man, Jhuri, Ooj, Sukhar, Khairi etc. Among them the Rapti is the largest and very important river in the district.

The district is considered as one of the hottest districts in the country. According to the hydrological and meteorological data of 2008, the maximum temperature and annual rainfall in Nepalgunj was 42.5^0 C and 2104 mm respectively.

1.1.2 Strategic Road Network in Banke

There are 12 major roads in the district with a total length of 226 km of roads of which, 150 km are blacktop, 42 km are gravel and 34 km are earthen. The total number of bridges along these roads is 51.

All the strategic roads and bridges in the district are managed by Nepalgunj Division of DoR. The division is also responsible for strategic roads and bridges of Bardiya and Surkhet Districts. The Division is headed by Division Chief (SDE). The other staff in the division are 6 Engineers, 7 Sub-engineers, 1 Account Officer, 1 Section Officer and 24 support staff.

1.2 Criteria for Identifying Priority Assets/Systems for the Vulnerability Assessment

In the road sectors (both DoR and DoLIDAR) it is considered that the primary assets or systems are the road links joining important centers of population or production for example a feeder road joining a national highway to a district centre is considered as a system. The priority assets in that system are the parts or sections of the link which, if affected by an extreme weather event, would cause serious disruption to the movement of traffic on the link.

The key criteria for prioritisation 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

In each district the consultant in consultation with the division chief prepared final lists of the priority structures of the district. The list was prepared following the criteria provided in District Office Report.

1.3 Description of Priority System

Considering the prioritization criteria following road and bridge are selected for VA and AP.

1. Nepalgunj-Baghouda Road
2. Dyke at Agaiya

1.3.1 Nepalgunj-Baghouda Road at 11+500

After crossing the Rapti River at Bhalubang, MRM runs parallel to the river along the right bank up to Samsherganj. At Samshergunj, the river changes its direction and proceeds towards the south whereas MRM moves towards the west. Due to lack of a bridge across the Rapti River, several VDCs at the south of the district starting from Bhalubang to Samshergunj were deprived of vehicular access. Hence the people of that area could visit Nepalgunj and other parts of the country only via India. In order to connect these southern villages with national road network, DoR is upgrading/constructing Nepalgunj-Bagoudha Road. DoR constructed a bridge across the Rapti River which crosses the road at km 11. While the upgrading works were in progress, there occurred a big flood at the Rapti River in 2012 which damaged roads, cultivated land and other properties. The major damage occurred to a 500 m long road section adjacent to the bridge at the left bank (see photos). For the purpose of this study the damaged 500 m long is considered as an "Asset". At present DoR is rehabilitating the damaged road section as well as upgrading the whole road.

1.3.2 Dyke for protection of MRM at Agaiya

MRM is one of the most important National Highways of the country. Its total length is 1027.67 km out of which 147 km lies in Banke District.

Agaiya is a small settlement in Banke District developed at the road side after the construction of MRM. Rapti River is very near to MRM at this location. Department of Irrigation (DoI) recently constructed an intake at Rapti River for Sikta Irrigation Project adjacent to this settlement. This is the largest irrigation project in the district. Due to the intake, the flow of the Rapti River is obstructed and the level of Rapti becomes higher. In order to protect the road (MRM) and Agaiya from an increase in the level of the Rapti River, GoN constructed about 500 m long dyke between the river and the road. This asset was found very unique in Nepali context and hence was short listed for the Baseline Assessment.

2 VULNERABILITY ASSESSMENT METHOD

2.1 Summary of method/process

The VA of the assets is carried out following the procedure as outlined below:

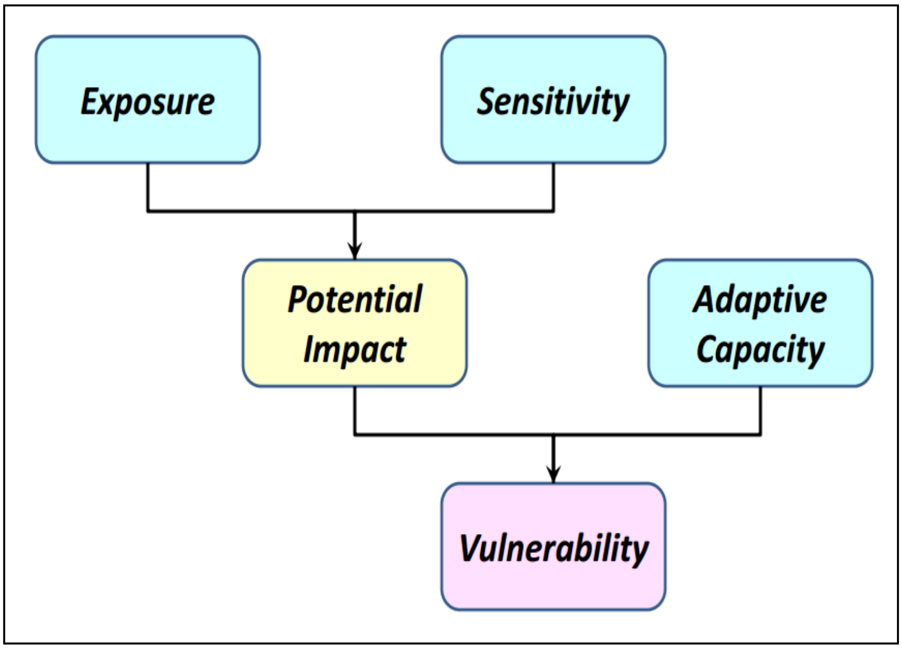

Fig 1: VA Process

There are two components in this phase

I. Assessing the impact of a climate threat on an asset and system; and

II. Defining the level of vulnerability of the asset and system to the projected threats.

2.1.1 Impact Assessment

The potential impact (or level of risk) is a function of the level of **exposure** to climate change induced threats and the **sensitivity** of the target asset or system to that exposure.

Exposure: exposure is the degree of climate stress on a particular asset. It is influenced by long-term changes in climate conditions and by changes in climate variability, including the magnitude and frequency of extreme events.

The following criteria influence exposure:

- Duration (e.g. hours or days of flooding)
- Location (e.g. distance from flood)
- Intensity (e.g. strength of rainfall, speed of flow)
- Magnitude (e.g. volume, flow or size of event)

Sensitivity: Sensitivity is the degree to which a system will be affected by, or be responsive to, climate change exposure.

The following variables affect infrastructure sensitivity:

i. Construction quality
ii. Levels of maintenance
iii. Protective system (e.g. river training wall to protect asset)
iv. Design (including safety margins)

A key tool in the process is the use of the **Climate Change Impacts Matrix** (Fig.2). The matrix is completed using descriptors for exposure and sensitivity, for example, 'very low' to 'very high'. If the exposure of a bridge to the threat of high flash floods is **High**(due to catchment area and topography) and its sensitivity to scour is **Very High** (due to soil type and foundation design) then the Matrix tells us that the **Impact** of the threat is **Very High**.

		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*

Fig.2: Impact Assessment Matrix

2.1.2 Vulnerability Assessment (VA)

A vulnerable system or asset is one that is sensitive to changes and extremes in climate and hydrology and one for which the ability to adapt is constrained. The vulnerability of an asset is therefore a function of the potential impact of changes in climate and the ability **(Adaptive Capacity)** of the responsible authority to respond to any possible impact.

The following variables affect the **adaptive capacity** of the responsible institution:

i. Institutional Strengths/Weaknesses
ii. Financial Resources
iii. Technical Capacity
iv. Ability to respond effectively to extreme events in the District

The Vulnerability of an asset is determined by applying the Impact value given by the Impacts matrix and the assessed value of adaptive capacity to the **Vulnerability Assessment Matrix** (Fig. 3).

This value of **Vulnerability** obtained (from Very High to Very Low) is then carried forward to the Adaptation Planning phase of the Climate Change Risk Management methodology

		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*

Fig 3: Vulnerability Assessment Matrix

2.2 Interpretation of the climate vulnerability assessment methodology criteria for the Roads Sector

In the highways sectors there are two major elements which make up a road link:

1) Road Pavement & Side Drainage
2) Cross drainage structures

It is necessary to consider for both these elements their sensitivity and exposure to the various increased threats due to climate change.

2.2.1 Sensitivity

The following tables outline the sensitivity of the two road elements to various climate threats.

Table 1. Road pavement and side drains sensitivity to climate threats

CLIMATE THREAT	SENSITIVITY	IMPACT
Increased rainfall Increased intensity of rainfall	Depends on condition of existing pavement – a pavement in poor condition will have a High sensitivity	Damage to surface of pavement
Increased rainfall Increased intensity of rainfall	Side drains which are in good condition and well maintained will have a low sensitivity	Damage to side drains
Increased rainfall increases instability of hillside Increased intensity of rainfall increases instability of slope High flow in river scours base of hillside & causes landslide	A road across an hillside prone to landslides will have a Very High sensitivity A road above a river which is eroding the toe of the hillside will have a Very High Sensitivity	Landslide destroys road & side drains
Increased rainfall causes high monsoon flood Intense rainfall causes flash flood	A road constructed next to a river will have a Very High sensitivity	Road running along river valley damaged by adjacent river

Table 2. Cross road drainage sensitivity to climate threats

CLIMATE THREAT	SENSITIVITY	IMPACT
Increased rainfall causes riverine flooding	A road with adequate cross drainage structures for today's floods will have an increasing sensitivity as climate change takes effect	Road on embankment crossing flood plain washed out
Increased intensity of rainfall causes large flash flood	Design and condition of bridge foundations will cause sensitivity to vary from Medium to Very High	Bridge on river with small catchment area is damaged by flood
Increased intensity of rainfall increases size of flash flood	Design and condition of causeway slab and retaining walls will mean sensitivity will vary from Medium to Very High	Causeway for stream with small catchment area washed out by flood
Increased temperature variation from cold to hot season	The condition and design of the expansion joints & bearings will cause the sensitivity to vary from Low to High	Large Bridge over major river – damage to bearings & expansion joints
Increased rainfall causes high monsoon flood	The condition and design of the bridge piers and abutments will cause the sensitivity to vary from Low to Very High	Settlement or scour at pier or abutment

2.2.2 Exposure

The above tables illustrate examples of the sensitivity of various elements in the highway infrastructure to climate change. It shows that for both roads & bridges the major climate change threats are increased rainfall and intensity of rainfall which result in high monsoon floods, riverine floods and flash floods. For large bridges, very high temperature variations will be a threat to the viability of expansion joints and bearings.

The table below provides interpretation of exposure for different road and bridge assets to the climate threats identified for Banke district. This general interpretation can be used along with consideration of the relative magnitude of the climate change threat at the target system site to assess the exposure of the assets of the target system.

The highway infrastructure in Banke District will generally, depending also on upstream catchment area and topography, have a High or Very High Exposure to climate change.

Table 3. Interpretation of climate change threats and exposure for road and bridge assets

TYPE OF ASSET	CC THREAT	EFFECT OF THREAT	EXPOSURE
Large bridge on large river	Increase in max. temperature	Increase in expansion of deck – more stress on joints and bearings	Low to Medium
	Increase in wet season flow	Increased velocity of flow increases likelihood of scour to foundations	High to Very High
		Increased height of flood threatens stability of bridge deck and causes erosion of approach roads	Medium to Very High
		Increased sedimentation reducing clearance under bridge	Medium to Very High
Smaller bridge on smaller river	Increasing risk & severity of flash floods during wet season	Increased velocity of flow increases likelihood of scour to foundations	Medium to Very High
		Increased height of flood threatens stability of bridge deck and causes erosion of approach roads	Medium to Very High
Pipe culverts & causeways on roads crossing watershed	On hill roads - increasing risk & severity of flash floods during wet season	Increased velocity of flow threatens to wash out pipe/ causeway & headwalls	High to Very High
	On flood plain roads - increase in wet season flow	Increase volume of flow threatens to wash out pipe/ causeway & headwalls	High to Very High
Hill road crossing watershed on sloping ground	Increasing risk of landslides	Road blocked or totally destroyed	Medium to Very High
Hill road running along valley bottom adjacent to river	Increasing wet season flow	Road eroded by height & high velocity of flow	High to Very High
	Increasing risk & severity of flash floods		
	Increasing risk of landslides	Road destroyed as erosion to toe of hillside causes landslide	
Road crossing flood plain	Increasing wet season flow and water levels	Road overtopped by flood water and pavement/ embankment destroyed	Medium to Very High

2.2.3 Impact

The impact of extreme weather event on an asset is a function of the Sensitivity and the Exposure and can be found by considering the Climate Change Impacts Matrix given in Fig. 2 and interpolating between the value of Sensitivity and the value of Exposure to give a value for Impact.

The value for Impact obtained by using the Impacts Matrix should be judged from a practical engineering point of view and if considered incorrect then the values used for Exposure and Sensitivity should be revisited. In particular, for road infrastructure, the value for sensitivity is very difficult to determine without carrying out detailed condition surveys for the particular asset under review. If sufficient design detail is unavailable, or the ground conditions difficult to judge, then an expert judgment of Sensitivity needs to be made and clear notes made justifying the decision.

2.2.3 Adaptive Capacity

Evaluating the Adaptive Capacity of the Department of Roads in a District is not a simple task. Baseline assessments including consultations and site visits have shown that the DRO which is responsible for strategic roads and bridges in the Banke District has:

- Extensive experience in design and construction of roads and bridges;
- Sound financial resources;
- Sufficient trained and skilled man power available for design and construction of bridges;
- Adequate management system; and
- Good ability to respond promptly to disasters.

However in the baseline assessments (see Baseline Assessment Report for the Banke District) for the district it was also observed:

a) Approved Budget funds are not released on time;
b) Programmes are not approved on time;
c) Very low bids are submitted by the contractors; and
d) Contractors receive mobilization advance but do not execute the work on time.

DoR has shown it is able to respond rapidly to emergencies where road links are disrupted. However the ability or preparedness of DoR to respond to possible future threats to the road infrastructure has yet to be demonstrated.

The above findings indicate that the Adaptive Capacity of the DoR Division offices is "High"

Vulnerability Scoring: Based on the impact and adaptive capacity assessments, the vulnerability of the asset against the climate change threats is estimated using the guiding Vulnerability Matrix as provided in Fig.3.

3 VULNERABILITY ASSESSMENT OF THE ASSET

3.1 Asset Description

3.1.1 Nepalgunj-Baghouda Road at km 11+500.

The following table describes the important aspects of Nepalgunj-Baghouda Road

Table 4: Salient Features of Nepalgunj-Baghouda Road and the asset

Name of the Road	Nepalgunj-Bagouda.
Total length	47.6 km; (black top-4km, gr. = 32.5 km, 11.1 km)
Road Category	Feeder Road
Service Provided by the Road	Connects southern VDCs of the district with national road network.
Responsible Agency	Nepalgunj Division of DoR
Location of Asset	Km 11+500

Major Components of the Asset	Cross drainage structures, road embankment etc.
Existing Condition of different components	Road embankment: very poor, washed away at several locations Bank protection works: poor, damaged at several locations Cross drainage structures: poor, blocked, Not sufficient during flood.

Fig. 4a: Rapti River has washed away a road section of left approach road. The washed away section is about 200m from the bridge towards Baghouda side. DoR has planned to construct a 20 m long Bailey Bridge at this location. The steel truss bridge across Rapti River can also be seen on photo.

Fig. 4b: This is another washed away road section. It is located at about 250m from the bridge or 50 m proposed location of the Bailey Bridge towards Baghouda side. DoR has started constructing 50m long concrete causeway at this location.

Fig. 4c: 90 cm dia pipe is laid but the headwalls are still not constructed. The location of the PC is about 270 m from the bridge.

Fig. 4d: Triple cell and double cell PC were constructed to discharge the overflow from Rapti River in the past. Past damages to road show that these structures are not sufficient to drain the water discharge during high flood.

3.1.2 Dyke atAgaiya

The following table describes the important aspects of the asset

Table 5: Salient Features of the dyke.

Name of the Road	Mahendra Raj Marga (MRM)
Road Category	National Highway
Service Provided by the Road	- Connects the entire terai districts. - One of the most important roads of the country. - Links various places of Nepal.
Responsible Agency	Nepalgunj Division of DoR
Location of Asset	Agaiya; small settlement developed after the construction of MRM.
Major Components of the Asset	Dyke, gabion protection works at river side, gabion launching apron
Existing Condition of different components	Earthen Dyke: good; Gabion/rip rap protection works: good; Gabion launching apron: good.

5a: Photo of dyke. It is an earthen dyke of about 4-5 m height. The top width of the dyke is 3 m. At the river side (left side) the slope is protected by gabion mattress at the lower portion and by stone rip rap at the top. Gabion mattress (launching apron) is provided at the bed for protection against scouring.

5 b: View of MRM from the top of the dyke. The road is about 25 m from the dyke at this location. It seems that the dyke is functioning properly as there is no damage to the road.

5c: View of the dyke from intake. The river side slope of the dyke is protected by gabion mattress and stone rip rap. It condition is good.

5d: Gabion launching apron is provided at the bottom to protect the dyke from scouring. Its condition is good.

3.2 Climate Change Threat to Infrastructures in Banke District

3.2.1 Threat due to Temperature Increase

As per the threat profiles, the average temperature increase in Kathmandu District by 2060 will be up to 2.15^0.

- ***Adverse effect on the asset due to above temperature rise will be nominal.***

3.2.2 Threat due to Precipitation and Flood Increase

The threat profile findings are as follows:

- Increasing number of extreme rainfall events – events that now occur every 5 years are projected to occur every 2 years;
- Increasing wet season flow on the Rapti River at Kusum – peak monthly average flow in wet season will increase by up to 5%

The above findings show that there will substantial increase in frequency and magnitude of extreme discharge. Hence following aspects need serious consideration while designing road and bridge structures:

<u>Design life</u>: At present the important bridges are designed for 100 years return period and rural road bridges for 50 years return period. The drainage structures, in general are designed for 10, 20 or 25 years depending upon the importance of the roads. In order to accommodate the increased flood volumes, bridges as well as drainage structures should be designed for higher return periods. For example there may be a need to design important bridges for 200 years return period (instead of 100), rural road bridges for 100 years return period (instead of 50) and drainage structures for 50 years return period (instead of 25) to accommodate the increasing flood volumes.

Invert level of bridges/culverts: Due to increase in discharge, the high flood level (HFL) will increase. This will require increasing the invert level of bridges/culverts.

Foundation depth of bridges/culverts: The increased discharge will cause more scouring requiring more foundation depth.

Size of drainage structures: Sizes of both side drainage and cross drainage structures should be increased to accommodate increased flood volumes.

Road pavement: Roads lying in low land and adjacent to rivers will be highly affected by increased flood. The wetting of subgrade for longer duration will decrease its strength (CBR) requiring thicker road pavement.

3.3 Vulnerability Assessment Results

The following tables show the VA results of the assets.

Table 6: Vulnerability Analysis of Nepalgunj-Baghouda Road at km 11+500 (Asset 1)

Climate Change Threats	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Component 1: Road embankment							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow.	Threat of damage to previously built embankment from increased flows.	VH[1]	VH[2]	VH	The road embankment collapsed at several occasions in the past during high flood. The increase in flood will accelerate this process.	H[3]	H
Component 2: Bank protection works							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Higher possibility of failure of bank protection works from increased flows.	VH[4]	VH[5]	VH	Bank protection works are frequently damaged by the flood in the past. With increase in flood the damage will be more severe and frequent.	H[3]	H
Component 3: Cross drainage structures							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Higher probability of damage of cross drainage structures due to increased flows.	VH[6]	H[7]	VH	Existing cross drainage structures are not sufficient to pass the current discharge during high flow. With increased flow, this problem will become more severe and	H[3]	H

					probability of damage to those structures will be high.		

Notes:

1. *The road embankment is located at highly vulnerable to flood. It was washed away several times in the past.*
2. *The embankment is not protected (by gabions or stone rip rap). The embankment collapse will cause road closure in rainy season and will affect large number of people residing at the southern parts of the district.*
3. *The adaptive capacity of DoR Division Road Office is **High**; see section 2.2.4.*
4. *Bank protection works are very near to the main river course. They were damaged several times in the past;*
5. *Bank protection works are constructed without proper design. Similarly, launching aprons are not provided in many cases.*
6. *Cross drainage structures are directly affected by the flood.*
7. *The quality of structures is good but their capacity is inadequate.*

Note: The Vulnerability Assessment Matrix shows that the vulnerability of road embankment and bank protection works is "high". In actual the vulnerability is "very high" because the DoR cannot adequately manage the magnitude of disaster which occurred in 2012.

Table 7: Dyke atAgaiya (Asset 2)

Climate Change Threats	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Component 1: Earthen Dyke							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	The increase in flood will raise the water level of the river. The increased water depth will cause more static and dynamic lateral pressure to the dyke.	H[1]	L[2]	M	There may be minor erosion at the embankment. The embankment will not collapse because the size (cross sectional area) of the dyke is sufficient and it is properly protected.	H[3]	M
Component 2: Gabion/rip rap protection works							
• Increasing intensity and duration of rainfall; • Increasing number of extreme rainfall events; • Increasing risk and severity of flash floods	Increased flood possess more damaging capacity.	H[4]	M[5]	H	There will be some damage to stone rip rap and gabion mattress especially the stones will be displaced and gabion wires will break down with time.	H[3]	M
Component 3: Gabion launching apron							

• Increasing intensity and duration of rainfall; • Increasing number of extreme rainfall events; • Increasing risk and severity of flash floods	The scour is directly proportional to flood. Hence the probability of damage of the launching will increase.	H[6]	M[7]	H	The launching apron may settle significantly causing breaking of gabion wires and displacement of stones.	H[3]	M

1. *The dyke is located where it is regularly affected by increase of water level of Rapti River*
2. *The cross section of the dyke is sufficient. The quality of works is good. It is adequately protected.*
3. *The adaptive capacity of DoR Division Road Office is High; see section 2.2.4.*
4. *The gabion/rip rap protection works are constantly hit by river flow.*
5. *The quality of rip rap and gabion protection works is good. But they are not durable for long period.*
6. *Large River like Rapti possesses high scouring capacity.*
7. *The quality of launching apron is good. Gabion wires break after some years.*

3.4 Vulnerability Assessment Summary

The vulnerability assessment summary of both the assets is provided in the following tables:

Table 8: Vulnerability Assessment Summary of Nepalgunj-Baghouda Road at km 11+500 (Asset 1)

THREAT	IMPACT	EXPOS.	SENSIT.	IMPACT	ADAPT. CAP.	VULN.	COMMENTS
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Damage to road embankment	VH	VH	VH	H	H	The road embankment is located at very high vulnerable area. As a consequence it was damaged several times in the past. The scale of damage is very high. Although the "Vulnerability Assessment Matrix" shows that the vulnerability is only "high" but in actual the vulnerability is "very high".
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Damage to bank protection works.	VH	VH	VH	H	H	The exposure of the bank protection works is very high as they are located very near to the water current. Although the "Vulnerability Assessment Matrix" shows that the vulnerability is only "high" but in actual the vulnerability is "very high". The quality of bank protection works is not good.
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Damage to cross drainage structures.	VH	H	VH	H	H	Existing cross drainage structures are not sufficient to pass the water during high flood. However, the probability of their damage is not very high because the quality of construction works is good.

Table 8: Vulnerability Assessment Summary of Dyke atAgaiya (Asset 2)

THREAT	IMPACT	EXPOS.	SENSIT.	IMPACT	ADAPT. CAP.	VULN.	COMMENTS
• Increasing intensity and frequency of extreme rainfall events. • Increasing wet season flow	Damage to dyke.	H	L	M	H	M	Although exposure of the dyke to water current is high, the vulnerability is found medium because the section of the dyke is sufficient and it is adequately protected.
• Increasing intensity and frequency of extreme rainfall events. • Increasing wet season flow	Damage to stone rip rap and gabion mattress.	H	M	H	H	M	The water current will hit the protection works and may cause minor damage. Such damage can be repaired under regular maintenance.
• Increasing intensity and frequency of extreme rainfall events. • Increasing wet season flow	Damage to gabion launching apron	H	M	H	H	M	Rapti River has high scouring potential. But the vulnerability will be medium only because the quality of works is good.

ANNEX 1 SITE VULNERABILITY ASSESSMENT SHEET

ANNEX 2 VULNERABILITY ASSESSMENT COMPARISON TABLE

SAME AS OF DOLAKHA

ANNEX 3 CLIMATE CHANGE THREAT PROFILE (NOT ATTACHED)