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# RURAL ROAD SECTOR (DOLIDAR):
# CHITWAN VULNERABILITY ASSESSMENT REPORT


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|---|---|
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# 1 DISTRICT ASSETS/SYSTEM PRIORITIES

## 1.1 Briefing on Chitwan District

*Overall View*

Chitwan District is located in the western part of Narayani Zone in Central Development Region. The total area of the district is 2,218 km² of which major part lies in Siwalik Region. According 2011 census the population of the district was 566,661. Chitwan is particularly rich with flora and fauna. Nepal's first national park "Bharatpur National Park" together with the adjacent Parsa Wildlife Reserve supports species diversity much higher than any other part in the Indian subcontinent.

Major Rivers in the districts are: Narayani, Trishuli , East Rapti, Lothar, Bhorle, Kali, Khahare etc

Bharatpur, the headquarter of Chitwan District is the seventh largest city of the country. It is also a commercial and service centre of central south Nepal and major destination for higher education, health care and transportation of the region.

*Rural Road Network*

In total 595 rural roads (village and core network) with a total length of 2271.9 kilometres are constructed or under construction in the district. Out of the total, 137 km is gravel and 2136.9 km is earthen. There is no black top rural road in the district (as per rural road data of DoLIDAR; FY 2009/10).

For planning/implementation of rural road networks, DDCs/DTOs of all districts of the country are required to prepare District Transport Master Plan (DTMP). Chitwan District is preparing the DTMP and has planned to complete in near future.

All the infrastructural works including rural roads of the district are being managed be District Technical Office (DTO). Chitwan DTO is headed by a senior divisional engineer (SDE). The other staff in the DTO are: 4 Engineers, 3 Sub-engineers, 4 Accountant Officer 1 and 7 support staff.

*Climatological Record*

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

Table 1: Climatological Record of Chitwan District

Location: Rampuri; Latitude: 27$^{o}$ 37' N; Longitude: 84$^{o}$ 25E; Elevation: 256 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 |
| 30.7 | 18.3 | 24.5 | 40.0 May | 4.2 Jan | 87 | 74 | 2743 | 155/Sept | 112 |

*Source: Department of Hydrology and Meteorology*



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Table 2: Monthly Rainfall of Chitwan District

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.1 | 0 | 7.3 | 274.2 | 179.2 | 465.5 | 753.5 | 126.3 | 101.1 | 0 | 2 |

*Source: Department of Hydrology and Meteorology*

## 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.

## 1.3 Description of Priority System

In total three assets were covered in baseline report. From them, Ladari Bridge and rural road in Gitanagar settlement are selected for vulnerability assessment and adaptation planning due to their uniqueness.

*Ladari Khola Bridge*

DDC constructed a multi span slab bridge across Ladari Khola in 2008. The bridge has 10 equal spans of 6 meter each. The superstructure of the bridge is RCC and the piers and abutments are constructed of brick masonry in cement sand mortar. The left pier of the bridge settled and the bridge collapsed about 3 years ago 2-3 years after its completion. As the DDC/DoLIDAR did not possess the design drawings, the consultant thoroughly inspected the site and consulted local people to find out the causes of bridge collapse. The findings showed that:

- The foundation depth of the bridge is about 2meter only, which is not sufficient for bridges located in Chure range where excessive scouring and siltation is common.
- The DDC made a contract for extraction of riverbed materials with a local contractor. The contractor extracted the materials from the bridge site making the foundation more vulnerable.
- The bridge lies in the bend. Due to bend the Khola is scouring the left bank and making deposition at the right bank. This may be one reason for the collapse of the abutment and piers on the left side.

*Rural Road in Gitanagar Settlement*

Gitanagar is a recently developed settlement and is located at about 10 km from Bharatpur. The main settlement consists of 300 m long road and about 100 houses at both sides. The houses are constructed blocking the natural/existing drains Due to this, the rain water accumulates on the road for a very long period. This is creating inconvenience to the pedestrians and vehicles. Moreover, the water is also damaging the road and adjoining properties.

# 2 VULNERABILITY ASSESSMENT METHOD

## 2.1 Summary of method/process

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

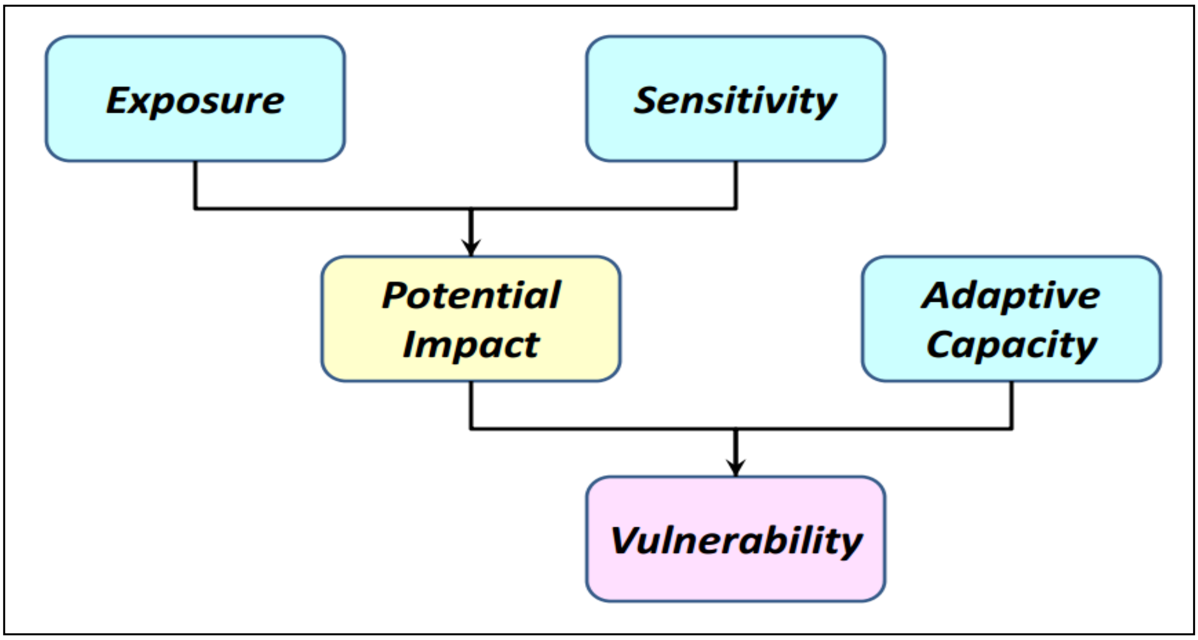


**Fig 1: VA Process**

There are two components in this phase

1. Assessing the impact of a climate threat on an asset and system; and
2. 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.2: 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*<br>*Inconvenience (days)* | *Low*<br>*Short disruption to system function (weeks)* | *Medium*<br>*Medium term disruption to system function (months)* | *High*<br>*Long term damage to system property or function (years)* | *Very High*<br>*Loss of life, livelihood or system integrity* |
| *Adaptive Capacity* | *Very Low*<br>*Very limited institutional capacity and no access to technical or financial resources* | *Medium* | *Medium* | *High* | *Very High* | *Very High* |
| | *Low*<br>*Limited institutional capacity and limited access to technical and financial resources* | *Low* | *Medium* | *Medium* | *High* | *Very High* |
| | *Medium*<br>*Growing institutional capacity and access to technical or financial resources* | *Low* | *Medium* | *Medium* | *High* | *Very High* |
| | *High*<br>*Sound institutional capacity and good access to technical and financial resources* | *Low* | *Low* | *Medium* | *Medium* | *High* |
| | *Very High*<br>*Exceptional institutional capacity and abundant access to technical and financial resources* | *Very Low* | *Low* | *Low* | *Medium* | *High* |

**Fig 3: Vulnerability Assessment Matrix**

## 2.1 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.

### *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<br>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<br>Increased intensity of rainfall | Side drains which are in good condition and well maintained | Damage to side drains |

| | | |
|---|---|---|
| | will have a low sensitivity | |
| Increased rainfall increases instability of hillside<br>Increased intensity of rainfall increases instability of slope<br>High flow in river scours base of hillside & causes landslide | A road across an hillside prone to landslides will have a Very High sensitivity<br>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<br>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 Climate Change Threat Profile for Banke District show that the flood magnitude will increase in the range of between 16-41 % in 2040 and 40-57 % in 2060 for different return periods.

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 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 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 |

*Impact*

The impact of an 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 DoLIDAR and DDC/DTO is not a simple task. Baseline assessments including consultations and site visits have shown that the DTO Chitwan which is responsible for rural roads and bridges in the district has the following capacities:

- Sufficient experience in rural road and trail bridge construction;
- Do not have sufficient experience in design of roads and bridges
- Insufficient technical manpower in comparison to the number of projects;
- Inadequate financial resources;
- Inadequate management system; and
- Not very prompt in responding to disasters.

However, the efficiency and technical capability of DTO has increased in the last few years after the involvement of big donors such ADB, WB, DfID etc in the rural transport sector.. Considering the above factors, it is deemed that the adaptive capacity of DoLIDAR/DDC/DTO as **'Medium'.**

**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 Assessment Matrix provided in Fig.3.

# 3 VULNERABILITY ASSESSMENT OF ASSETS

## 3.1 Asset Description

*Ladari Khola Bridge*

*The following table describes the important detail aspects of the asset*

***Table 4: Salient Features of the Asset***

| | |
|---|---|
| **Location** | 2 km from Parsa, a small town along MRM |
| **Total Length and no. of spans** | Total length= 60 km; No. of spans = 10 |
| **Service Provided by the Bridge** | Provides motorable road service to Birendranagar, Bhumetar VDCs. |
| **Responsible Agency** | DDC/DTO, Chitwan |
| **Major Aspects of the Asset** | - Superstructure: Concrete slab |

| | |
|---|---|
| | - Sub-structures: Brick masonry in cement mortar<br>- Foundation: Open |
| **Existing Condition of different components** | - The bridge has collapsed and is not motorable any more. |

Fig. 4a: Photograph of the damaged bridge from the left bank. As seen, the bridge has collapsed due to settlement of piers.

4 b: View of damaged portion of the culvert from the left abutment. As seen, the pier has completely settled and the concrete slabs are displaced/missing.

Fig. 4c: Earthen embankment is constructed at the left bank to regulate the river course through the bridge and protect the farm land. As seen on photo, the river is in bend. Due to the bend, the river is scouring at left bank and causing silting on right bank.

*Gitanagar Settlemet*

The following table describes the important detail aspects of the asset

**Table 5: Salient Features of the Asset**

| | |
|---|---|
| **Name of the Road** | Bharatpur-Narayanpur-Gitanagar-Patihani Road |
| **Road Category** | District Road Core Network (DRCN) |
| **Service Provided by the Road** | Provides motorable road service to south-western VDCs of the district. |
| **Responsible Agency** | DDC/DTO, Chitwan |
| **Location of Asset (Culvert)** | Km 8+700 |
| **Major Aspects of the Asset** | - Roads<br>- Houses at both sides<br>- Side drains and cross drains are completely missing along the whole 300m long section of the road. |
| **Existing Condition of different components** | - Road: poor, too many pot holes and cracks on the pavement.<br>- Inundation of road for a long period during rainy season. |

Fig. 4a: Starting point of Gitanagar settlement. There is no side drains at both sides.

4b: Damage to the road pavement due to accumulation of water for a long period.

Fig. 4c: Houses are constructed at both sides of the road without provisioning of side drains.

## 3.2 Climate Change Threat to Infrastructures in Banke District

In order to find out the climate change effect on roads and bridges, climate change threat profiles for Chitwan District is prepared. Findings of the threat profiles are briefly described in the following sections.

*Threat due to Temperature Increase*

As per the threat profiles, the average temperature increase in Chitwan District will be $1.6^0$ by 2060.

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

*Threat due to Precipitation and Flood Increase*

A study was made on Rapti River at Meghauli to find out the increase in flow due to climate change. (see Annex 1; 2.10 Change in annual recurrence interval). The findings showed that:

- Annual recurrence interval of flood in 100 years interval (which is usually used for design of major bridges) will occur at an interval of 30 yrs;
- Annual recurrence interval of flood in 25 years interval (which is usually used for drainage and retaining structures) will occur at an interval of 10 yrs;

***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 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.

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

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

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

<u>Road pavement</u>: 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 table below presents the vulnerability assessment for the differe*nt components of the asset are presented below.*

**Table 6. Vulnerability assessment *of Ladari Khola Bridge (the bridge has already collapsed)***

| Climate change threats | Interpretation of threat | Exposure | Sensitivity | Impact Level | Impact Summary | Adaptive capacity | Vulnerability |
|---|---|---|---|---|---|---|---|
| **Component 1: Bridge** | | | | | | | |
| • Increasing intensity and duration of rainfall<br>• Increasing number of extreme rainfall events<br>• Flooding at the (natural) drainage system | HFL will increase.<br>The scour depth will be higher due to increase in flood volume. | VH[1] | H[2] | VH | The water level will rise and may hit the superstructure. Due to increase in flood, scouring at the bridge site will increase and cause collapse to the bridge. It is to be noted that the bridge has already collapsed. With flood increase such event will be more frequent | M[3] | VH |
| **Component 2: Bank protection works** | | | | | | | |
| • Increasing intensity and duration of rainfall<br>• Increasing number of extreme rainfall events<br>• Flooding due to | Higher flood will cause more damage to bank protection works. | VH[1] | L[4] | H | Possibility of damage to bank protection works will increase. As it is located in the curve damage process will be even more. | M[3] | H |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| accumulation of water on the cultivated land | | | | | . | | |

***Notes:***

1. *The exposure is Very high because the bridge is located at the foothill of Chure hill which is characterized by heavy flash floods*
2. *The sensitivity is high because the construction quality is poor.*
3. *Refer to section 2.2.4.*
4. *The sensitivity is low because there will no heavy loss of lives and properties. Moreover, the quality of works is good.*

**Table 7: Vulnerability assessment for Gitanagar Settlement**

| Climate change threats | Interpretation of threat | Exposure | Sensitivity | Impact Level | Impact Summary | Adaptive capacity | Vulnerability |
|---|---|---|---|---|---|---|---|
| **Component 1: Roads** | | | | | | | |
| • Increasing intensity and duration of rainfall;<br>• Increasing number of extreme rainfall events;<br>• Increasing risk and severity of flash floods | The area will be inundated for a longer period. | VH[1] | H[2] | VH | Damage to road will be more. Vehicle and pedestrian traffic will be obstructed for longer period. | M[3] | VH |
| **Component 2: Buildings at both sides of the road** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| • Increasing intensity and duration of rainfall<br>• Increasing number of extreme rainfall events<br>• Flooding due to accumulation of water on the cultivated land | Increased water level will spread to the house compounds and surrounding areas. | VH[4] | M[5] | VH | There will be lot of inconvenience to the residents such as moving outside, grazing animals etc. Similarly the inundation will damage grain storage, vegetable, gardens etc. | M[3] | VH |

***Notes:***

1. *The asset lies in the high rainfall area. The exposure is further increased due lack of proper drainage system.*
2. *The road pavement is constructed without design. Hence the pavement strength is low. With inundation of water, the damaging process will accelerate.*
3. *Refer to section 2.2.4.*
4. *The asset is located in the high rainfall intensity area. Due to flat slope and lack of proper drainage system the water cannot drain in short period.*
5. *The quality of houses is good and hence the sensitivity is considered medium.*

## 3.4 Asset Vulnerability Summary

Vulnerability summary of both the assets is provided in table 8 and 9.

**Table 8. Summary of Vulnerability assessment of Ladari Bridge**

| THREAT | IMPACT | EXPOSURE | SENSITIVITY | IMPACT | ADAPTIVE CAPACITY | VULN. | COMMENTS |
|---|---|---|---|---|---|---|---|
| Increasing intensity and frequency of extreme rainfall events will accelerate scouring process. | The bridge has already collapsed. With rainfall and flood increase such events will further increase. | VH | H | VH | M | VH | To protect the bridge from such event, the design should be carried out considering possible increase in flood, HFL, scour depth, waterway width.<br>The sensitivity is high the quality of design and construction is poor. |
| Increasing intensity and frequency of extreme rainfall events | Possibility of damage to bank protection works will increase.. As it is located in the curve damage process will be more. | VH | L | H | M | H | The sensitivity is very low because the construction quality is good. |

**Table 9. Summary of Vulnerability of Gitanagar Settlement**

| THREAT | IMPACT | EXPOSURE | SENSITIVITY | IMPACT | ADAPTIVE CAPACITY | VULN. | COMMENTS |
|---|---|---|---|---|---|---|---|
| Increasing intensity and frequency of extreme rainfall events | Damage to road will be more. Vehicle and pedestrian traffic will be obstructed for longer period | VH | H | VH | M | VH | The sensitivity is high because the design and construction of road is poor (without adequate drainages). Due to flat slope, the sensitivity is further increased. |
| Increasing intensity and frequency of extreme rainfall events | There will be lot of inconvenience to the residents such as moving outside, grazing animals etc. Similarly the inundation will damage grain storage, vegetable, gardens etc. | VH | M | VH | M | VH | The sensitivity is medium because the loss of lives and properties will not be high. |