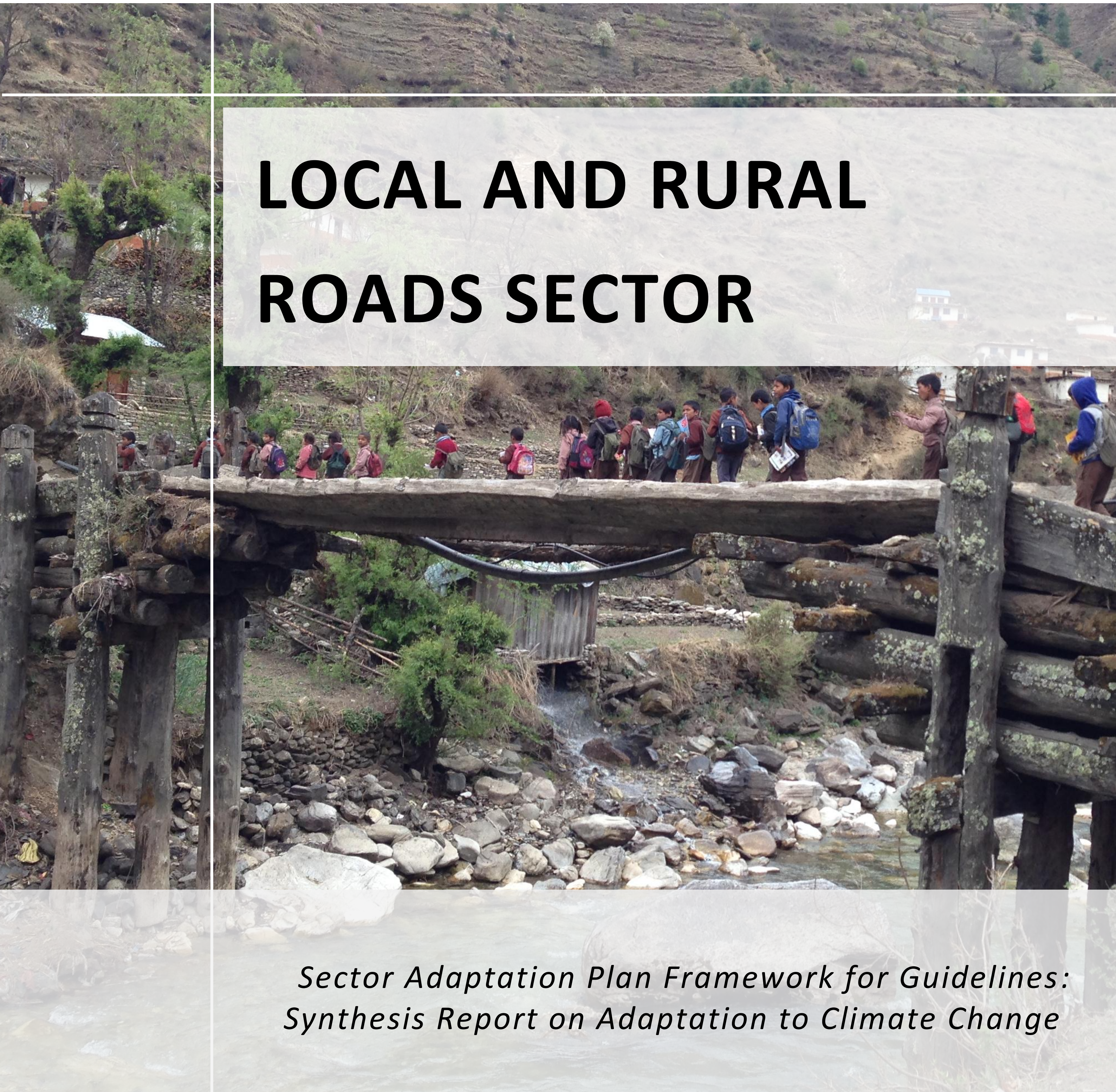
TA7984-NEP: MAINSTREAMING CLIMATE CHANGE RISK MANAGEMENT IN DEVELOPMENT

1 Main Consultancy Package (44768-012)



LOCAL AND RURAL ROADS SECTOR

Sector Adaptation Plan Framework for Guidelines: Synthesis Report on Adaptation to Climate Change

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Pilot Program for Climate Resilience - PPCR3, Mainstreaming Climate Change in Development

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EXECUTIVE SUMMARY

INTRODUCTION

The objective of this report is to set out the procedures that have been undertaken as part of the project in order to identify those elements of the rural roads infrastructure which are particularly susceptible to Climate Change threats. The report will also recommend interventions into selected guidelines and policies so that the risks imposed by Climate Change are reduced.

Studies were carried out in eight Districts to provide a baseline of data regarding the existing institutional capacity of DoLIDAR and the condition of the existing rural road network. In addition, examples of infrastructure assets which had suffered under past weather events were identified and examined.

Climate Profiles setting out the Climate Change Threat to each of the eight Districts were drawn up by the modelling team and then used as a basis of determining the possible future threats to the identified assets.

Having identified the possible threats to the existing assets from Climate Change the vulnerability of the assets was determined and adaptations to reduce the risk from the threats proposed with recommendations as to their urgency and priority,

In conclusion the report recommends which guidelines, standards and policies should be reformed so that the road infrastructure of Nepal has increased resilience to climate variability and climate change.

ROAD SECTOR IN NEPAL

Development of roads in Nepal gained momentum after the democracy in 1951. In the early periods, roads were constructed by different government agencies such as Public Works Department (PWD), Road Transport Organization (RTO) etc. In order to develop the road networks in a planned way, Government of Nepal (GoN) established Department of Roads (DoR) in 1970. DoR was responsible for planning, construction and maintenance of all type of roads until the establishment of Department of Local Infrastructure and Agricultural Roads (DoLIDAR) in 2001. After 2001, GoN assigned DoLIDAR and DDCs for implementation of all type of rural roads.

The total length of the Rural Road Network reached 50,943 kilometers by the year 2012.

This rapidly increasing workload, together with a lack of a commensurate increase in the capacity of the Department has inevitably led to difficulties in the management, construction and maintenance of the road network. Budgets are poorly managed, design is sometimes not to the required standard, contracts are awarded to inexperienced contractors who submit bids which are too low, contracts frequently over-run with construction quality poor and there is a large maintenance backlog. The lack of records of design and as-built drawings for bridges and other important structures makes the assessment of the resilience of such structures very difficult.

THREAT TO ROAD SECTOR FROM CLIMATE CHANGE

Studies done by the National & International Hydrological Modeling TA Team in close consultation with Department of Hydrology and Meteorology (DHM) show that climate change induced threats would affect differently people living in various regions in Nepal, their socio-economic development, biological diversity and other sectors. The results of such climate change induced threats are increased risks of floods, landslides, glacier outbursts, drought and other natural calamities.

The Rural Road Network in Nepal is highly vulnerable to climate change. Geomorphological systems are dynamic, natural systems are already stressed so that even relatively minor weather events can cause major disturbances. The very nature of the rural road network which reaches all parts of Nepal inevitably means that many sections of road cross rivers and streams which are prone to floods and hillsides which are unstable.

The climate change THREATS to the RRN are determined through an analysis of past extreme events and trends and through climate modelling and downscaling of future climate and hydrology against various scenarios.

BASELINE STUDY

The TA team recommended a geographic approach to identifying case studies whilst ensuring that the locations identified allow the case studies to cover the issues raised by each sector. During the Orientation Workshop the TA team consulted with the sector focal points and counterparts to prepare criteria for identifying the case study locations and subsequently identified six case study districts based on the criteria. The case study locations were chosen to ensure sufficient coverage of sector infrastructure and climate change issues and to represent the diverse ecological, infrastructure, climate, climate hazard and population density of Nepal.

Following the selection exercise conducted by sector Focal Points and the national team, and based on the priorities set under the NAPA and subsequent national vulnerability assessment studies, the case study assessments would be undertaken in the vulnerable districts of: (i) Mugu (ii) Dolakha (iii) Accham; (iv) Kathmandu Valley; (v) Banke; and (vi) Chitwan. Subsequently Mugu was dropped and replaced by Mustang with Pachthar and Achham added in order to broaden the extent of the baseline studies.

The Consultant's National Roads and Bridges Engineer visited all the Districts, met the District Engineers and with their assistance drew up Baseline Reports which describe the road network and set out the resources available in the District. The Reports also highlight the trends and some of the issues affecting the management of the roads infrastructure.

Several road infrastructure locations were selected with the help of the help of the District Officers which illustrated the effects of previous severe weather events. Included were some examples of adaptation plans which had been implemented after severe weather related events.

VULNERABILTY ASSESSMENT & ADAPTATION PLANNING

The climate change vulnerability and adaptation process has been used at the case study level. It is a flexible process and set of tools which can be applied to sectors, areas and communities down to specific infrastructure level. It is applicable to varying assessment scales from localized projects to settlements up to city size, and to larger spatial planning units such as watersheds and provinces. The methodology combines international best-practice in climate change science and hydrological modelling with best-practice in a number of rapid assessment methodologies such as Strategic Environmental Assessment, life-cycle analysis, socio-economic analysis, energy efficiency audits, risk management and participatory planning. In this project the CAM process will be integrated with existing methods in Nepal and shaped and adjusted by national teams and stakeholders to suit local conditions.

In the Roads Sector the CAM methodology has been used to identify those sections of the road infrastructure which are vulnerable to particular climate change threats and to assess the degree of vulnerability. The methodology then sets out the possible adaptation actions that can be implemented to reduce the identified vulnerabilities together with a prioritisation process which generates a timetable for carrying out the adaptations.

The methodology for carrying out this process is set out in the Section 7 of the report.

TYPICAL CLIMATE THREATS AND IMPACTS FOR THE ROAD SECTOR

Climate Threat Profiles have been produced by the modelling team for each District and each Sector. These Profiles set out the specific threats likely to occur in each District.

They identify the major threats to the road network as being:

- Increased total rainfall causing increased riverine floods and increase in average river levels

- Increase in number and intensity of storms causing increased frequency and intensity of rainfall
- Increase in intensity of rainfall causing increase in flash floods and debris flows
- Increase in the likelihood of Glacial Lake Outburst Floods (GLOF)due to increased ice melt and increased rainfall
- As a result of the increase in total rainfall and in the intensity of rainfall an increase in the number of landslides

This report sets out examples of the effect of the above threats on existing sections of the road network together with the corresponding Vulnerability Assessment and Adaptation Planning options.

CONCLUSION

The report recommends:

- In the short to medium term the elimination of the maintenance deficit must be considered the top priority.
- Vulnerability Assessments should be carried out along the most important road links in order to determine which sections are most vulnerable to extreme weather events
- Increase the technical and physical capability of the Department to respond to disruption caused **by severe weather events.**

REFORMS TO GUIDELINES, POLICIES & PLANS

Reforms are proposed in to the following Policies, Guidelines and Plans

- Institutional

Nepal Road Sector Assessment Study

- Policies & Plans

District Transport Master Plan (DTMP)

Annual Road Maintenance Plan (ARMP)

- Guidelines, Standards & Manuals

Environmental Assessment

Initial Environmental Examination (IEE)

Design Standards

Nepal Rural Road Standards (2055) Revised 2012.

Design of Roads & Bridges

Project Design

ACRONYMS

AADT	: Average Annual Daily Traffic
ADB	: Asian Development Bank
ARMP	: Annual Road Maintenance Plan
AP	: Adaptation Planning
CC	: Climate Change
DDC	: District Development Committee
DoI	: Department of Irrigation
DoLIDAR	:Department of Local Infrastructure and Agricultural Roads
DoR	: Department of Roads
DoT	: Department of Transport
DR	: District Roads
DWIDP	: Department of Water Induced Disaster Project
DWSS	: Department of Water Supply and Sewerage
EIA	: Environment Impact Assessment
ESMF	: Environmental and Social management Frameworks
FR	: Feeder Roads
HFL	: Highest Flood Level
HMIS	: Highway Management Infromation System
HRD	: Human Resource Development
IEE	: Initial Environment Evaluation
MOLD	: Ministry of Local Development
MoPIT	: Ministry of Physical Infrastructure and Transport
MRM	: Mahendra Raj Marga
NEA	: Nepal Electricity Authority
NH	: National Highways
NMRM	: Naubise Mugling Raj Marga
NSET	: Nepal Society for Earthquake Engineering
NT	: Nepal Telecom
PRM	: Prithvi Raj Marga
PWD	: Public Works Department
RTO	: Road Transport Organization
SDE	: Senior Divisional Engineer
SED	: Strengthened Equipment Division
SRN	: Strategic Road Network
TRP	:Tribhuban Rajpath
UNDP	: United Nations Development Project
UR	: Urban Roads
VA	: Vulnerability Assessment
VCDPF	:Vulnerable Community Development Policy Framework
VDC	: Village Development Committee
vpd	: Vehicle per Day
VR	: Village Roads

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1 INTRODUCTION

This synthesis report was prepared as part of the TA – 7984 NEP: *Mainstreaming Climate Change Risk Management in Development Project* supported by ADB with funding from the Climate Investment Fund (CIF), and implemented by the Ministry of Science, Technology and Environment (MOSTE) in partnership with ICEM – International Centre for Environmental Management.

The project involves line departments working together with MOSTE in eight districts to develop and test a vulnerability assessment and adaptation planning approach tailored for their needs. The aim is to distil the lessons of the district experience into reforms at national level for planning and managing more resilient infrastructure. The national agencies are those concerned with infrastructure development throughout Nepal such as irrigation, roads and bridges, water induced disasters, urban planning and water supply and sanitation systems (Figure 1).

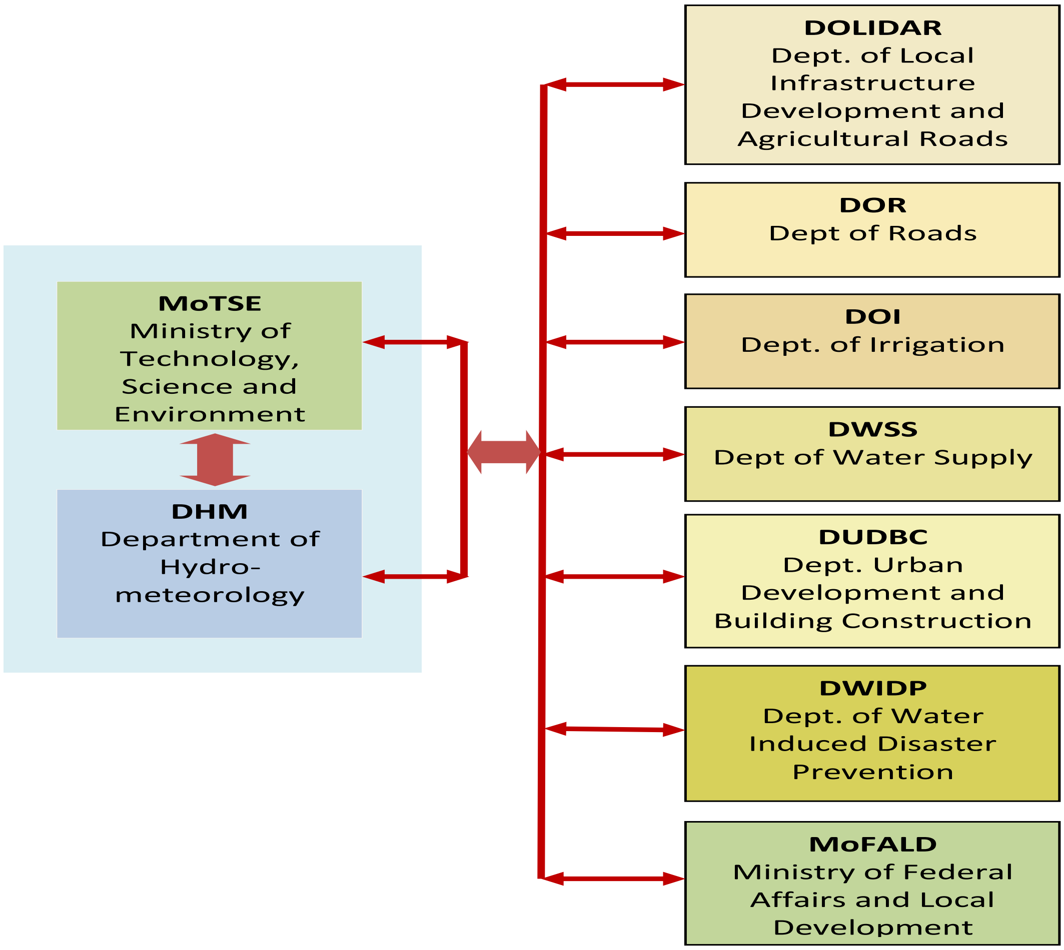

Figure 1: TA – 7984 NEP infrastructure sector department partners

A core group of technical staff from each of the departments participated in working sessions and missions to the eight districts of Kathmandu, Dolakha, Achham, Banke, Myagdi, Chitwan, Panchthar and Mustang (Figure 2) where vulnerability assessments and adaptation planning exercises were conducted for existing strategic infrastructure assets. The target districts were identified by core group members to reflect the diverse ecological zones of the country and varying environmental and social conditions in which infrastructure is built. The district assessments were supported by climate change threat analysis and hydrological modelling at each case study location.

The core group comprised of some 30 members from 9 government agencies with each agency having a wider range of staff involved in the process of setting and implementing reform priorities with support from the project team (Figure 3). Sector focal points on the core group have a key role in promoting the climate change mainstreaming in their departments so that the design and management of existing and planned infrastructure progressively adjusts to become more resilient to the most significant projected changes and their associated potential impacts.

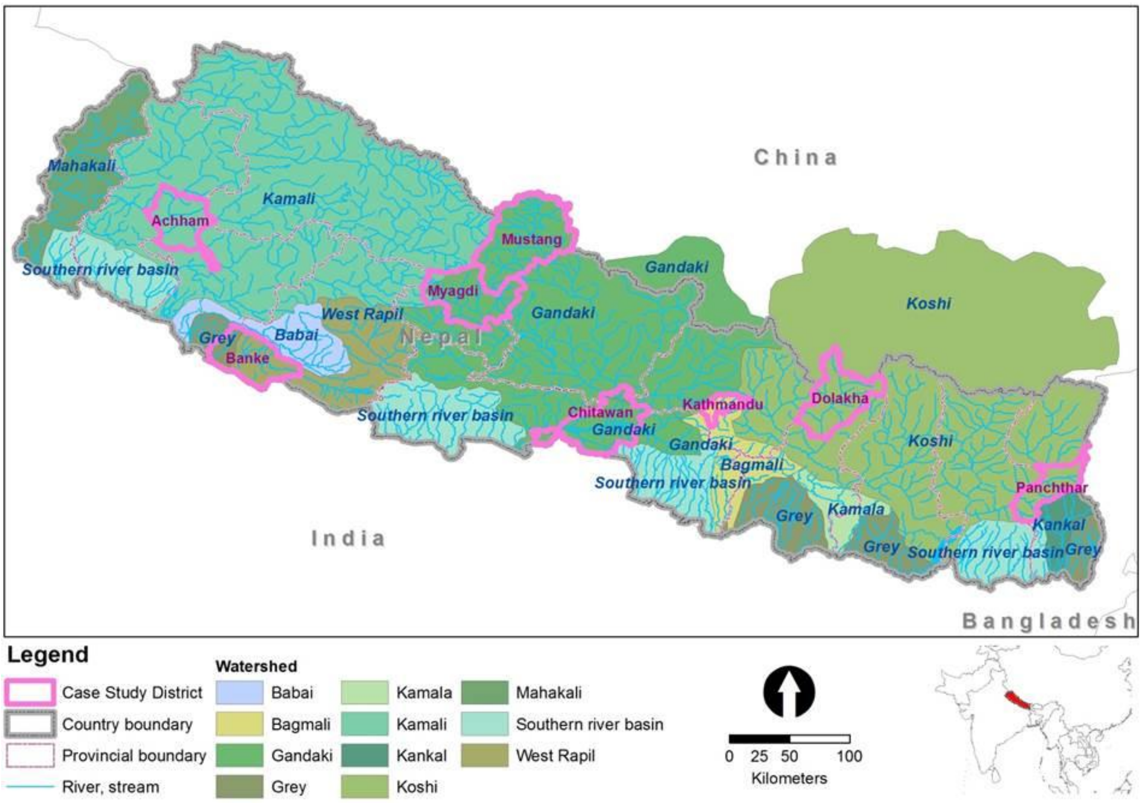

Figure 2: Target districts for developing an approach to infrastructure vulnerability assessment and adaptation planning

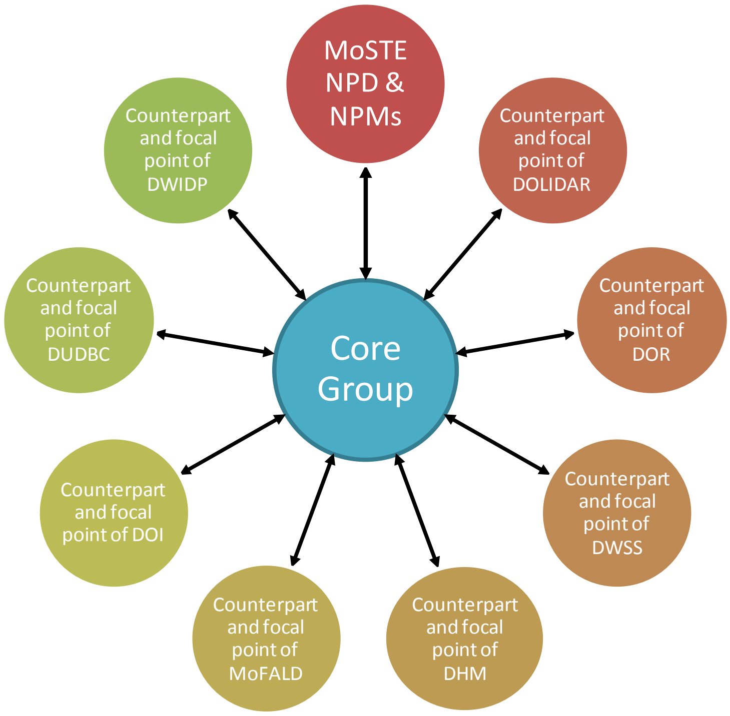

Figure 3: Infrastructure sector department climate change core group

Through the project, a "climate change risk management system" (CCRS) has been developed based on the district and international experience. The CCRS includes tools to facilitate climate change vulnerability assessment and adaptation planning and a dedicated process for the development of *sector adaptation plans for action* (SAPAs) that complement Nepal's existing climate change planning framework consisting of the National Adaptation Plan for Action (NAPA) and Local Adaptation Plans for Action (LAPAs).

The district case studies inform a sector vulnerability assessment and adaptation planning process that demonstrates the elements of a future SAPA process including the shape of SAPA reports (in the form of sector synthesis reports). The end result of this process is a sector oriented review of climate change vulnerability of key assets and a sector adaptation plan identifying the policy, procedures and structural reform priorities for building resilience in the sector and its infrastructure. The *sector synthesis reports* are being used as the basis for a sector specific training of government staff at the national and district levels on how to give effect to the reforms identified using the SAPA process and to apply the vulnerability assessment and adaptation planning tools developed by the core group and project team.

This Local and Rural Roads Sector Synthesis Report was prepared with DOLIDAR and involved a program of consultations in the districts and with the sector core group members and departmental officials. That process culminated in a national workshop at which government roads experts presented and discussed the synthesis conclusions and reform priorities. The government staff closely involved in the local and rural roads consultations and in the preparation and commentary on this report and the various linked sector district reports, climate change threat assessments and institutional analyses are listed in Annex V.

2 BACKGROUND

2.1 ROAD SECTOR IN NEPAL

Development of roads in Nepal got momentum after the democracy in 1951. In the early periods, roads were constructed by different government agencies such as Public Works Department (PWD), Road Transport Organization (RTO) etc. In order to develop the road networks in a planned way, Government of Nepal (GoN) established Department of Roads (DoR) in 1970. DoR was responsible for planning, construction and maintenance of all type of roads until the establishment of Department of Local Infrastructure and Agricultural Roads (DoLIDAR) in 2001. After 2001, GoN assigned DoLIDAR and DDCs for implementation of all type of rural roads.

Until the end of 1990, GoN mainly concentrated on roads linking headquarters and other important places. Rural roads started to get priority from early 2000 when major donors such as the World Bank (WB), Asian Development Bank (ADB), and Department for International Development (DFID), UK, Swiss Development Corporation (SDC) etc. started to allocate substantial fund in rural road sector.

The total length of the Rural Road Network reached 50,943 kilometers by the year 2012. The length of roads according to surface types is presented in Table 1.

Table 1: Length of Rural Road Network as per Surface Type

Total Population	Total Area of Nepal (sq. km)	Total number of Roads	Road Length (km)				Road Density	
			Total	Black top	Gravel	Earthen	Per 100 sq. km.	Per 1000 person
26,620,809	147,181	6,683	50,943	1,575	14,601	34,766	34.61	1.91

Source: Road Data Base; Website of DoLIDAR, 2012

In spite of GoN's high priority in road sector, Nepal's road network is one of the least developed among the SAARC countries. This is one of the main reasons for poor growth of other sectors such as industry, agriculture, hydropower etc. The poor road network is also hindering the effective and comprehensive participation of rural population in the country's economic growth process. Beside poor network, the condition of existing roads is also far from satisfactory due to lack of timely maintenance and rehabilitation. The study shows more than half of the total rural roads are not trafficable due to their very poor condition.

2.2 CLASSIFICATION OF ROADS

GoN classified the roads in following five categories and published in Road Classifications (Second Revision), 2050 (1992).

(I) National Highways (NH);
(II) Feeder Roads (FR); FRs are further classified into FR (major) and FR (minor);
(III) District Roads (DR);
(IV) Urban Road (UR);
(V) Village Roads (VR)

For effective management of road network in the country and to make the best use of available resources, GoN/DoR further classified the roads in four classes on the basis of functional and administrative importance as defined below.

(a) The Strategic Road Network (SRN) - comprising NH and FRs.

(b) The District Transport Network- comprising District Roads, Main Tracks and Main Trails.
(c) The Urban Road Network – comprising all non-strategic within the municipal boundaries.
(d) The Village Transport Network – includes short non-through roads, tracks and local trails linking single villages to the District Transport Network.

The Department of Roads has responsibility for the Strategic Road Network (SRN). A separate sector synthesis report has been produced for the SRN. District and Village Roads, which are also known as the Rural Road Network, are implemented and managed by a consortium of DDC/VDC/MOFALD and DoLIDAR. This report focuses on this rural road network. Urban Roads are the responsibility of the respective municipalities.

2.3 INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTATION OF LOCAL INFRASTRUCTURE SECTOR

The Local Infrastructure Development (LID) Policy (2004) designates that local bodies shall be "responsible for the formulation, implementation, monitoring and evaluation, maintenance and operation of local infrastructure", including rural and urban roads.

The DDCs are ultimately responsible for the management of the rural roads. Although elected district councils are supposed to be in place to approve plans and budgets, formulate policies and strategies and monitor progress, the last elected councils were dissolved in July 2002. At present the district council does not exist and is replaced by a joint committee of representatives from local political parties (All Party Mechanism or *Sanyantra*), who make up the members of the DDC, chaired by the Local Development Officer (LDO) who is appointed by MoFALD and formally has the position of DDC Secretary. At present the DoLIDAR/ DTOs support the DDCs in all technical aspects.

2.4 WORK IMPLEMENTATION MECHANISM

The LID Policy designates the Ministry of Federal Affairs and Local Development (MoFALD) as the liaison ministry for local infrastructure coordination. DOLIDAR assists MoFALD to coordinate and support local bodies regarding local infrastructure. DOLIDAR also provides technical support to the DDCs through its District Technical Offices (DTO) which is placed under the DDCs. The DTOs report to DOLIDAR and are responsible for providing technical assistance regarding all local infrastructure including rural roads in the district. Formally, the DTOs are seen as a transitional measure, providing time to the DDCs to create their own technical unit. In general, the capacity of DTO and DDC engineers is not sufficient due to the large number of local infrastructure projects and limited number of technical manpower.

The central office of DoLIDAR is headed by a Director General (DG). There are 3 Deputy Director Generals (DDGs) in the central office to support him. Following sections/units, headed by Deputy Director General, are formed in the central office:

- Local/Agricultural Road Section
- Project Monitoring and Foreign Project Coordination Section
- Other Local Infrastructure Sections

The Other Local Infrastructure Sections are further divided into several divisions such as: (i) Local/Agricultural Road Division, (ii) Trail Bridge Division,(iii) Drinking Water, Sanitation and Building Division (iv) Irrigation, Flood Control and Other Infrastructure Division (v) General Administration Division (vi) Account Section etc.

DoLIDAR executes large scale projects such as RAIDP, DRILP, RRRSDP etc. by establishing separate project offices. Most of them are headed by Senior Divisional Engineer.

GoN/MOFALD/DOLIDAR has established DTO Office in all the 75 DDCs. The main function of the DTO is to support the districts for planning, implementation and maintenance of all type of infrastructure works as directed by the LID Policy. In general the staffs of DTO are either deputed by DoLIDAR or DDC. The DTO is headed by a civil engineer (Gazetted second class or third class depending upon the district). He is supported by engineers, sub-engineers, accountants and auxiliary staffs.

2.5 LEGISLATIONS AND POLICIES

GoN has prepared following documents on Legislations and Policies on rural infrastructures sectors.

- Local Body Financial Administration Regulations, 2064 (2007
- Local Body Financial Administration Act
- Local Infrastructure Development Policy, 2061 (2004)
- Local Infrastructure Development Strategic Action Plan 2007-2010, 2064 (2007)
- Local Self Governance Regulations, 2056 (1999 – fourth amendment 2010
- Local Self Governance Act, 2055 (1999)
- Local Administration Act, 2028 (1971 - fifteenth amendment 2010)
- Roads Board Act, 2058 (2002 – first amendment 2010)
- Roads Board Regulations, 2060 (2004)
- National Transport Policy, 2058 (2002)
- Public Roads Act (second amendment), 2046 (1990

2.6 DESIGN STANDARDS

MOFALD/DOLIDAR revised the Nepal Rural Road Standard (2055) in 2012. The standard has classified the rural roads and terrain in the following manner.

RURAL ROAD CLASSIFICATION

District Road (Core network) - An important road joining a VDC HQ's office or nearest economic centre to the district headquarters, via either a neighboring district headquarters or the Strategic Road Network.

Village Road - Smaller roads not falling under District Road (Core Network) category are Village Roads, including other Agriculture Road.

TERRAIN CLASSIFICATION

A simple classification of Terrain into 'Terai' and 'Hill' is adopted based on the topography of country. While classifying terrain, short isolated stretches of varying terrain should not be taken into consideration. Generally, 'Terai' covers the plain and rolling terrain and varies from 0 to 25 percent cross slope, 'Hills' covers mountainous and steep terrain and varies from 25 to 60 percent and more.

The other aspects covered by the standards are:

- Traffic (Vehicle type and dimension, Equivalency Factors, Design Capacity, Design Speed)
- Cross Section (Carriage Way Width, Shoulder Width, Road way width
- Right of Way (RoW)
- Stopping Sight Distance
- Lateral and Vertical Clearance
- Horizontal Alignment (Super elevation, Minimum Curve Radius, Widening of Curve, Hairpin Bend)
- Vertical Alignment (Gradient, Vertical curve, Valley Curve)
- Co-ordination of Horizontal and Vertical Alignments

- Camber Cross Slope
- Passing Zone and Lay-bys
- Carriageway Width at Culvert/Bridge
- Level of Road Embankment above HFL etc.

2.7 INSTITUTIONAL ISSUES

The following governance issues are highlighted by the Baseline Studies:

- Delays in approving and releasing budgets
- Delays in approving programmes
- Inexperienced contractors who submit bids which are unrealistic
- Contracts not started or completed on time
- Too many village roads are being constructed
- Insufficient technical staff
- Insufficient and old equipment
- The requirement set out in District Transport Master Plan that the roads selected as being part of the District Core Road Network (DCRN) are maintained before expenditure is made on other roads is not followed.
- There is a backlog of maintenance on the DCRN

3 NATURAL HAZARDS IN NEPAL AND THEIR EFFECTS ON THE ROAD SECTOR

Nepal is one of the countries most vulnerable to natural hazards. Because of its topographical variation and geological characteristics, together with torrential rain during the monsoon season, the country frequently experiences several types of hazards such as landslides, debris flows, floods and earthquakes. These phenomena cause loss of life of several hundred people as well as loss of properties worth of million rupees every year. Besides above, they also pose severe threats to physical infrastructure, and disrupt social and economic development. Their impacts are worsened by: (a) poor economic condition (people as well as country) (b) lack of awareness and preparedness and (c) absence of measures for mitigating their impacts. The major natural disasters being experienced in Nepal are given in **table 2**.

Table 2: Types of natural hazards in Nepal and their effect on road sector

S.No.	Types of Hazard	Prevalence	Effect on Road Sector
1	Earthquake	Whole Nepal lies on high-hazard earthquake zone	High; several roads and bridges were damaged in the past.
2	Flood (inundation, bank cutting and sediment deposition)	Terai, Middle Hills	Very high; Several roads and bridges are damaged every year causing heavy loss of lives and properties.
3	Landslides	Hills and Mountain,	Very high. Causes severe damage roads, bridges and properties.
4	Debris Flow	Hills and Mountain,	Medium; Instances of debris flow in the past is low. Debris flow totally washed away bridge at Larcha (along Arniko Highway), Beni-Jomsom Road at Marpha (Mustang) etc.
5	Glacier Lakes Outburst Floods (GLOF)	Higher Himalaya; its effect will reach to Higher Mountains, and middle Hill regions.	Large scale damage to roads and bridges by GLOF is not recorded.
6	Avalanche	Higher Himalaya	None
7	Fire (forest)	Forest of Hills and Terai	Very low
8	Drought	All over the country	Vulnerability to roads and bridges will reduce.

4 BASELINE STUDIES

4.1 SELECTION OF DISTRICTS

In total eight districts were selected to assess the climate change effect on road sector. One of the major criterions for their selection was their degree of vulnerability to natural hazards. The list of the districts including details such as location, terrain and type of hazards is given in **table 3**.

Table 3: List of Districts and Frequently Occurring Natural Hazards

S. No.	District	Location (Development Regions/ Zone)	Terrain	Frequently Occurring Natural Hazards
1	Panchthar	Eastern/Koshi	Hills and Mountains	Landslides, floods, fire, debris flow , drought
2	Dolakha	Central/Janakpur	Mountains	Landslides, floods, debris flow drought, GLOF
3	Kathmandu	Central/Bagmati	Valley and mountains	Landslides, floods, fire, drought
4	Chitwan	Central/Narayani	Terai, Chure,	Landslides, floods, debris flow, fire, drought
5	Myagdi	Western/Dhaulagiri	Mountains	Landslides, floods, debris flow drought
7	Banke	Mid Western/Rapti	Terai	Floods, fire, drought
8	Achham	Far Western/ Seti	Mountains	Landslides, floods, debris flow, drought

4.2 SELECTION OF ASSETS

In general five assets (mostly roads and bridges) were selected in all districts for Asset Baseline Report and Adaptation Audit Report. The key criteria for selection included:

- 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; and
- At least one planned infrastructure.

Beside above, following aspects were also considered:

- Suggestions of DtO Chief;
- Different type of structures are covered by the study;
- Different types of problems faced by roads and bridges are covered by the study;

The final list of assets and the reasons for their inclusion is given in Table 4.

Table 4: List of Assets

Districts	Assets		
	Name (or type of works)	**Type**	**Reasons for inclusion**
Panchthar	Shiwa Khola Bridge	Bridge	It is a single span 25 m long bridge along Phidim-Ranigaun-Yachok Road. It is an example of successful completion of motorable bridge by DOLIDAR/DDC/DTO. This shows that the capacity of the DDC/DTO has increased in recent years.
	Ithum-Tamakhe-Tribeni-Phidim	Road	This is a village road and was constructed with the initiation of local people. The road is closed for two years by landslides at km 16. The local people/VDC/DDC are not able to clear the landslide because the number of such roads are very high and funding them in regular basis is not possible due to limited fund. With CC effect, such incidence will increase and the fund deficit will be more. It is a good example to show that the numbers of roads should be limited to keep them in maintainable condition.
	Samdin-Chokmagu-Siwa-Panchami Road.	Bridge	This is one of the important roads of the district and provides motrable link to several VDCs. The road is frequently blocked by a landslide at km 4.5 although DDC has spent large sum for its stabilization. Good example of landslide problem in the district.
Dolakha	Naypul-Pohati-Dandakharka Road	Rural Road	It is an important road on the district. The vehicular traffic on this road is frequently blocked At km 13+500 due to landslides.
	Sunkhani-Sanwa-Ladak Road	Road	This road falls in the priority of the district and hence it was included in RRRSDP for upgradation. There is a big landslide at km 5+500.
	Charnabati Pedestrian Bridge	Suspension Bridge	This is an old suspension bridge constructed more than 25 years ago and is still functioning satisfactorily. Several structures are constructed to protect it. Example of different types of adaptation measures.
Kathmandu	Matatirtha-Deuralikhani-Hetauda Road	Rural Road	It is one of the prioritized roads of Kathamndu DDC. It is the shortest motorable route between Kathmandu and Hetauda.
	Kageswori Chakrapth	Rural Road	This road serves the heavily populated area of eastern Katnamandu. Recently the road is rehabilitated providing breast wall, geo-grid and bio-engineering. This shows that the advanced technique is gradually being adopted for rural roads also.
Chitwan	Ladari Motorable Bridge	Medium Bridge	The pier at left bank has settled due to scouring and extraction of river bed materials. As a consequence, two spans of superstructure collapsed. At present the vehicles cannot move through this bridge. To show the example of poor design, construction and monitoring of DDC/DoLIDAR.
	Gitanagar Settlement	Local Road	To show the drainage problems in new settlements which are developed without properly considering the drainage management aspects.
	Concrete Causeway along Parsa-Kumaroj Road	Drainage Structure	The DoLIDAR recently completed the construction of a concrete causeway of 20 m length and a depressed land where the road was frequently closed during high flood. After the construction of the causeway, it has become easier for vehicles and pedestrians. To show the good example of proper selection of structures.
Myagdi	Suspended Bridge across DoWA Khola (Planned)	Pedestrian Bridge	The site as well as design of the bridge was changed due to deposition of large amount of debris by Dowa Khola in July 2012.
	Beni-Darbang-Dhorpatan	Local Road	This road fall in the priority of the district. The road was frequently closed by landslide at Lampata (km 15). DDC is adopting several measures to stabilize the landslide. This is a typical case of landslide due to toe erosion by the Myagdi River.

	Beni-Arthunge-Patlekhet-Pakhapani-Kuine Mangale	Local Road	This road fall in the priority of the district. The road was frequently closed by landslide at Lampata (km 15). DDC is adopting several measures to stabilize the landslide.
Mustang	Kaligandaki Bridge at Jomsom	Bridge	It is a very important project as it provides uninterrupted traffic flow to Jomsom-Ghoktan Road sector. It is a large scale and complex structure for DDC/DTO and it will be an appropriate example to assess the capacity of DTO.
	Kagbeni-Ghaite Section of Jomsom-Ghoktan Road Section.	Road	Although this is a strategic road, it is being implemented by DDC/DoLIDAR. This is the most important road of the district. The road lies beyond Himalaya which is a unique case for Nepal. The lessons learnt on CC effect from this road will be very useful for other roads in similar regions.
	Bank protection works at Kagbeni	Protection structures	Long concrete walls are being constructed to protect the Kachhuti Gumba, temple and houses at left bank of the Kaligandaki River. Such protection works of concrete walls are rare because almost all the bank protection works along Kaligandaki River are gabions. It can be a good example for alternative type of protection works if it functions properly.
Banke	RRM-Samjhanachowk-Khajura-Radhapur	Class A Road	Important road of the district but in very poor condition. The road is being upgraded (including raising of embankment height to protect the road during monsoon)by RAIDP , a WB funded project
	RRM-Titiiriya-Sonpur-Udhrapur-Sitapur Road	Class A Road	Important road of the district. The road is damaged due to improper selection (of less capacity) of cross drainage structure.
	RRM-Titiiriya-Sonpur-Udhrapur-Sitapur Road.	Culvert	The approach road was damaged due to overflow from the culvert.
Achham	Mangalsen-Oligaun-Jupu-Sila Road	Local Road	It is one of the important roads in the district and its length is 28 km. Until now DDC has constructed 15 km of earthen track. At present vehicles cannot go beyond km 4 due to landslides. DDC is not able to clear the landslide as it does not have sufficient budget. This shows that DDC's financial capacity is very poor and cannot manage/execute large number of roads.
	Sanfebagar-Mastamandu-Malika Road	Local Road	It is another important road of the district and provides transport facilities to 8 VDCs of the district. Its total length is 35 km. At km 5, the road alignment passes through the northern as well as southern faces of a small hillock. Two years ago there were landslides at both faces. At present the schools as well as the houses which are located at the top of hillock are threatened by the landslides from both faces.
	Budhi Ganga Suspension Bridge	Pedestrian Bridge	The bridge was constructed about 40 years ago with support from US Aid. The condition of the bridge is good until now. Several adaptation measures are provided to protect the bridge.

4.3 DAMAGE ASSESSMENT OF ASSETS AND POSSIBLE ADAPTATION MEASURES

Damage assessment was done of all the above mentioned assets. Assessment was done by:

- Conducting field verification
- Collecting information from the respective DoR Divisions.
- Interviewing local people
- Studying drawings if available etc.

While selecting the assets, one of the criteria was that they are affected/damaged by some kind of natural hazard. The main reason for it is to figure out the probable additional damages on them by climate change effect. In several cases, DoLIDAR has already provided adaptation measures. These measures will be very useful for adapting measures on roads and bridges due to climate change effect and hence they are considered as an important part of the study.

5 CLIMATE CHANGE THREATS TO ROAD SECTOR

5.1 TYPICAL CLIMATE THREATS FOR THE ROAD SECTOR

Several studies have assessed and documented the impacts of climate change on road sector in developed countries. As such studies have not been carried out in Nepal experience from developed countries was used to inform the assessment presented in this report. The findings from of the studies conducted in developed countries especially on road sector are summarized in Table 3.

Table 3: Road Infrastructures, Potential Impacts, and Design Parameters

Climate Event	Potential Impacts	Vulnerability to Roads and Bridges	Mitigation Measures	
			General	**Specific**
Temperature	Temperature increase can cause pavement deterioration due to liquidation of bitumen.	Moderate	Use stiff bitumen to withstand additional heat.	Include additional clauses in the Specifications.
Rainfall	Increased rainfall intensity will create: - More floods affecting drainage structures, bridges, road pavement, driving condition and visibility. - Increase in HFL, waterways, scouring of bridge foundation etc. - Will trigger more landslides and mudslides in mountainous roads causing frequent road blocks	High	Review (and revise if required) the current practice of: - Calculating return period, design discharge, high flood level, clearance above high flood level, length of waterway, water current force etc. - Design methodology of slope protection works (retaining and breast walls), subsurface drains, catch drains etc. - Design of pavement including selection of appropriate type of base and sub-base, materials - Increase road surface camber for quick removal of surface water. - Increase frequency of periodic maintenance.	Revise the road and bridge design parameters conducting consultation with the departmental staffs, designers, hydrologists, meteorologists and CC specialists. Avoid landslide areas as much as possible. Revise the landslide design parameters with consultation with other concerned agencies.
Storms and storm surges	Rainfall and winds associated with storm/cyclone can create flooding, inundation of embankments, and affect road transport.	Moderate; heavy storms are rare in Nepal.	Increase the capacity of side drains, cross drains, road embankment height etc.	Find out the probable increase in rainfall and design the structures accordingly. For this, involvement of DHM and prominent hydrologists of the country is very important.

This experience was later synthesised with climate threat modelling conducted specifically for the project. The modelling methodology and findings are discussed briefly below.

5.2 CLIMATE THREAT PROFILE MODELLING

District-level climate threat profiles were prepared to assess future climate change impacts on irrigation systems relying on localised projections of future climate change for the period 2040-2060 compared to a baseline of 1980-2000. Monitoring data and results from the regional dynamic downscaling model PRECIS (Providing Regional Climate Scenarios for Impact Studies) were used for the climate projections. The monitoring data was projected using climate change statistics (averages, variability/variance, number of dry days and extreme values) from the PRECIS results and then interpolated with orographic adjustment into the high resolution grids necessary for development of district-level models. This procedure can be described as combined dynamic/statistical downscaling.

The results of the downscaling were incorporated into the IWRM basin-wide hydrological model which computed changes in temperature, precipitation amounts and intensities, river discharges and flood amounts and runoff for every 120 x 120m grid cell in each district. Hydrological and other processes were computed in each grid cell and the grid cells were connected through mass transport above ground (e.g. rivers and overland flow) and through the soil (e.g. groundwater flow). The model grid was constructed by combining together soil, land use, topography and river networks. Observed and projected meteorological data as well as water utilisation and infrastructure were added to the model together with the grid.

Despite the limitations in data coverage and quality and time available for model calibration the model represented quite well the hydrological characteristics within each of the target districts. Based on calibration results using historical events, modelling could also be deemed reliable in representing changes caused by climate change scenarios.

The findings of the climate threat profiles are summarized in the following sections.

5.3 THREAT DUE TO TEMPERATURE INCREASE

The increase in maximum temperature in all districts for 2040-2060 is given in table 4

Table 4: Increase in Maximum Temperature in 2040-2060 due to Climate Change Effect.

Increase in maximum temperature (^{0}C)	Districts							
	Panchthar	Dolakha	**Kathmandu**	**Chitwan**	**Myagdi**	**Mustang**	**Banke**	**Achham**
	1.6	1.7	**1.85**	**1.66**	**1.7**	1.7	2.15	1.5

It is considered that the adverse effect on road and bridge infrastructure due to above temperature rises will be nominal.

5.4 THREAT DUE TO PRECIPITATION AND FLOOD INCREASE

The climate change effect will increase the rainfall intensity and duration and will also increase the flow volume in the rivers. The change of rainfall and flow increase pattern in all districts is given in Table 5.

Table 5: Increase of Rainfall and Flood due to Climate Change

Districts	Increasing intensity of rainfall events	Increasing number of extreme rainfall events; Frequency of occurrence		Increasing wet season (peak monthly average) flow	Increasing risk and severity of flash floods during wet season	Remarks
		1980-2000	2040-2060			
Panchthar	Yes	every 20 years	every 2 years	up to 170 % (Tamor River)	Yes	Average number of dry days in January will increase from 6.3 to 6.9 days
Dolakha	Yes	every 100 years	every 52 years	up to 140 % at Tamakoshi River in Busti.	Yes	
Kathmandu	Yes	every 5 years	every 2 years	up to 68% (Bagmati River)	Yes	pooling will increase by up to 220mm; irrigation demand will increase by up to 980mm
Chitwan	Yes	every 6 years	every 2 years	up to 36% (Rapti River)	Yes	
Myagdi	Yes	every 10 years	every 2 years	up to 89% (Kaligandaki River)	Yes	The flood frequency of Myagdi River at Mulaghat will increase by 78 %
Mustang	Yes	every 60 years	every 2 years	up to 257% (Kaligandaki River)	Yes	The average number dry days in June is increasing from 5.5 to almost 7 days
Banke	Yes	every 50 years	every 35 years	up to 5% (West Rapti River)	Yes	
Achham	Yes	every 50 years (Benighat)	every 30 years (Benighat)	up to 36% (West Rapti River)	Yes	The peak flow will shift from July to August

5.5 KEY CLIMATE CHANGE THREATS TO ROADS INFRASTRUCTURE

The above findings show that there will substantial increase in the number of extreme rainfall events and in the frequency and magnitude of extreme river flows. 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.

BRIDGE DESIGN: Design of bridges should endeavour to make the structure more resilient to over topping by high floods. Abutments and piers should have piled rather than open foundations wherever possible to reduce the risk of failure from scour.

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 increased foundation depth.

SIZE OF DRAINAGE STRUCTURES: Sizes of both side drainage and cross drainage structures should be increased to accommodate increased flood volumes.

FREQUENCY OF DRAINAGE STRUCTURES: In addition to assessing whether to increase the size of cross drainage structures it will be necessary to consider whether additional structures will be more beneficial or more cost effective.

ROADS ADJACENT TO RIVERS: Roads lying in low land and adjacent to rivers will be highly affected by increased flood flows. Additional protection works to resist erosion and scour will be required

ROADS CROSSING FLOOD PLAINS ON EMBANKMENT: Roads on embankment crossing the flood plains of the larger rivers will require additional cross-drainage structures to allow for the increased flows predicted due to Climate Change. The construction of submersible roads at a low level for roads crossing flood plains is a possible option that should be investigated. These would have the additional advantage of not impeding flood flows across flood plains.

RREVIEW OF SPECIFICATIONS: Specifications for materials and mixes used in drainage structures and road pavements should be reviewed in order to increase their resilience to the impact of increased rainfall, increased flows and greater temperature variations.

6 CLIMATE RELATED IMPACTS ON EXISTING ROAD INFRASTRUCTURE

6.1 CLIMATE CHANGE IMPACTS ON KEY ROAD INFRASTRUCTURE ASSETS

A selection from the assets visited during the baseline studies is given below to illustrate the effects on existing infrastructure of weather events similar to those predicted to become more severe because of climate change. The chosen assets are described below.

Asset	Weather Related Threat	Damage/Adaptation
ASSET I		
Beni - Dhorpatan Road Myagdi District	River eroding toe of slope below road	Landslide cut road
 *General view of the landslide*	 Stone masonry toe wall to protect the slope from erosion by the Myagdi River	
ASSET II		
RRM – Titiriaya - Sitapur Road Banke District	High riverine flood on floodplain	New triple cell pipe culver constructed as cross drainage structure
 *Triple cell pipe culvert constructed following cutting of road embankment constructed across flood plain. The overall construction quality of the culvert is good. This structure is not sufficient to drain the water.*	 *Washed away section of the road towards Sitpur side from the culvert. The damage was before the construction of culvert.*	

<table>
<tr><th colspan="2">Asset</th><th colspan="2">Weather Related Threat</th><th>Damage/Adaptation</th></tr>
<tr><td colspan="5">ASSET III</td></tr>
<tr><td colspan="2">Bridge across Ladari Khola Chitwan District</td><td colspan="2">Flash Flood in Ladari Khola</td><td>Scour of river bed causing settlement of piers on open foundations</td></tr>
<tr><td colspan="3">
View of the bridge from upstream showing settlement of piers constructed on open foundations due to scour</td><td colspan="2">
Embankment is constructed upstream on 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 causing scouring at left bank and siltation on right bank.</td></tr>
<tr><td colspan="5">ASSET IV</td></tr>
<tr><td colspan="2">Culvert across Kiron Nala with concrete causeway on approach road Banke District</td><td colspan="2">High Flow in on flood plain of Kiron Nala River</td><td>Approach road to culvert damaged by high flood. Adaptation of concrete causeway</td></tr>
<tr><td colspan="3">
View of the culvert from US. The structure has already started to show sign of distress due to lack of adequate maintenance. The newly constructed concrete causeway is located at the left side of the culvert.</td><td colspan="2">
Recently built causeway at the damaged portion of the road. The total length of the causeway is 20m and its condition is good. There is no damage to the causeway after it was constructed two years ago. Such structure may be replicated at other locations also.</td></tr>
</table>

Asset	Weather Related Threat	Damage/Adaptation
ASSET V		
Suspension Bridge across Budhiganga River Achham District	High Flow/Flash Flood	Scour damages gabion walls protecting surrounding areas
		
The condition of the bridge is good forty years after its construction		*Long gabion walls are provided at the left bank to protect the major area of Sanfebagar bazaar. If the walls collapse there will be heavy loss of lives and properties.*
ASSET VI		
Kageswori – Chakrapth Road Kathmandu District	Increased rainfall	Increased rainfall caused landslide which cut road. Adaptation works consisting of gabion retaining walls, subsoil drainage and bio-engineering have stabilized hillside.
		
Road slope seen from the valley side. The condition of the toe wall and bio-engineering works is good. The whole slope is in stable condition		*Overall view of the road. The road is blacktopped and its condition is good. The gabion walls and bio-engineering works are located at the right side.*

7 VULNERABILITY ASSESSMENT & ADAPTATION METHODOLOGY

7.1 SUMMARY OF METHOD/PROCESS

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

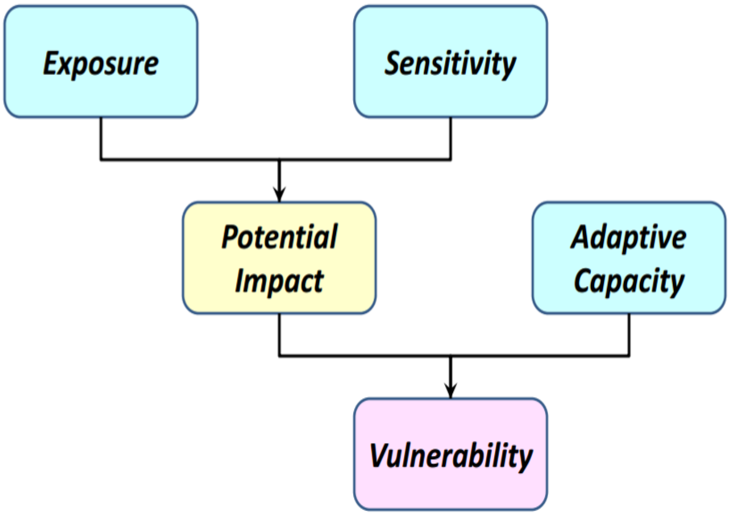

Figure 4: Vulnerability Assessment Process

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** (Figure 5). 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*

Figure 5: 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** (Figure 6).

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

Figure 6: Vulnerability Assessment Matrix

7.2 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.

SENSITIVITY

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

Table 10: 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 (the threat/exposure is High/V. High so the impact is H/VH)
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 (threat is H/VH but for well maintained drains the sensitivity is medium so the impact is M/VH
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 (the threat is V/VH and the sensitivity is H/VH so the impact is VH)
Increased rainfall causes high	A road constructed next to a river will have	Road running along river

monsoon flood **Intense rainfall causes flash flood**	a Very High sensitivity	valley damaged by adjacent river (Threat of high flood or flash flood is M/H and sensitivity is VH so impact is VH)

Table 11: 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 (the threat of flood is H/VH but sensitivity is dependent on adequacy of cross drainage and can vary from M to VH so impact is M to VH)
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 (the threat of flash flood on river with small catchment is M/H and the sensitivity can vary from m to VH depending on condition so impact casn vary from M to H)
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 (as above)
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 (the threat is M/H and the sensitivity L to H so the impact is M/H
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 (threat is H/VH and sensitivity L to VH so impact is L to VH depending on condition

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 12: Interpretation of climate change threats and exposure for road and bridge assets

Type of Asset	Climate Change 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 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. 3 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 Dolakha 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 the number of projects;
- Inadequate financial resources;
- Inadequate management system; and
- Not very prompt in responding to disasters.

However, the efficiency of DDC/DTO has increased in the last few years after the involvement of big donors such ADB, WB, DfIDetc in the rural transport sector. Considering the above factors, it is considered 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 Matrix as provided in Figure 3.

7.3 VULNERABILITY ASSESSMENT OF ASSETS

SELECTION OF ASSETS

In general three assets were covered in each district in baseline report. Out of three, two assets, which are in more vulnerable condition, are selected for VA and AP in all districts except Dolakha. In Dolakha, only one asset is selected. Their list is given in Table 13.

Table 11. List of Assets for Vulnerability Assessment

Districts	Assets	Description of Assets
Panchthar	Shiwa Khola Bridge	The bridge is located along Phidim-Ranigaun-Yachok Road. It is a single span bridge with a total of 25m. It is constructed on open foundation. The carriageway width and overall width of the bridge is 4.25m and 5m respectively. The whole bridge structure is constructed of RCC. Its construction was completed one year ago. The total cost of the bridge including approach roads and protection works is about 20 million rupees. This asset is selected because (i) it is the first bridge implemented by DDC/DTO in the district and (ii) it is resilient to climate change effect.
	Ithum-Tamakhe-Tribeni-Phidim	The road, which is in the form of earthen track, starts from Ithum, a small settlement along Mechi Highway, passes through Tamakhe and terminates at Phidim. The total length of the road is about 20km. The road was constructed by the local people about 7 years ago. There are very few structures on the road. In 2009, there was a big landslide at km 16 (from Ithum). Although the local people cleared the landslide several times, it occurred time and again. Due to poor condition at other locations as well, very few vehicles ply on this road.

Dolakha	Naypul-Pohati-Dandakharka Road.	This is an important road in the district. It starts from the Tamakoshi Bridge (located on Lamsangu-Jiri Road) and runs along the left bank of Tamakoshi River (Note: Tamakoshi-Manthali Road lies at the left bank of the river). The total length of the road is 26 km and the motorable track is opened up to the first 19 kilometers. This road serves Phasku, Pawati, Ghyangsuthokar, Bhedpu, Melung and Dandakharka VDCs. The existing condition of the road is very poor. Major section of the road is earthen and very few drainage and retaining structures are constructed on it.
Kathmandu	Kageswori Chakrapth (Ring Road)	The construction works of the road started on June 2011 and completed on March 2012. The total cost of the whole works including improvement works at Km 7+148 was 5.7 million rupees. The works comprised the followings: • Construction of gabion walls • Filling of road embankment • Providing geotextile. • Bio-engineering works • Surface water management. The unique aspect of the design and construction of this road is the provision of geotextile and bio-engineering on rural roads which is rare in Nepal.
Chitwan	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 after 2-3 years of its completion. This is a good example of poor design, construct ion and monitoring.
	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. As a result, 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.
Myagdi	Suspended Bridge across Sunari Khola (Planned)	DDC had planned to construct a pedestrian (suspended) bridge across Sunari Khola. The selected bridge site was about 50m upstream from its confluence with Kali Gandaki River. The bridge was designed of 60 m length. While the DDC was about to start its construction, a big flood at the Sunari Khola transported large amount of debris and deposited at/around the bridge site in July 2013. Due to debris, the bed level was up by about 2.5-3m. As a consequence, the vertical clearance of the proposed bridge became less than required by the design guidelines. Hence DDC selected new bridge site at about 200m upstream from that location and designed a 108m long bridge.
	Beni-Darbang-Dhorpatan Road at km 15	Construction of this road was started by DDC about 10-12 years ago. In the beginning this road was only a motorable track. Later this road was upgraded/improved by DRILP. For the past few years the road was frequently closed by landslide at km 15 (Lampata). Observing the site condition it seems that the main reason of landslide is the toe cutting of the slope by the Myagdi River. At present DDC/DoLIDAR is constructing a stone masonry toe wall at the bottom of landslide area and is realigning about 80 meter long section of the road.

Mustang	Kaligandaki Bridge at Jomsom (under construction	The proposed structure is a RCC bridge across the Kaligandaki River. It is located very near to Jomsom Bazar. The estimated cost of the bridge is 29 million rupees. The amount includes cost of bridge, approach road, bank protection and other miscellaneous works. Construction works of this bridge was started one year ago. Until now the contractor has completed the foundation works of pier (see photo). Indian Government is the main financer and DDC/DoLIDAR is the implementing agency of the bridge.
	Bank protection works at Kagbeni	DDC Mustang is constructing concrete bank protection wall at the left bank of Kaligandaki River near its confluence with Kag Khola. The confluence is considered as one of the holiest places of Hindus in that area. The main objective of the wall is to protect Kagbeni Bazaar. The length of the wall at upstream and downstream from the confluence is about 120m and 20m respectively. The average height of the wall from the bed level is about 2m. This asset is also being financed by the Indian Government.
Banke	RRM-Tirtiriya-Udhrapur-Sitapur Road	This road is located in the western part of the district. It starts from MRM and proceeds towards south and terminates at Sitapur. The road has a total length of 11.31 kilometre with gravel surface at major sections. Cross drainage structures(CDs) are constructed at several locations but they are not sufficient. There is one water channel at km 9+200 which is draining the water from the surrounding area. The channel is not functioning properly as local people annexed its substantial area for cultivation. In 2012, DDC/DTO with the support of local people constructed a three cell, 90 cm dia pipe culvert at this location. The culvert is not sufficient to drain the water and hence the excess water overflows through the road and damages it and adjoining areas.
	Culvert across KironNala along Nepalganuj-Paraspur-Gaughat Road	The culvert is located at Km 8+500 along Nepalgunj-Paraspur-Gaughat Road and was constructed about 12 years ago. The culvert has two spans of 6m each and has a carriageway width of 4.25m. The road is one of the important roads in the district and hence is already black topped. The left approach road of the culvert was washed away during the flood of 2011 due to overflow of water from the culvert. DDC constructed 20 m long causeway at washed away section. The condition of the causeway is good.
Achham	Landslide at km 4 of Mangalsen-Oligaun-Jupu-Sila Road	It is one of the important roads of the district. It provides motorable link to several central VDCs with Mangalsen (district headquarter). The total length of the road is 28 km. DDC started to construct this road on 2008 and the earthen track is opened up to 16 km. DDC has spent about 6 million rupees for opening of the track. But vehicles do not ply on this road due to landslides at several locations. The road also lacks basic structures (retaining and drainage). In 2012, there occurred big landslides near km 4 causing complete road closure. The total cost of for clearing and stabilizing all the landslides is estimated to be around 10 million rupees. This amount is very big for Achham DDC/DTO which has resource constraint and hence is not able to clear and stabilize until now.
	Budhiganga Suspension Bridge	The bridge is located inside the core area of Sanfebagar, a major settlement in Achham District. It was constructed about 40 years ago with support from US Aid. The total length of the bridge is 80m. Until the construction of motorable bridge, it was the only crossing structure for the people residing at both sides of the river. Although the bridge was constructed long time ago, its condition is good. Major problems, except damage to bank protection walls were not observed.

VULNERABILITY ASSESSMENT OF ASSETS

In total vulnerability assessment of 15 assets in all eight districts is carried out. Out of them 3 assets are located in terai, 2 in higher mountain/lower Himalaya (Mustang), 2 in Kathmandu Valley and the rest in mountains. The vulnerability assessment summary of the assets is presented in Annex III.

8 ADAPTATION PLANNING FOR TYPICAL ASSETS

8.1 OBJECTIVES

The main objectives of the adaptation planning are:

- To provide DDC/DTO/DoLIDAR with a methodology for identifying elements which are susceptible to the increasing threat of extreme weather events caused by climate change within the system;
- To identify which particular threats may affect different elements within the system;
- To provide a means of prioritising which are the most sensitive elements to any particular threat; and
- To provide a programme for monitoring and maintaining the system so that vulnerable elements are identified in time for action to be taken before serious damage occurs.

8.2 ADAPTATION PLANNING PROCESS

The Adaptation Planning process is defining adaptation priorities and plans for the most vulnerable assets and areas based on VA. The major aspects considered in the AP are presented below.

SIGNIFICANCE OF IMPACTS

Significance of the impact is assessed according to the degree of likelihood and seriousness as given in table 12.

Table 12: Significance of Impacts

		Seriousness of Impact				
Likelihood of impact happening		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

Very High = Extreme impact requiring immediate action;
High = High impact requiring additional research or some immediate action;
Medium = Moderate impact that are likely to benefit from adaptation measures;
Low or Very Low = Low impact that can be dealt with as and when they happen or they are considered acceptable should they happen.

LIKELIHOOD

Likelihood is the chances of an impact occurring and resulting threat due to the particular impact. For the purpose of the study, likelihood of impact occurring is classified in the following five categories:

Very Low: < 25 %;
Low: 25-50 %;
Medium: 50-75 %

High: 75-90 %
Very High: 90-100%

SERIOUSNESS

Following criteria are major influencing factor for deriving the degree of seriousness.

- Loss of life
- Loss of property – i.e. destruction of property
- Damage to property
- Loss of productivity and income
- Impeding of function

ADAPTATION PRIORITIES

Adaptation priorities are fixed according to feasibility of action and effectiveness in dealing with impact and are assessed as per following table.

Table 13: Assessment of adaptation priorities.

		Effectiveness in Dealing with Impact				
Feasibility of Action		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

FEASIBILITY OF ADAPTATION OPTIONS

The major factors for assessing the feasibility of options are:

- Is the action technically feasible without additional R&D or does action requiring some development?
- What is the time required to implement – can it be implemented immediately or does it require long surveys and design time?
- What is its cost – how expensive is the measure? Is government budget available?
- What are the capacities of community/user group (e.g. commitment, labor, materials)?
- What are the capacities of government to support the action (e.g. skills, institutional arrangements, equipment)?

EFFECTIVENESS

Degree of effectiveness of the adaptation options is found out as outlined in table 14.

Table 14: Factors that influence the effectiveness of Adaptation Options

	Effectiveness in Dealing with Impact				
	Very Low	Low	Medium	High	Very High
Can the impact be avoided completely?	Not at all	Partially			Yes
To what extent will deal with impact?	< 25 %	25- 50 %	25- 50 %	25- 50 %	100 %
How long wills the adaptation	1 year	2 years	2-10	10-20	Permanent

measures last?			years	years	

8.3 PRIORITIZATION AND PHASING OF WORKS

Prioritization is one of the very important aspects of adaptation planning. In general prioritization is done according to the followings:

- Loss of lives (The works which can save lives should get highest priority);
- Traffic closure (Traffic closure especially on busy or important roads should be avoided by carrying out repair/rehabilitation/reconstruction of damaged works);
- Saving high reconstruction cost (If minor remedial works can save substantial reconstruction cost, such works should also get high priority);
- Repair and maintenance of road drainage structures;
- Bank protection works (which are protecting lives and properties) etc.

After work prioritization is fixed, the works should be carried out in different phases. For the purpose of this study the work phasing is divided into the followings:

- Regular (R); throughout the year
- Immediate (I); generally within 6 months
- Short (S), medium (M) or long term (L) (2, 5, 10, 15 years or more)

Following the above procedures, a selection of the types of adaptation responses recommended for different types of assets identified in this report is summarized in Table 15. A detailed assessment of the adaptation options for the selected assets is presented in Annex IV.

Table 15: Summary of Adaptation Options for Different Assets

Asset	Physical Threat	Component	Climate Threat	Impact	Adaptation options
Beni-Darbang-Dhorpatan Road at km 15 MYAGDI	**Instability of hillside**	**Toe Wall**	IIDR, INRE, IWSF	Damage to toe wall will cause failure of slope and road.	Provide adequate scour protection works.
		Hill side slope and Road	IIDR, INRE, ILE	Intensity and frequency of landslides will increase.	Construct surface and sub-surface drains. Provide bio-engineering works.
RRM-Titiriaya-Udharpur-Sitapur Road BANKE	**Road embankment eroded & road cut**	**Road embankment**	IIDR, INRE, IWSF	Damage to road embankment due to accumulation of drainage water collected from the surrounding areas.	Proper management of surface water by: -reinstating drainage channel -constructing additional cross drainage structure - constructing guide walls
		Pipe culvert	IIDR, INRE, IWSF	Damage to pipe culvert due to flood water.	-Clean the PC at regular interval - Manage surface water by cleaning side drains and water

Asset	Physical Threat	Component	Climate Threat	Impact	Adaptation options
					path at outlets.
Ladari Bridge **CHITWAN**	Failure of Bridge	**Bridge**	IIDR, INRE, IWSF	Damage to bridge due to increase in HFL and scour depth.	Height of the bridge should be sufficient to accommodate increased flood. Similarly, the foundation depth should be increased.
		Bank protection works	IIDR, INRE, IWSF	Damaging effect will be more due increase in flood volume	Design and construct bank protection works in such a manner that it is safe from scouring and flood impact.
Culvert across Kiron Nala **BANKE**	Bridge damaged and road embankment cut	**Road embankment**	IIDR, INRE, IWSF	Damage to road embankment due to overflow of excess water from the culvert.	Construct 30m long dyke at left bank
		Abutments, pier and wing walls	IIDR, INRE, IWSF	The excess water will further damage abutments, pier and wing walls.	Repair the damaged/ deteriorated components
Budhiganga Suspension Bridge ACHHAM	Bank protection works damaged	Bank protection walls	IIDR, INRE, IWSF	Damage to walls will be more. Some sections of the wall may collapse.	Repair/rehabilitate damaged walls on regular basis.
Kageswori chakrapath (ring road) **KATHMANDU**	Landslide cuts road	Road Pavement	IIDR, INRE, IDRW	Damage to road pavement due to weakening of sub-grade.	Proper management of surface water
		Gabion Retaining Wall	IIDR, INRE, ILE	Damage to wall due to slope failure	Manage surface and sub-surface water at/around the wall.
		Bio-engineering works and earth filling.	IIDR, INRE, ILE	Increased accumulation of surface water will cause landslides/slips damaging the bio-engineering works	Manage surface water by safely disposing it to drainage structures or other safe locations.

***Abbreviation used in tables**

IIDR = Increase in intensity and duration of rainfall events

INRE = Increasing number of rainfall

IWSF = Increasing wet season flow

ILE = Increasing landslide events

IDRW = Increasing duration of road pavement wetting

9 CONCLUSIONS

9.1 BASELINE REPORTS

- **Condition of Existing Rural Road Network Infrastructure**

The visit by the Project Road & Bridge Engineer to all eight Districts allowed a fairly comprehensive survey of the condition of the SRN infrastructure to be carried out. **Annex II** gives a summary of his findings.

His observations confirm that the overall condition of the SRN network is poor with a significant backlog of routine and periodic maintenance. A road network where there is a backlog of maintenance (or maintenance deficit) is more susceptible to damage from any weather event. The infrastructure is therefore Vulnerable to the threats of severe weather predicted by the Climate Threat Profiles. Any work to reduce the maintenance deficit will reduce the vulnerability of the road network and is therefore an Adaptation.

- **District Transport Master Plan**

The introduction of the requirement that all Districts draw up a District Transport Master Plan **(DT**MP) should enable the maintenance of the Rural Road Core Network to be better managed. The DTMP provides a method of prioritising the roads in each District so that the limited funds available can be concentrated on reducing the maintenance deficit on the most important roads.

- **Institutional Issues**

The comments entered as Issues in the Baseline Reports were provided by officers in the Districts. It is clear from these comments that Governance is a major problem.

  - Budgets are insufficient and not provided on time
  - Programmes are not approved on time
  - Resources are diverted from managing and maintaining the SRN to construct roads which are not the direct responsibility of DoR
  - Limited technical capacity
  - Inexperienced contractors who submit low bids and do not complete the work on time and to the required quality
  - Village roads are constructed on an ad hoc basis without any design being carried out and with very limited drainage included in the initial construction work

The capacity for DoLIDAR in the District Offices to manage and maintain the rural road network effectively and to respond to critical events is severely limited by the difficulties set out above. The increasing risk of severe disruption to the road network because of extreme weather events brought about by Climate Change makes the strengthening of the capacity of these offices a prime objective.

9.2 CLIMATE THREAT PROFILES

The Climate Threat Profiles predict that extreme weather events will become more frequent and more severe in all the eight Districts considered. The magnitude of these events will vary from District to District and also within each District.

9.3 VULNERABILITY ASSESSMENT REPORTS

The Vulnerability Assessments carried out on the selected assets in the eight Districts show that they all have a high or very vulnerability to extreme weather events. These events may be increased rainfall, more frequent storms with greater intensity rainfall or high river flows caused be increased rainfall over the catchment area upstream.

However, the limitations in predicting accurately the magnitude and likelihood of an extreme event at a particular location mean that in the short term it is not possible to assess the vulnerability of any asset with any confidence.

9.4 ADAPTATION PLANNING REPORTS

The Adaptation actions set out in the Adaptation Planning matrices completed for the selected assets are nearly all actions which can be classified as work to be carried out under either routine or periodic maintenance programmes.

With the limited resources available at District level the Adaptation Planning process should be used to prioritise the maintenance interventions.

9.5 COMMENT

- The poor condition of the fabric of the road network makes it vulnerable to damage and failure from relatively minor weather events. Efforts to improve the condition of the roads will have an immediately beneficial effect in that it will reduce the likelihood of damage from all weather events and reduce the cost of transporting goods and people by increasing traffic speed and reducing wear and tear on vehicles.
    - **In the short to medium term the elimination of the maintenance (adaptation) deficit must be considered the top priority.**
- The lack of the necessary information to allow more precise determination of the sensitivity of an asset together with the uncertainty over the likelihood and magnitude of any climate related threat means that making a commitment to major expenditure on a single intervention is very risky.
    - **Reconstruction of an existing element in the road infrastructure should only be contemplated if there is strong evidence of imminent failure of the element.**
- The extensive nature of the DoLIDAR rural road network in that it extends over the whole country linking villages to the core road network makes it particularly vulnerable to any extreme weather event. The cutting of a road at any place along its length disrupts the whole road and causes hardship and economic loss to the communities at both ends of the road. At present it is not possible to predict where an event may occur which will disrupt the road because: 1. It is not possible to predict where along a road a weather event will take place; 2. The information regarding where the most vulnerable places are along the road is not available.
    - **Vulnerability Assessments should be carried out along the most important roads in order to determine which sections are most vulnerable to extreme weather events**[1]
- In the short to medium term it must be accepted that severe weather events will disrupt the core road network without warning at locations which cannot be predicted. It is therefore necessary to increase the ability to respond to major disruption caused be extreme weather events.

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[1] Ref. Road Vulnerability Map as proposed in Fig 2 on page 20 of ADB publication "Climate Proofing ADB investments in the Transport Sector: Initial Experience".

- **Increase the technical and physical capability of the Department to respond to disruption caused by severe weather events.**

10 REFORMS ON SECTOR ISSUES

10.1 ROUNDTABLE DISCUSSIONS

During roundtable discussions the following areas were identified as possible entry points for mainstreaming climate resilience into DoLIDAR activities:

1. District Transport Master Plan (DTMP)
2. Nepal Rural Road Standards
3. Initial Environmental Examination (IEE)
4. Design Standards and Guidelines

10.2 PROPOSED REFORMS

1. Institutional

1.1. Nepal Road Sector Assessment Study

1.1.1. In paragraph 12, Safeguards, a clause stating that the possible risks associated with the threats from Climate Change should be assessed in all areas of DoLIDAR's responsibility.

2. Policies & Plans

2.1. District Transport Master Plan (DTMP)

2.1.1. Prepare standard Terms of Reference (ToR) to include consideration of the threats from Climate Change when Consultants are drawing up future DTMP's

2.2. Annual Road Maintenance Plan (ARMP)

2.2.1. Prioritisation of Maintenance Procedures
Prioritise maintenance expenditure on most important roads

3. Guidelines, Standards & Manuals

3.1. Environmental Assessment

3.1.1. Initial Environmental Examination (IEE)

In the Prepare standard ToR to include CC resilience when Consultants are drawing up future IEE's

3.2. Design Standards

3.2.1. Nepal Rural Road Standards (2055) Revised 2012

Include a new section - Drainage Design
This section to set out standard designs for Side Drainage, Cross Drainage, Causeways, Outfalls etc. Include a requirement that the future threats from Climate Change should be assessed when designing drainage works.

3.2.2. Design of Roads & Bridges

Latest prediction of climate change effects obtained from DHM and used in assessing:

- Bridges
  - Location
  - Maximum flood discharge for a given return period
  - Type of Depth of Foundation
  - Total Span & Number of Piers
  - Bridge Deck Level
  - River training works at approaches to bridge
- Roads
  - Alignment

- Cross Drainage
- Side Drainage
- Retaining Walls & Toe Walls
- Stability of roads crossing unstable ground
- Extent of bio-engineering required

3.2.3. Project Design

In preparing designs for new projects the increased threats brought about by Climate Change as calculated by DHM should be taken into account when assessing:

- Stability of slopes
- Design of cross drainage
- Design of side drains
- Viability of road alignments constructed along river valleys adjacent to rivers subject to flash floods
- Road embankments constructed across flood plains

ANNEX I: LIST OF SELECTED ASSETS IN EIGHT DISTRICTS

Districts	Assets		
	Name (or type of works)	Type	Reasons for inclusion
Panchthar	Shiwa Khola Bridge	**Bridge**	**It is a single span 25 m long bridge along Phidim-Ranigaun-Yachok Road. It is an example of successful completion of motorable bridge by DOLIDAR/DDC/DTO. This shows that the capacity of the DDC/DTO has increased in recent years.**
	Ithum-Tamakhe-Tribeni-Phidim	**Road**	**This is a village road and was constructed with the initiation of local people. The road is closed for two years by landslides at km 16. The local people/VDC/DDC are not able to clear the landslide because the number of such roads are very high and funding them in regular basis is not possible due to limited fund. With CC effect, such incidence will increase and the fund deficit will be more. It is a good example to show that the numbers of roads should be limited to keep them in maintainable condition.**
	Samdin-Chokmagu-Siwa-Panchami Road.	**Bridge**	**This is one of the important roads of the district and provides motrable link to several VDCs. The road is frequently blocked by a landslide at km 4.5 although DDC has spent large sum for its stabilization. Good example of landslide problem in the district.**
Dolakha	**Naypul-Pohati-Dandakharka Road**	**Rural Road**	**It is an important road on the district. The vehicular traffic on this road is frequently blocked At km 13+500 due to landslides.**
	Sunkhani-Sanwa-Ladak Road	**Road**	**This road falls in the priority of the district and hence it was included in RRRSDP for upgradation. There is a big landslide at km 5+500.**
	Charnabati Pedestrian Bridge	**Suspen sion**	**This is an old suspension bridge constructed more than 25 years ago and is still functioning satisfactorily. Several structures are constructed to protect it. Example of different types of**

Districts	Assets		
	Name (or type of works)	Type	Reasons for inclusion
		Bridge	adaptation measures.
Kathmandu	Matatirtha-Deuralikhani-Hetauda Raod	Rural Road	It is one of the prioritized roads of Kathamndu DDC. It is the shortest motorable route between Kathmandu and Hetauda.
	Kageswori Chakrapth	Rural Road	This road serves the heavily populated area of eastern Katnamandu. Recently the road is rehabilitated providing breast wall, geo-grid and bio-engineering. This shows that the advanced technique is gradually being adopted for rural roads also.
Chitwan	Ladari Motorable Bridge	Medium Bridge	The pier at left bank has settled due to scouring and extraction of river bed materials. As a consequence, two spans of superstructure collapsed. At present the vehicles cannot move through this bridge. To show the example of poor design, construction and monitoring of DDC/DoLIDAR.
	Gitanagar Settlement	Local Road	To show the drainage problems in new settlements which are developed without properly considering the drainage management aspects.
	Concrete Causeway along Parsa-Kumaroj Road	Drainage Structure	The DoLIDAR recently completed the construction of a concrete causeway of 20 m length and a depressed land where the road was frequently closed during high flood. After the construction of the causeway, it has become easier for vehicles and pedestrians. To show the good example of proper selection of structures.
Myagdi	Suspended Bridge across DoWA Khola (Planned)	Pedestrian Bridge	The site as well as design of the bridge was changed due to deposition of large amount of debris by Dowa Khola in July 2012.
	Beni-Darbang-	Local	This road fall in the priority of the district. The road was frequently closed by landslide at Lampata (km 15). DDC is adopting several measures to stabilize the landslide. This is a typical case of landslide

Districts	Assets		
	Name (or type of works)	Type	Reasons for inclusion
	Dhorpatan	Road	due to toe erosion by the Myagdi River.
	Beni-Arthunge-Patlekhet-Pakhapani-Kuine Mangale	Local Road	This road fall in the priority of the district. The road was frequently closed by landslide at Lampata (km 15). DDC is adopting several measures to stabilize the landslide.
Mustang	Kaligandaki Bridge at Jomsom	Bridge	It is a very important project as it provides uninterrupted traffic flow to Jomsom-Ghoktan Road sector. It is a large scale and complex structure for DDC/DTO and it will be an appropriate example to assess the capacity of DTO.
	Kagbeni-Ghaite Section of Jomsom-Ghoktan Road Section.	Road	Although this is a strategic road, it is being implemented by DDC/DoLIDAR. This is the most important road of the district. The road lies beyond Himalaya which is a unique case for Nepal. The lessons learnt on CC effect from this road will be very useful for other roads in similar regions.
	Bank protection works at Kagbeni	Protection structures	Long concrete walls are being constructed to protect the Kachhuti Gumba, temple and houses at left bank of the Kaligandaki River. Such protection works of concrete walls are rare because almost all the bank protection works along Kaligandaki River are gabions. It can be a good example for alternative type of protection works if it functions properly.
Banke	RRM-Samjhanachowk-Khajura-Radhapur	Class A Road	Important road of the district but in very poor condition. The road is being upgraded (including raising of embankment height to protect the road during monsoon)by RAIDP , a WB funded project
	RRM-Titiiriya-Sonpur-Udhrapur-Sitapur	Class A Road	Important road of the district. The road is damaged due to improper selection (of less capacity) of cross drainage structure.

Districts	Assets		
	Name (or type of works)	Type	Reasons for inclusion
	Road		
	RRM-Titiiriya-Sonpur-Udhrapur-Sitapur Road.	Culvert	The approach road was damaged due to overflow from the culvert.
Achham	Mangalsen-Oligaun-Jupu-Sila Road	Local Road	It is one of the important roads in the district and its length is 28 km. Until now DDC has constructed 15 km of earthen track. At present vehicles cannot go beyond km 4 due to landslides. DDC is not able to clear the landslide as it does not have sufficient budget. This shows that DDC's financial capacity is very poor and cannot manage/execute large number of roads.
	Sanfebagar-Mastamandu-Malika Road	Local Road	It is another important road of the district and provides transport facilities to 8 VDCs of the district. Its total length is 35 km. At km 5, the road alignment passes through the northern as well as southern faces of a small hillock. Two years ago there were landslides at both faces. At present the schools as well as the houses which are located at the top of hillock are threatened by the landslides from both faces.
	Budhi Ganga Suspension Bridge	Pedestrian Bridge	The bridge was constructed about 40 years ago with support from US Aid. The condition of the bridge is good until now. Several adaptation measures are provided to protect the bridge.

ANNEX II: CONDITION OF EXISTING RURAL ROAD INFRASTRUCTURE

1 CONDITION OF EXISTING INFRASTRUCTURES

During the visit by the National Roads and Bridges Engineer the following observations can be made regarding the resilience of the Strategic Road Network Infrastructure in the project districts.

1.1 General Observations; applicable to all districts.

- Roadside drains are inadequate, extensively damaged and poorly maintained;
- Cross road drainages structures are inadequate, extensively damaged and poorly maintained;
- Much of the road network is constructed across steep slope which are prone to landslides in hill areas.
- Several road sections in terai area are located at flood prone areas and are frequently damaged by flood;
- The road pavements are in poor condition making them liable to further damage under severe weather condition;
- The records of the condition of existing infrastructure are inadequate making planning of periodic or emergency maintenance difficult;
- The design drawings of road, bridges and structures are not available making assessment of their long term stability difficult to determine;
- Condition of several district roads is very poor. Due to absence of basic structures (cross drainages, retaining wall, gravelling etc.), the roads are not passable during rainy season. In some instances, the road is blocked by landslides for a quite long time as the DDCs are not able to clear them due shortage of fund.

1.2 Specific Observations

Rural Roads

District	Findings/Observations
Panchthar	DDC/VDC/local people are not able to clear the landslides due to scarcity of fund; • A medium landslide at km 16 of Ithum – Tamakhe – Tribeni - Phidim Road is completely obstructing the traffic flow for more than 2 years. DDC and local people are not able to clear it due to lack of fund. This is the result of large number of projects in the districts.
	The condition of almost all the district and village roads is very poor. They are not passable during rainy season; • The road surface of Samdim – Naomidanda - Panchami Road is earthen and vehicles cannot pass along it during rainy season. In addition to this, the road is frequently blocked by landslide at km 5.
	Extraction of naturally occurring materials is not properly regulated; • Local people are extracting river bed materials from upstream of the Shiwa Khola Bridge. If the extraction is left controlled, it may

District	Findings/Observations
	cause damage to the newly constructed bridge in future.
Kathmandu	• The condition of almost all the district and village roads is very poor. They lack basic structures (side drains, cross drains, retaining walls etc.) as well as maintenance. • Matatirtha – Deuralikhani - Hetauda Road; Several minor slips throughout the road. There are very few (insufficient) drainage and retaining structures along the whole road section. The road has very poor road geometry;
	DDC has initiated new technology in district roads; • The damaged section of Kageswori Chakrapth is stabilized after construction of retaining walls and provision of geotextile and bio-engineering measures. It is an example of applying appropriate technology for landslide stabilization.
Chitwan	The district roads are constructed without provisioning of adequate drainage system; • The road pavement along Gitanagar Settlement is severely deteriorated due to lack of adequate drainage management.
Myagdi	**The district roads are frequently blocked by big landslides;** **Beni – Darbang - Dhorpatan Road at Lampata (km 15) is frequently blocked by landslides. DDC is realigning the road and constructing bank protection works to prevent further landslides.**
Mustang	Gabion protection walls at both banks of Kaligandaki River are in damaged condition; • Gabion bank protection walls at both upstream and downstream of under construction Bridge across Kaligandaki Bridge are heavily damaged.
	The whole area along Jomsom - Ghoktan Road is highly erodible; • There are several landslips along the whole Jomsom-Ghoktan Road. These landslips cause road blockage at frequent interval.
Banke	**Several district and village roads are damaged by flood.** **RRM – Titiriaya – Sonpur – Udharpur - Sitapur Road at Km 9.5 area is frequently flooded during rainy season. The flood washed away road section and caused heavy loss of properties several times in the past;**
	Maintenance of structures is very poor; Culvert across Kiron Nala (stream) is not maintained for a long period. As a result brick masonry abutments and pier are highly deteriorated.
Achham	Several district roads are blocked by landslides. DDC is not able to clear them due to shortage of fund; • Road traffic is blocked for more than 1 year by big landslide at km 4 of Mangalsen-Oligaun-Jupu-Sila Road. DDC is not able clear and stabilize the landslides due to insufficient budget.

ANNEX III: VULNERABILITY ASSESSMENT FOR TYPICAL ASSETS

SELECTION OF ASSETS

The assets set out in paragraph 5 are selected below as examples of the VA and AP process.

VULNERABILITY ASSESSMENT OF ASSETS

The matrix below sets out the Vulnerability interpretation process for the selected assets.

Abbreviation used in tables

IIDR = Increase in intensity and duration of rainfall
IWSF = Increasing wet season flow
IDRW =Increasing duration of road pavement wetting
INRE = Increasing number of rainfall events
ILE = Increasing landslide events
VL = Very low; M = Medium; L = Low; H = High; VH = Very High

Asset	Physical Threat	Components	Climate Threat	Interpretation of Threat	Exposure.	Sensitivity.	Impact	Adaptive. Capacity	Vulnerability	Comments
I Beni-Darbang-Dhorpatan Road at km 15 MYAGDI	Erosion at toe destabilises hillside & causes landslide	Road	IIDR, INRE, ILE	Increase in rainfall intensity will speed up the frequency and intensity of road failure.	VH [1]	H [2]	VH	M [3]	VH	The sensitivity is high because there is high probability of road slip. If the road slips, the traffic will be closed for long period and reconstruction cost will be very high.
		Slope failure	IIDR, INRE, ILE	Probability of slope failure will significantly increase due to: (i) more surface water at the hill slope above the road and (ii) more toe erosion due to higher flood at the Myagdi River	VH [4]	M [5]	VH	M [3]	VH	The slope failure, in general, will be manageable. It may close traffic for few hours/days but it will not create heavy loss of lives and properties. Hence the sensitivity is considered medium.
		Toe wall	IIDR	Threat to walls will	VH	H [7]	VH	M [3]	VH	Myagdi River is hitting the bottom of

			INRE IWSF	increase due to: - Increase in pore pressure due to higher rainfall; - More scouring Higher impact by the river at/near the wall	[6]					the slope. This is the main cause of very high vulnerability of toe wall.

1. *The asset has high exposure and is already suffering from frequent landslide problem. With climate change effect, the exposure will increase.*
2. *The asset is located along district road and has less traffic. The loss of lives and properties will not significant. However, the reconstruction cost of the road will be high.*
3. *Refer to section 2.2.4.*
4. *Slope failure is occurring at frequent interval. Frequency and intensity of such incidence will significantly increase.*
5. *Small slope failure will close the road for hours/days. However, big slope failures may wash away whole road section. Cost of road reconstruction could be high.*
6. *The wall has high exposure to climate change effect because pore pressure at the wall will increase. Bed scouring at /near the wall and river impact to the wall will significantly increase.*
7. *If the wall fails the whole slope including road will slip.. Significant DDC budget will be required to reconstruct the road. Loss of lives will not be high.*

II RRM-Titiriaya-Udharpur-Sitapur Road BANKE	Failure of Road Embankment	Road embankment	IIDR INRE IWSF	Increase in intensity and duration of rainfall causes the flooding at the natural drainage system and will damage the road embankment.	H[1]	L[2]	M	M[3]	M	The road embankment may be damaged by flood. But the vulnerability will not be high because the reconstruction cost will not be high and traffic on road is very low.
		Pipe culvert	IIDR, INRE, IWSF	Increase in intensity and duration of rainfall causes the flooding and damages the pipe culvert.	H[4]	VL[5]	M	M[3]	M	The sensitivity is very low because the construction quality is good and road has very little traffic. As result the vulnerability was found medium.

1. *The exposure is high because the road section is located at low land area (previously a natural drainage channel). All the accumulated water in the field passes through it. The road embankment was damaged several times in the past due to this phenomenon.*
2. *The road embankment is not protected and may suffer damage. The road will be closed for few days due to damage but it will not create big impact as the road has nominal traffic.*
3. *Refer to section 2.2.4.*

4. *The exposure is high because the road section is located at low land area (previously a natural drainage channel). All the accumulated water in the field passes through it.* 5. *The pipe culvert cannot pass the flood and hence the accumulated may damage the pipe culvert. But the damage will not be high because the construction quality of pipe culvert is good. The road has little traffic*										
III Ladari Khola Bridge CHITWAN	Failure of Bridge	Bridge	IIDR, INRE, IWSF	HFL will increase. The scour depth will be higher due to increase in flood volume.	VH[1]	H[2]	VH	M[3]	VH	To protect the bridge from such event, design should be carried out considering possible increase in flood, HFL, scour depth, waterway width. The sensitivity is high because the quality of design and construction is poor.
		Bank protection works	IIDR, INRE, IWSF	Higher flood will cause more damage to bank protection works.	VH[1]	L[4]	H	M	H	The sensitivity is very low because the construction quality is good.
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.*										
IV Culvert across Kiron Nala BANKE	Failure of bridge & Erosion of approach road embankment	Abutments, pier and wing walls of the bridge	IIDR INRE IWSF	Increase in flooding at the stream will damage the abutments, pier and wing walls	H[1]	VL[2]	M	M[3]	M	The sensitivity is very low because: • the bridge elements are structurally sound; • the road section has little traffic.
		Concrete causeway	IIDR INRE IWSF	Increase in intensity and duration of rainfall causes the flooding at the stream. The overflow from the stream passes through the causeway and damages it.	H[4]	VL[5]	M	M[3]	M	The sensitivity is very low because the construction quality is good and road has very little traffic.

1. *The asset lies in the high rainfall area. The bridge site suffered high flooding in the past.*
2. *The section of abutments and pier is heavy. Flood at stream cannot damage them. .*
3. *Refer to section 2.2.4.*
4. *The asset is located in the high rainfall intensity area. The overflow of the river washed away the road embankment at this location.*
5. *The quality of concrete causeway is good. The overflow water cannot damage the structure.*

V Budhiganga Suspension Bridge BANKE	Erosion of bank protection wall	Bank protection wall	IIDR INRE IWSF	Increase in wet season flow will cause more scour and flood impact to the bank protection walls.	VH[1]	M[2]	VH	M[3]	VH	There were not any extreme events due to wall failure. However, with increase in wet season flow, the probability of wall collapse will increase. Hence the sensitivity is considered medium.

1. *The bank protection wall is located very near to the main river course.*
2. *The wall is regulating the river course and it is also protecting the airport and main settlement area of Sanfebagar. There will be huge loss of lives and properties if the wall collapses. However, major incident has not happened in the past. As the condition of wall is good. the sensitivity is considered medium.*
3. *Refer to section 2.2.4.*

VI Kageswori -Chkrapth (Ring Road) KATHMANDU	Landslide cuts road	Road Pavement	IIDR, INRE, IDRW	Increase in intensity and duration of rainfall will weaken the sub grade consequently accelerating the pavement damage	H[1]	L[2]	M	M[3]	M	The sensitivity is low because the road section is black topped and the surface water management is satisfactory.
		Gabion retaining walls	IIDR, INRE, ILE	Increase in pore water pressure and damage to wall.	M[4]	L[5]	M	M[3]	M	The sensitivity is low because the increase in pore water pressure will be nominal due to bio-engineering. The quality of wall is also good.

		Fill slope and bio-engineering	IIDR, INRE, ILE	Increase in accumulation of surface and sub-surface water will damage bio-engineering works and will cause slope failure.	H[6]	L[7]	M	M[3]	M	The slope is protected by retaining wall and bio-engineering works. The quality of walls and bio-engineering is good.
1. The exposure is high because the area is located where the rainfall intensity will have significant effect *2. The road is blacktopped; probability of penetration of surface water to the subgrade is nominal.* *3. Refer to section 2.2.4.* *4. The exposure is medium because the surface water management is satisfactory. It will not be highly affected by rainfall.* *5. The quality of wall is good. Development of more pore water pressure will be low as the slope is covered with bio-engineering.* *6. The exposure is high because the area is located in the where the rainfall intensity will have significant effect* *7. The sensitivity is low because the slope is designed and constructed with the provision of bio-engineering and the quality of bio-engineering works is good;*										

ANNEX IV: ADAPTATION PLANNING PROCESS

Asset	Physical Threat	Component	Climate Threat	Impact	Significance			Adaptation options	Priority adaptation			Adaptation phases
					Likelihood	Seriousness	Significance		Feasibility	Effectiveness	Priority	Regular (R) Immediate (I), Short (S), medium (M) long term (L)
I **Beni-Darbang-Dhorpatan Road at km 15 MYAGDI**	**Instability of hillside**	**Toe Wall**	IIDR, INRE, IWSF	Damage to toe wall will cause failure of slope and road.	H[1]	H[2]	H[3]	Provide adequate scour protection works.	H[4]	H[5]	H[6]	**S[7]**
		Hill side slope and Road	IIDR, INRE, ILE	Intensity and frequency of landslides will increase.	H[8]	H[9]	H[10]	Construct surface and sub-surface drains. Provide bio-engineering works.	H[11]	H[12]	H[13]	**I &S[14]**

1. *Pore pressure will increase. Scouring effect and impact to wall by Myagdi River will be higher due to increase in flood.*
2. *There is a probability of loss of lives. The traffic will be closed. Reconstruction cost of road could be high.*
3. *As per matrix.*
4. *Scour protection works are feasible because they can prevent wall collapse and save considerable amount of money.*
5. *It is highly effective measure*
6. *As per matrix*
7. *The toe wall is already under construction and should be completed immediately.*
8. *The hill side slope and the road is already suffering from landslides. Higher rainfall intensity will accelerate the process.*
9. *The loss of lives and properties will not be high. But reinstatement of slope and road reconstruction will be costly.*
10. *As per matrix*
11. *Adequate drainage system and bio-engineering works will be highly feasible.*
12. *The proposed adaptation measures are highly effective. These measures are found very effective in Nepal*
13. *As per matrix.*

14. The works should be immediately started and completed within 2 years											
II **RRM-Titiriaya-Udharpur-Sitapur Road BANKE**	**Road embankment eroded & road cut**	**Road embank-ment**	IIDR, INRE, IWSF	Damage to road embankment due to accumulation of drainage water collected from the surrounding areas.	H[1]	L[2]	M[3]	Proper management of surface water by: -reinstating drainage channel -constructing additional cross drainage structure -constructing guide walls	M[4]	M[5]	M[6]	**S[7]**
		Pipe culvert	IIDR, INRE, IWSF	Damage to pipe culvert due to flood water.	M[8]	L[9]	M[10]	-Clean the PC at regular interval -Manage surface water by cleaning side drains and water path at outlets.	H[11]	M[12]	H[13]	**I & R[14]**
1. The asset was frequently damaged in the past due to flooding. *2. There will not be any loss of lives. Rehabilitation cost of the embankment will not be very high. Traffic on road is low.* *3. As per matrix.* *4. The adaptation measures will protect road, cultivated land and houses of the surrounding areas.* *5. The adaptation measure will be highly effective in dealing with impact.* *6. As per matrix.* *7. The proposed works should be completed before the monsoon.* *8. The likelihood of flood is high but the damage to PC will be low (due to good construction quality .* *9. There will some loss of properties.* *10. As per matrix* *11. Cost of water management is very less in comparison to the rehabilitation cost of different components.* *12. The effectiveness in dealing with impact will be medium.* *13. As per matrix.* *14. Water management should be done immediately as well as on regular basis. .*											
III **Ladari Bridge**	Failure of Bridge	**Bridge**	IIDR, INRE, IWSF	Damage to bridge due to increase in HFL and scour depth.	M[1]	M[2]	M[3]	Height of the bridge should be sufficient to accommodate increased flood. Similarly, the	H[4]	H[5]	H[6]	**I & L[7]**

CHITWAN								foundation depth should be increased.				
		Bank protection works	IIDR, INRE, IWSF	Damaging effect will be more due increase in flood volume	M[8]	L[9]	M[10]	Design and construct bank protection works in such a manner that it is safe from scouring and flood impact.	M[11]	M[12]	M[13]	**S & L[14]**

1. *The new bridge which will be properly designed and constructed will have medium effect. The bridge may be damaged in case of extreme flood.*
2. *The loss of lives and properties will not be high.*
3. *As per matrix.*
4. *The new bridge will be highly feasible. It will provide uninterrupted traffic to several villages.*
5. *The adaptation measure will be effective*
6. *As per matrix.*
7. *The proposed works should be start within short period. But completing the whole works will take few years.*
8. *The new bank protection works which will be properly designed and constructed will have medium effect. The protection works may be damaged in case of extreme flood There will some loss of properties.*
9. *Loss of lives and properties will be nominal.*
10. *As per matrix*
11. *Bank protection works is feasible because it will save lot of properties.*
12. *The effectiveness of bank protection works can be considered medium in this case.*
13. *As per matrix.*
14. *The proposed works should be start within short period. But completing the whole works will take few year*

IV **Culvert across Kiron Nala** **BANKE**	Bridge damaged and road embankment cut	**Road embankment**	IIDR, INRE, IWSF	Damage to road embankment due to overflow of excess water from the culvert.	M[1]	L[2]	M[3]	Construct 30m long dyke at left bank	M[4]	M[5]	M[6]	**M[7]**
		Abutments, pier and wing walls	IIDR, INRE, IWSF	The excess water will further damage abutments, pier and wing walls.	M[8]	L[9]	M[10]	Repair the damaged/ deteriorated components	H[11]	H[12]	H[13]	**R &S[14]**

1. Probability of damage to road embankment is less after the construction of the construction of concrete causeway. *2. There will not be any loss of lives. Rehabilitation cost of the embankment will not be very high. The traffic on road is low.* *3. As per matrix.* *4. Construction of dyke will be feasible in longer term.* *5. The adaptation measure will reduce impact. But it may not completely solve the problem.* *6. As per matrix.* *7. The dyke may be constructed within 2-3 years.* *8. The likelihood of further damage due to increase in flood is not high. .* *9. The bridge will not collapse. There will some increment in repair and maintenance cost.* *10. As per matrix* *11. Repair and maintenance is always feasible.* *12. The well maintained structure is always more effective.* 13. *As per matrix.* 14. *The proposed works fall under the regular maintenance and hence should be completed within short period*												
V Budhiganga Suspension Bridge ACHHAM	Bank protection works damaged	Bank protection walls	IIDR, INRE, IWSF	Damage to walls will be more. Some sections of the wall may collapse.	VH[1]	M[2]	H[3]	Repair/rehabilitate damaged walls on regular basis.	VH[4]	VH[5]	VH[6]	**S&R[7]**
1. The walls are located very near to the river course. Its exposure to increase in wet season flow will be very high. *2. Any serious incidence is not recorded due to wall failure in the past. The quality of wall is fair. Loss of lives and properties will be high if the walls collapse. Considering the above factors, seriousness is considered medium.* *3. As per matrix.* *4. Repair and rehabilitation cost will be very less in comparison to the damage due to wall collapse. .* *5. It is highly effective measure* 6. *As per matrix* *7. The repair/rehabilitation works should be completed within short period and should be continued on regular basis*												
VI Kageswori	Landslide cuts road	Road Pavement	IIDR, INRE, IDRW	Damage to road pavement due to weakening of sub-grade.	M[1]	L[2]	L[3]	Proper management of surface water	VH[4]	VH[5]	VH[6]	**I & R[7]**

chakrapath (ring road) KATHMANDU		**Gabion Retaining Wall**	IIDR, INRE, ILE	Damage to wall due to slope failure	M[8]	M[9]	M[10]	Manage surface and sub-surface water at/around the wall.	VH[11]	VH[12]	H[13]	**I & R[14]**
		Bio-engineering works and earth filling.	IIDR, INRE, ILE	Increased accumulation of surface water will cause landslides/slips damaging the bio-engineering works	M[15]	L[16]	VL[17]	Manage surface water by safely disposing it to drainage structures or other safe locations.	H[18]	VH[19]	H[20]	**I & R[21]**

1. *The road section black topped. Probability of the surface water penetrating to subgrade is not high.*
2. *There will not be any loss of lives. Rehabilitation cost of the pavement will not be very high.*
3. *Very few traffic. The pavement failure will not cause serious impact.*
4. *Cost of water management is very low in comparison of pavement rehabilitation cost.*
5. *The effectiveness of the study will be very high.*
6. *Water management and timely repair are the most essential works for road preservation.*
7. *The said works should be carried out immediately as well as on regular basis.*
8. *Surface water will have very little effect as the slope is covered with bio-engineering. However, there is not sufficient provision for sub-surface water management.*
9. *If the wall will fail, the whole road section will collapse causing road closure. The rehabilitation cost will be substantial for DDC/DTO who is implementing more than 100 roads in the district.*
10. *The reconstruction of the wall will not be high. Similarly, traffic will not be interrupted for a long period.*
11. *Cost of water management is very less in comparison to the replacement cost of wall.*
12. *Water management is one of the most effective ways to preserve the road asset.*
13. *Water management should always be given top priority.*
14. *The water management should be done immediately as well as on regular basis.*
15. *Surface water management is satisfactory. Likelihood of damage to bio-engineering works is medium.*
16. *There will be no loss of lives. Rehabilitation cost of bio-engineering works will not be high.*
17. *It will have very little impact on the stability of the road section as well as on vehicular traffic.*
18. *Cost of water management is low in comparison to the repair of bio-engineering works.*
19. *Water management is one of the most effective ways to preserve the road asset.*
20. *Safe disposition of the surface water will save the bio-engineering works and should get high priority.*
21. *Water management should be done immediately as well as on regular basis.*

ANNEX V: LIST OF GOVERNMENT OFFICIALS PARTICIPATING IN TIFFIN TALK & ROUND TABLE MEETINGS

No.	Name	Position/Organization
1	Mr. Bhim P. Upadhyaya	DG, DoLIDAR
2	Mr. Ram Krishna Sapkota	DDG, DoLIDAR
3	Mr. Jeevan K. Shrestha	DDG, DoLIDAR
4	Mr. Madhav Bhattarai	SDE, DoLIDAR
5	Mr. Ashok Jha	SDE, DoLIDAR
6	MMr. Pushkar P. Paudyal	SDE, DoLIDAR
7	Mr. Jeevan guragain	SDE, DoLIDAR
8	Mr. Guru prasad sharma	SDE, DoLIDAR
9	Mr. Siddheshwor shrestha	Engineer, DoLIDAR
10	Mr. Mohadatta bhatta	Engineer, DoLIDAR
11	Mr. Lokhnath regmi	SDE, DoLIDAR
12	Ms. Sova Shrestha	Engineer, DoLIDAR
13	Mr. Bhupendra Lal Shrestha	SDE, DoLIDAR
14	Mr. Kumr Jhapa	SDE, DoLIDAR
15	Mr. Amrit Shrestha	SDE, DoLIDAR
16	Mr. Bhagawan Shrestha	Officer, DoLIDAR
17	Mr. Sudina Kuikel	Engineer, DoLIDAR
18	Mr. Smita Sharma	Engineer, DoLIDAR
19	Mr. Hari Pd. Pokharel	S.O, DoLIDAR

No.	Name	Position/Organization
20	Mr. Sagar Nepal	Engineer, DoLIDAR
21	Mr.Ishwor Marahatte	Engineer, DoLIDAR
22	Mr. Ashesh Regmi	Engineer, DoLIDAR
23	Ms. Pritha Chudal	Engineer, DoLIDAR
24	Mr. Bibek Ghimire	Engineer, DoLIDAR
25	Mr. Mahesh P. Yadav	Engineer, DoLIDAR
26	Mr. Rajesh Sharma	Senior Engineer, DoLIDAR
27	Mr. Rishi Acharya	Under Secretary, DoLIDAR
28	Mr. Badri Pd. Dhungel	Engineer, DoLIDAR
29	Mr. Ram Sharan Acharya	Engineer, DoLIDAR
30	Mr. Ganga Bdr Basnet	SDE, DoLIDAR
31	Mr. Laxman Shrestha	Engineer, DoLIDAR
32	Mr. Bishu B. Shah	Deputy Team Leader, DRSP/DRICP-CISC
33	Mr. Uma Shankar Shah	SDE, DoLIDAR

ANNEX VI: ISSUES RAISED AT 22/23 SEP WORKSHOP WITH RESPONSES

Issues raised in Sept 22 - 23 presentation (DoR/DOLIDAR)

Raised by	Issues	Response
Mr. ……Shah, SE, DUDBC	At several roads of Kathmandu City, traffic is disturbed due to excessive accumulation of water or for any other reasons. Can some system be installed so that the road users could get the information beforehand?	Traffic management is the responsibility of the Department of Transport and Kathmandu Traffic Police
Mr. Akhanda Sharma, NPM	Condition of assts is explained using parameters such as exposure, sensitivity, likelihood etc and their degree (VH, H, M, L and VL). The consultants need to discuss in detail with the related departments to agree on using the above terminology for VA and AP.	The relative values of the parameters used in the VA & AP assessments are part of the ongoing discussions with DoR and DoLIDAR
	Effect of CC will not be same for road pavement, retaining wall, bridge etc. Hence they should be dealt separately.	The VA & AP analysis should be carried out for all the different elements in the Strategic and Rural Road Networks
	Bridge sector should be addressed separately.	Agreed.
	Synthesis Report does not include the effect of CC on snowfall, fog, visibility etc.	The Climate Threat Profiles do not provide sufficient information for these effects to be included in the threat analysis
	Planning/developing training package should be provided in detail.	Training packages/modules are part of the next phase of the Project
Mr. Madan Manandhar, Director, METCON	Social aspects are missing in VA and AP.	Social vulnerabilities will be addressed for relevant assets
Mr. Suraj Pokharel, DG, Department of Environment	Can we prepare separate typical design of structures considering CC effect?	As the threats from CC become more accurately defined so designs can be modified to make structures more resilient

ANNEX VII: BIBLIOGRAPHY

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