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ROADS AND BRIDGES SECTOR

DoR

PANCHTHAR VULNERABILITY ASSESSMENT REPORT

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1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Briefing on Panchthar District

Overall View of the District

Panchthar district is located in Mechi Zone of the Eastern Development Region of Nepal. It has borders with Taplejung to the North, India to the East, Ilam to the South and Tehrathum to the West. The total area of the district is 1,252 sq. km having different types of topography. The elevation of the district ranges from 1000 m to 4000 m. As a result of the elevation differences, the district has two different types of climate: sub-tropical from 1000-2000 m and temperate above 2000 m. The district is famous for tea and cardamom. The total population of the district is 240,818 of which 119,671are male and 121,147are female (source: Nepal Population Report 2011, Ministry of Health and population, GoN). The headquarter of the Panchthar District is Phidim.

Major rivers in the district are; Hengwa, Nawa, Silsile, Marhang, Khaireni, Kabeli etc.

Strategic Road Network in the District

There are 12 strategic roads in Panchthar District. Their total length is 247.95 km of which 108.75 km is black top, 12.10 km is gravelled and 127.10 km is earthen. There are 4 bridges along these roads.

All the strategic roads and bridges in the district are managed by Ilam Division of DoR. Beside maintenance, the Division also carries out rehabilitation, upgrading and new construction of roads and bridges.

The Ilam Division is headed by a Senior Divisional Engineer (SDE). SDE is supported by Engineers, Sub-engineers, Senior Accountant, Administrative Officer and auxiliary staffs.

Climatological Record

The climatological record and monthly rainfall of the district is presented in Table 1 and 2.

Table 1: Climatological Record of Panchthar District

Location: Phidim; Latitude: 27° 09' N; Longitude: 84° 45E; Elevation: 1205 amsl (2008)

Air Temperature					Relative Humidity		Precipitation (mm)		No. of Rainy Days
Mean			Absolute Extreme		Observed at				
Max.	Min.	Daily	Max. & Date	Min. & Date	08:45 NST	17:45 NST	Total	Max. in 24 hrs. & Date	1:100
26.5	15.7	21.1	34.0/Jun.	4.9/Feb.	84	78	1438	73/July	129

Source: Department of Hydrology and Meteorology

Table 2: Monthly Rainfall of Panchthar District (mm) Location: Phidim

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	0	41.1	29.4	179.6	142.3	219.5	312.3	34.6	71.7	0	0

Source: Department of Hydrology and Meteorology (2009)

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 centres 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.

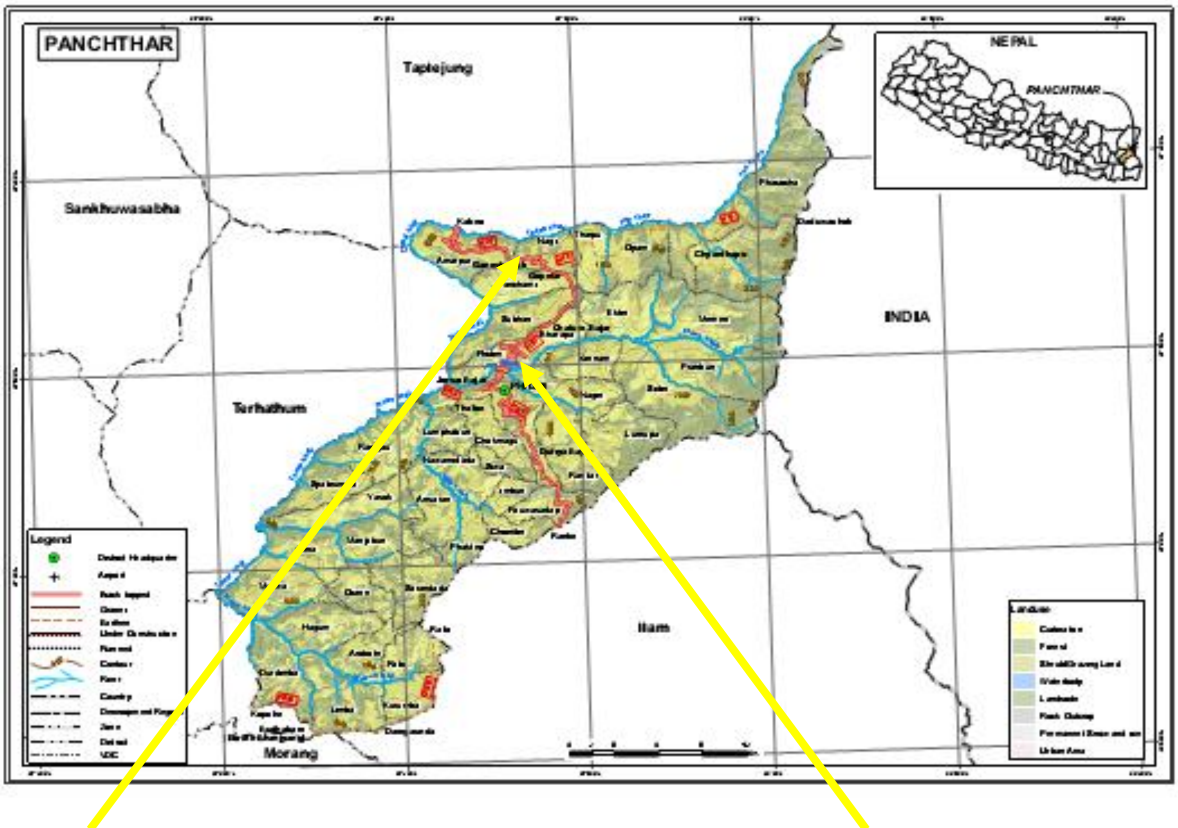
The key criteria for prioritisation include:

- 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.

1.2 Description of Priority System

In total five assets were covered in the baseline report. From them a landslide at Amarpur and Hengwa Khola Bridge are selected for vulnerability assessment and adaptation planning. Both assets lie along Phidim-Taplejung Road. Their location is shown in Fig.1.



Amarpur landslide (Asset 1) **Hengwa Bridge (Asset 2)**

Fig 1: Map of Panchthar District showing asset locations

Landslide at Amarpur

This site is located 49 kilometer from Phidim (towards Taplejung side). The size of the landslide is approximately 30 x 40 m (along road).

There was no landslide at this location before 3 years ago. The landslide started after the contractor excavated hill slope to extract gravels and stones during black topping of the road. The landslide obstructed the traffic for several times in the past. At present the landslide is not very active.

DoR has not provided any slope stabilizing structures. .

There were not any extreme events except closure of vehicular traffic for short duration.

It is a very good example of manmade disaster and it clearly shows the negligence of implementing (DoR) and supervising (Consultant) agencies.

Hengwa Khola Bridge.

The bridge is located at a distance of 9 kilometer from Phidim. The bridge has 3 spans and its total length is 45.92m. The superstructure and sub-structures (abutments and piers) are RCC. Its construction was completed in 1992.

The actual cost of the bridge was not available. According to the prevailing rates, the bridge cost is estimated to be around 30 million rupees.

The condition of the bridge is good. Any major rehabilitation/reconstruction and retrofitting works were not carried out in the past. However, some surface erosion was seen at the piers. DoR has constructed gabion walls to protect the piers from flood impact.

There were not any extreme events after the bridge construction

2. VULNERABILITY ASSESSMENT METHOD

2.1Summary of method/process

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

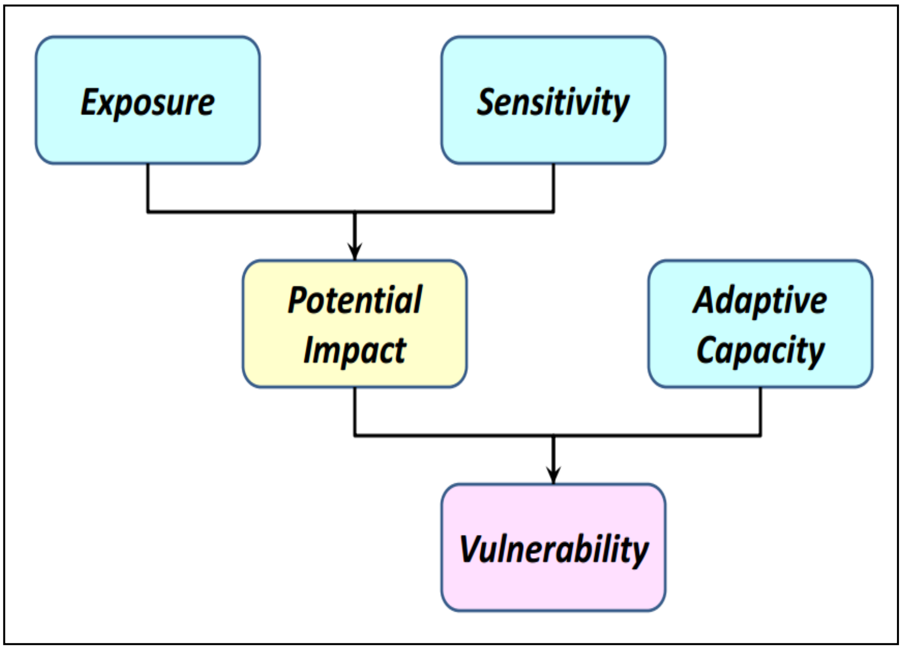


Fig 2: VA Process

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.

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.3: Impact Assessment Matrix

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 4: 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) Bridges and 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.

Sensitivity

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

Table 3. 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 4. 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

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 Panchthar 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 Panchthar District will generally, depending also on upstream catchment area and topography, have a High or Very High Exposure to climate change.

Table 5. 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	Medium to Very

		reducing clearance under bridge	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

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.

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 Panchthar 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 Panchthar 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.4.

3. VULNERABILITY ASSESSMENT OF THE ASSET

3.1 Asset Description

Landslide at Amarpur

The following table describes the important aspects of the asset.

Table 6: Salient features of Amarpur Landslide

Name of the Road	Mechi Highway
Road Category	National Highway
Service Provided by the Road	Connects Jhapa, Ilam, Phidim and Taplejung Districts in Eastern Development Region.
Location of Asset	At a distance of 49 km from Phidim towards Taplejung side
Length of the affected road section.	About 40 m
Responsible Agency for repair/rehabilitation of the asset.	Ilam Division of DoR
Major cause of the damage	Haphazard extraction of stones and gravels from the hill slope
Existing Condition of different components	Road: good. Major problem: The landslide is still not fully stabilized. : Lacks adequate protection measures.

Fig. 4a: Overall view of the landslide. At some locations the landslides are still active Main reason of landslide at this location is extraction of stones from the hill slope.

Fig. 4b: View of hill slope adjacent to landslide area (towards Taplejung side). The slope is stable due to interlocking of boulders. The condition of landslide area (Fig. 4a) was similar to the above before the stone extraction. Hence the authority should strictly prohibit extraction of stones from hill slope.

Fig. 4c: Loose materials hanging at the slope. These materials will slide during monsoon and may close the traffic. Combination of gabion breast walls and bio-engineering will stabilize the slope to a great extent.

Fig. 4d: Side drain is blocked by recent slides. The site condition shows that a gabion breast wall should be constructed to prevent such slide.

Hengwa Bridge

The following table describes the important aspects of the asset

Table 7: Salient Features of the Hengwa Bridge

Name of the structure	Hengwa Bridge
Design parameters	Total length =45.92m; Spans=3; Foundation type = open
Construction Materials	RCC (superstructure, sub-structure and foundation)
Name of Road	Mechi Highway
Location of Asset	At a distance of 9 km from Phidim towards Taplejung side.
Service Provided by the Road	Connects Jhapa, Ilam, Phidim and Taplejung Districts in Eastern Development Region.
Responsible Agency for repair/rehabilitation of the asset.	Ilam Division of DoR
Existing Condition of different components	Superstructure and abutments: good. Piers: Surface erosion due to boulders and gravels of the river Bank protection: damaged at few locations. Major concern: The river is steep and is causing impact damage to piers.

Fig. 5a: View of the bridge from upstream. It is a three span bridge with two piers in between. The length and height of the bridge is sufficient.

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Fig. 5b: Carriageway view of the bridge. Although the bridge was constructed more than 20 years ago its overall condition is good.

Fig 5c: Bank protection works at upstream at left side of the river. Similar type of walls is provided at upstream and downstream of both banks. These walls are damaged at few locations.

Fig 5d: Gabion mattress and small wall is provided to protect the pier. It is to be noted that the river gradient near the bridge is high and it transports big boulders. The bridge design would have been more appropriate if piers were avoided at the main river course. There is a probability of damage to piers and bridge collapse if the flood volume increases (due to climate change).

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3.2 Climate Change Threat to Infrastructures in Panchthar District

The experts of the study team prepared a climate threat profile. The profile is submitted in Annex 1 and its summary is given below.

Threat due to Temperature Increase

As per the threat profiles, temperature increase in Panchthar District will be 1.6^0 C by 2050.

Adverse effect on the road and bridge assets due to above temperature rise will be nominal.

Threat due to Precipitation and Flood Increase

The rainfall pattern will change in the following manner:

- Increasing number of dry days in all months except April and May – average number of dry days in January will increase from 6.3 to 6.9 days
- Increasing number of extreme rainfall events – events that now occur every 20 years are projected to occur every 2 years
- Increasing wet season flow on the Tamor River – peak monthly average flow in wet season will increase by up to 170%.

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:

Design life: 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 will be a need to design important bridges for more than 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.

3.3Vulnerability Assessment Results

The following tables show the VA results of the assets.

Table 8: Landslide at Amarpur (Asset 1)

Climate Change Threats	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Component 1: Hill Slope							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing landslides events.	The higher rainfall will weaken the slope stability.	H[1]	M[2]	H	The intensity and frequency of slope erosion and landslides will increase.	H[3]	M
Component 2: Road							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing duration of road pavement wetting	Duration of wetting of road pavement (especially sub-grade) will increase.	M[4]	L[5]	M	Higher moisture content at sub-grade for longer duration causes pavement failure.	H[3]	M
Component 3: Side drains							

• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events	Size of side drains will not be sufficient to drain surface water.	H[6]	M[7]	H	The water will overflow from the side drains. The overflow water will damage the road and adjoining properties.	H[3]	M

Notes:

1. *Slope erosion and landslide events at geologically weak areas are highly exposed to duration and intensity of rainfall.*
2. *The scale of landslide will not be high. The road can be cleared within hours. Loss of lives and properties will be nominal.*
3. *The adaptive capacity of DoR Division Road Office is **High**; see section 2.2.4.*
4. *The exposure of black top road to wetting of sub-grade by increased rainfall is considered medium.*
5. *Side drain is provided throughout the landslide area. The road can be cleared within hours. Loss of lives and properties will be nominal.*
6. *All the surface water is accumulated in side drain. Hence it is highly exposed to higher rainfall.*
7. *The overflow from side drains will cause damage to road, hill slope and other properties located at valley side. The loss of lives and properties will be nominal.*

Table 9: Hengwa Bridge(Asset 2)

Climate Change Threats	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Component 1: Bridge pier							
• Increasing intensity and duration of rainfall • Increasing number of	Higher flood will transport large boulders.	VH[1]	H[2]	VH	The increased impact due flood water and boulders will damage the piers.	H[3]	H

extreme rainfall events • Increasing wet season flow							
Component 1: Bank protection walls							
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	The increased flood will cause more scour and break gabion wires.	H[4]	L[5]	M	Increase in flood volume will cause more damage to protection structures.	H[3]	M

Notes:

1. *The river gradient is high. It transports big boulders during normal flow. Increasing flow will accelerate the process and will damage the pier.*
2. *The higher flood may damage to pier although its quality is good. Piers will collapse in case of extreme events. Traffic will be obstructed for several days/months.*
3. *The adaptive capacity of DoR Division Road Office is* ***High****; see section 2.2.4.*
4. *The bank protection walls which are made of gabions are directly in contact with river flow.*
5. *The damaged protection works can be rehabilitated within short time with reasonable cost. The loss of lives and properties will be nominal.*

Note: Superstructure, abutments and approach roads are not vulnerable to flood increase; hence their vulnerability analysis is not carried out.

3.4 Vulnerability Assessment Summary

Table 10: Landslide at Amarpur

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	The intensity and frequency of slope erosion and landslides will increase.	**H**	**M**	**H**	**H**	**M**	The slope is weak and fragile. It is being eroded by normal flood. There is no breast wall at landslide area.
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow	Higher moisture content at sub-grade for longer duration causes pavement failure.	**M**	**L**	**M**	**H**	**M**	Sub-grade is very sensitive to moisture content. With higher rainfall the moisture content at the sub-grade will increase. This will weaken the pavement strength and causes its failure. As the road is black topped, the damaging effect will be low to medium.
• Increasing intensity and duration of rainfall • Increasing number of extreme rainfall events • Increasing wet season flow • Increasing in	The water will overflow from the side drains. The overflow water will damage the road and adjoining properties.	**H**	**M**	**H**	**H**	**M**	Overflow from side drains causes damage to hill side and valley side slopes and weakens sub-grade. There are several instances when the overflow water from the side drains damaged cultivated land and houses

landslides							

Table 11: **Hengwa Bridge (Asset 2)**

THREAT	IMPACT	EXPOS.	SENSIT.	IMPACT	ADAPT. CAP.	VULN.	COMMENTS
• Increasing intensity and frequency of extreme rainfall events. • Increasing wet season flow	The increased impact due flood water and boulders will damage the piers.	**VH**	**H**	**VH**	**H**	**H**	The pier is vulnerable because the river gradient is steep and transport big boulders (see photo). DoR has put some gabion protection. The existing gabion protection will not be sufficient for increased flood. (Note: Pier should be avoided where the river gradient is high and transport big boulders))
• Increasing intensity and frequency of extreme rainfall events. • Increasing wet season flow	More floods will cause more damage to protection structures.	**H**	**L**	**M**	**H**	**M**	The existing gabion bank protection works are damaged at several locations. With higher flood the damage will be much more.