TA 7984: MAINSTREAMING CLIMATE CHANGE RISK MANAGEMENT IN DEVELOPMENT

Identification of high risk projects

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Objective of the TA and Output 1

Nepal is highly vulnerable to climate change. Geomorphological systems are dynamic, natural systems are already stressed, poverty is widespread and there is little capacity to mitigate disasters when they occur. Climate projections for the country suggest higher temperatures especially at higher elevations, changes in total precipitation in much of the country, increased glacial melt and an increased frequency of extreme events. Climate change is likely to have a major impact on both the rural poor as well as adding to the challenges of water supply and drainage in urban areas.

This **objective** of TA 7984-NEP Mainstreaming Climate Change Risk Management in Development (the TA) is to enhancing GoN's and ADB's ongoing climate change program in Nepal which focuses on institutional strengthening and capacity building, creating and disseminating knowledge and information about climate change and its impact on Nepal, and generating and applying tools for climate change risk management. The expected **impact** of the TA is that Nepal has increased resilience to climate variability and climate change. The expected **outcome** of the TA is that the GoN's infrastructure development programs, policies and projects incorporate safeguards to address the effects of climate change, and that specifically

To achieve these outcomes the TA has three **Outputs**. Output one is that **climate change risks are integrated into Nepal's development planning and implementation of development projects.** The end result of Output 1 is that MoSTE and sector agencies have the experience, skills, guidelines, frameworks and policies to incorporate consideration of climate change risks in their development projects. A key element of this is the development of climate change risk screening tools and the identification of high risk projects in the portfolio of each sector department.

1.2 Objective of this report

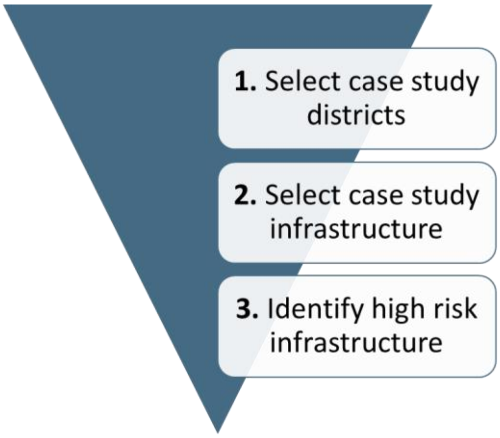
The objective of this report is to draw on existing reporting from the TA to provide a summary of high risk projects identified for each of the sector departments involved in the TA[1]. The identification of high risk projects provides a snapshot of the types and locations of high risk projects for each department, and can assist the departments in prioritizing where adaptation funds and efforts are best placed geographically and technically.

[1] Department of Roads, Department of Irrigation, Department of Urban Planning and Building Construction, Department of Water Supply and Sanitation, Department of Water Induced Disaster Prevention and the Department of Local Infrastructure Development and Agricultural Roads.

2 METHOD FOR IDENTIFYING HIGH RISK PROJECTS

With seven sector departments and hundreds of projects being implemented by each department a phased approach was selected to identify high risk projects. High risk projects in each department's portfolio were identified through three phases with each phase decreasing the number of projects under consideration (Figure 2-1). The approach does not necessarily identify the most high risk projects in each department's portfolio, but provides a snapshot of the types and locations of projects that have high risk. This can assist the departments in prioritizing where adaptation funds and efforts are best placed geographically and technically.

Figure 2-1 Process for identifying high risk projects



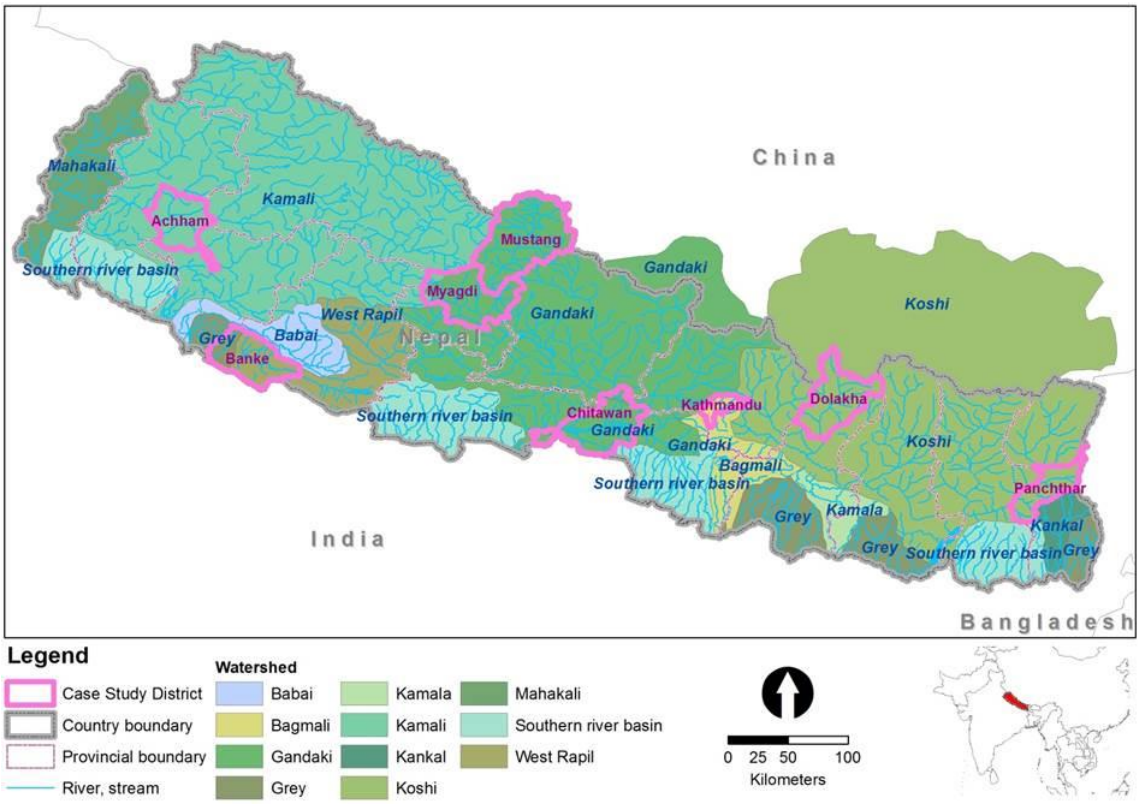
2.1 Selection of case study districts

Through consultations with sector departments and MoSTE, a set of criteria was established to identify case study districts (Table 2-1). A key element of the criteria was to select districts with very high and high vulnerability, and with infrastructure of strategic importance. Based on these criteria eight districts were identified by government focal points and team members: (i) Mustang; (ii) Dolakha; (iii) Accham; (iv) Kathmandu Valley; (v) Banke; (vi) Chitwan; vii) Myagdi; and iii) Panchthar (Figure 2-2). These districts represent the diverse ecological, infrastructure, climate, climate hazard and population density of Nepal.

Table 2-1. Case study location selection criteria

Main selection criteria
Representing the main ecological zones of the country (ie Terai, hills and mountains)
Representing a diversity (small to large) of infrastructure development
Areas with infrastructure of strategic importance for national development
Representing the main climatic zones (East – West)
Availability of past data/records
Represented in the NAPA and IWMI very high and high vulnerability rankings
Areas of high past disaster occurrence and at high risk of natural hazards
Representing key issues identified by each sector
Areas with key urban settlements

Figure 2-2 Case study district locations



2.2 Selection of priority infrastructure for analysis

Sector teams then undertook field visits to each of the districts and identified two to five priority infrastructure for each sector based on the following criteria:

- 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 new infrastructure.

In some cases additional criteria were included including:

- Infrastructure of importance to women (e.g. reduces workload, increases mobility, supports women's livelihoods);
- Infrastructure of importance to poor or marginalized groups (e.g. Dalit, Ethnic groups); and
- Ensuring a varied range of type and size of infrastructure.

2.3 Identification of high risk infrastructure

Detailed baseline information was collected for each priority infrastructure and a vulnerability assessment undertaken. The vulnerability assessment process is summarized below and described in detail in the report titled *Climate Change Vulnerability Assessment and Adaptation Planning Methodology for Infrastructure in Nepal: A guide for infrastructure departments.*

For each of the high priority infrastructure assets identified in each district, projected district climate change threats were analyzed with regards to how each asset would be **exposed** to the climate threat as well as the **sensitivity** of the asset to the threat. After an assessment of the exposure and sensitivity of each asset to the projected climate change threats, a relative ranking of **impact** was determined through a standard evaluation matrix based on selected criteria for exposure and sensitivity. To arrive at an assessment of the vulnerability of each asset to climate change threats, the **adaptive capacity** of each asset was evaluated in order to determine the degree of **vulnerability** to climate change. Again vulnerabilities of the assets were ranked according to an evaluation matrix with specified criteria for adaptive capacity. Infrastructure found to have **high or very high vulnerability** are considered to be at **high risk of negative impacts from climate change**.

3 HIGH RISK PROJECTS IDENTIFIED FOR EACH SECTOR

Detailed descriptions of the baseline and vulnerability assessments for the priority infrastructure selected for each district by each sector are outlined in the following report sets:

- *District adaptation plan guidelines: Consolidated Baseline, Vulnerability Assessment and Adaptation Planning* reports for each sector for each district; and
- *Adaptation plan framework for guidelines: Sector Synthesis Reports on Adaptation to Climate Change* for each sector.

The following chapter draws on the above mentioned report sets and provides a summary of the high risk infrastructure identified for each sector.

3.1 Department of Water Induced Disaster Prevention

Infrastructure designed to protect assets from water induced disasters are inherently at high risk from climate change. Most of these assets are located along riverbanks, floodplains or unstable slopes and therefore have a very high exposure to the climate change threats. Many are highly sensitive to increased rainfall intensities and/or resulting floods. Thus, the risk posed by climate change for water induced disaster prevention infrastructure is very high for most of DWIDP's assets.

Apart from shortcomings in design the following issues appear to make some DWIDP assets at higher risk of climate change impacts:

- **Use of Gabion Boxes:** In most cases gabion boxes filled with stones are the only units being used for protection works. The gabion wire used often appears not strong enough to resist the erosive power of large size sediment flow.
- **Lack of attenuation works in the upper catchment:** There is often insufficient attention for interventions in the upper catchments to reduce erosion and sediment transport. In addition, more attention should be given to landslides control works in the upper catchments.
- **Lack of monitoring and maintenance:** There is generally no practice of monitoring and maintenance of protection works.
- **Restriction of river channel width**: Due to difficulties in acquiring land the waterways of the river have been constricted in many of the stretches where DWDIP infrastructure is located. This can increase river bed and bank erosion, putting in-stream structures at risk.

3.2 Department of Roads

A summary of the high risk projects identified for the roads and bridges sector is provided in Table 3-1.

Table 3-1 High risk projects identified for the roads and bridges sector (strategic road network)

District	Asset/s	Description	Risk/Vulnerability
Banke	Hengwa Khola Bridge.	Multi-span bridge along Mechi Highway located 9 km from Phidim (towards Taplejung side).	The pier of the bridge is at risk because the river gradient is steep and transport big boulders. DoR has put some gabion protection but it will not be sufficient for increased flooding.
Dolakha	Charnabati Bridge and approach roads.	Several large scale structures are constructed for protection of bridge and approach roads. This is one of the most expensive protection works along Lamosngu-Jiri Road. Such expensive works are not constructed for protection of roads and bridges in other parts of the country as well.	The asset is very highly vulnerable to increasing intensity and frequency of extreme rainfall events causing bioengineering and drainage works to fail; and increasing occurrence of landslides on the left bank destroying the approach roads. It is also highly vulnerable to increasing wet season flow destroying the bridge abutment and protection works.
Kathmandu	Bagmati Bridge along Arniko Highway at Tinkune	The bridge was constructed in the 1970s by the Chinese Government. It is a multi-span RCC bridge on pile foundation. Due to heavy scouring, about 2-3 m top sections of the pile are exposed at all piers. If appropriate measures are not adopted immediately, the bridge may collapse.	The bridge is highly vulnerable to increasing extreme rainfall events and wet season flow causing foundation failure due to scouring, and damage to bank protection walls.
Chitwan	Lothar Bridge	Due to heavy siltation, the vertical clearance of the bridge which was 8m during construction in 1977 is reduced to 2.5m. The bridge may be washed away if appropriate measures are not adopted immediately.	The bridge is highly vulnerable to increasing intensity and duration of rainfall, increasing number of extreme rainfall events and increasing wet season flow causing the bridge to wash away; or causing damage to the dyke and bank protection works.
	Landslide Protection works at Mauri	Landslide Protection works at the hill slope of Narayanghat-Mugling Road near Mauri Bridge. Several check dams are constructed at upstream to protect road and bridges from debris, which is unique and successful.	The protection works are highly vulnerable to increasing intensity and frequency of extreme rainfall events, and increasing wet season flow leading to higher risk of landslides and damage to gabion check dams.
Myagdi	Beni-Pairothapla Road Section at	The road is located next to Kaligandaki River. In July 2012, Sunari Khola which joins the river at km 17, deposited large amounts of debris at the right bank. Due to this, the river	Kaligandaki is a large river with high damaging capacity. Hence it is eroding the road at several sections of the highway. With increasing flood volume, its damaging capacity

District	Asset/s	Description	Risk/Vulnerability
	Bhirkate (km 17*)*	has changed its course towards the left bank and severely damaged the road.	will be much higher. In such cases the road cannot be protected by providing typical walls and the only option to construct robust roads is to shift the road away from the river at critical areas.
	Under construction bridge across Lasti Khola	An instantaneous flood washed away all the formworks and reinforcements during construction.	With climate change these during-construction incidents will be more frequent and will cause more damage to infrastructure works.
Mustang	Road damage at Marpha (km 72).	In July 2013 there was extensive rain at/around Marpha area. The heavy rain caused flooding in Podkyu Khola. The flood washed away the road as well as depositing a large amount of debris.	The road is highly vulnerable to increasing intensity and frequency of extreme rainfall events, and increasing wet season flow leading to washing away and damage road sections, and increased bank erosion.
	Road erosion at Tukuche (km *65)*	About 1.5 kilometer of Beni-Jomsom Road is located very near to right bank of Kaligandaki River. The river is extensively eroding the bank and at one location it has washed away a 40m long road section.	The road is highly vulnerable to increasing intensity and frequency of extreme rainfall events, and increasing wet season flow leading to increasing intensity and frequency of bank erosion and road damage.
Banke	Nepalgunj-Baghouda Road	500 m long section of approach road at left bank of Rapti Bridge was severely damaged by flood. Although DoR constructed several cross drainage structures to protect the road, the damaging effect is still not controlled.	The road is highly vulnerable to increasing intensity and frequency of extreme rainfall events, and increasing wet season flow leading to damage to road embankment, bank protection works and cross-drainage structures.
Achham	Landslide at Tashi (km 9+920)	The hill slope of the road is very fragile. Due to this, landslides and road closures are common. The hill slope can be stabilized if appropriate measures (breast wall, drainage management, bio-engineering etc,) are adopted.	The bank protection works are highly vulnerable to being washed away as wet season flows and number of extreme events increase.
	Road erosion at km 11+ 900	There was a heavy flood on Budhiganga River in June 2013. The flood severely damaged a 60m section of the road and is endangering the stability of a 200m long section. If appropriate measures are not adopted immediately, a substantial road length will be washed away and will deprive Bajura District of road link.	Intensity and frequency of extreme rainfall events, and increasing wet season flow will ead to river bank erosion and the road being washed out.

3.3 Department of Irrigation

A summary of the high risk projects identified for the irrigation sector is provided in Table 3-2.

Table 3-2 Irrigation systems identified as high risk from climate change

District	High Risk System	Salient Features	Principal Climate Threat	Why high risk?
Banke	Chisapani Naubasta	A surface irrigation scheme original constructed by farmers and rehabilitated in 1996. The command area is 306ha and benefits 575 households. The crops grown are monsoon paddy followed by a combination of wheat, potatoes, pulses and oilseed. The diversion weir across the Man Khola has partially collapsed so that water from the khola is now unable to enter the main canal. Overall the condition of the headworks and main canal are poor and the apathy of the water user group to undertake any remedial works has compounded the deterioration of the diversion and intake structures.	Average monthly river flows are predicted to increase from July to September resulting in greater potential for sediment to enter the intake. The 1:100 year flood is predicted to increase by up to 50% in the July /August period. At the same time rainfall intensities (1:10 year10 min rainfall event) are predicted to increase in the pre-monsoon period by 20%. The Man Khola catchment area is in the Churia mountains, which are highly erodible, and higher runoff rates would cause soil erosion bringing down high sediment loads with the floods.	The present poor condition of the diversion weir would be further impacted by the larger flood flows unless it is rehabilitated or redesigned with better protection from larger boulders or stronger gabion baskets in the khola bed downstream of the core wall. Increased sediment loads could further damage the intake to the main canal.
Chitwan	Pithuwa	A government-constructed farmer managed Irrigation system commanding an area of 600ha with 600 households.	Maximum storm intensities are projected to increase between April to August with an increase of some 50% in July. In the less well protected and steeply sloping	The diversion structure is a temporary excavation of bed sediments and will continue to be sensitive to damage each flood season. Blockage of the intake and sediment entering through

District	High Risk System	Salient Features	Principal Climate Threat	Why high risk?
		The source river is the Kair khola which during the monsoon season carries a lot of sediment along with flash floods resulting in aggradation of the river bed. Though a perennial source, the discharge of Kair Khola diminishes considerably during the dry months. At the point of abstraction, water is diverted to the Pithuwa irrigation system through an earthen approach feeder canal where there is no sediment exclusion facility.	watershed area of the Churia Mountains this could generate more extreme flash floods in the rivers and larger volumes of transported sediment including boulders and gravels.	the intake will lead to suspension of irrigation to the command area. At present farmers are able to manage the system intake as the Water User Group is assisted by DOI providing mechanical support for intake and canal maintenance.
Mustang	Syang	An existing Farmer Managed Irrigation System commanding a net cultivable area of 42 ha. The system was rehabilitated 20 years ago under the ILO and NISP programmes. Crops grown in the project area are apple, buckwheat, naked barley, maize, potato and vegetables. The source of water for this irrigation scheme is Syang Khola. It is a snow-fed river having sufficient discharge throughout the year. The catchment area is fragile in nature with threats of landslide at both the intake site and along the main canal alignment.	Increasing number of dry days are predicted in January and February with the average number of dry days in June increasing from 5.5 to almost 7 days. Extreme rainfall intensity events (1:10 year10 min rainfall event) are projected to increase by 65% triggering more landslide events. Increasing temperatures of up to 4^{o}C during winter months will raise the permanent snow line to higher elevations in the river catchment decreasing the dependable river flows resulting from snow melt. This will impact on irrigation water	There is inadequate protective measures at the intake site from flash floods and to prevent landslides along the main canal damaging and sweeping away the canal system, resulting in no flows reaching the command area. There is a need for more frequent O&M works which in turn raises costs and is a significant burden on the water-users.

District	High Risk System	Salient Features	Principal Climate Threat	Why high risk?
			availability for summer crops. Larger river flows are expected in the pre-monsoon period due to increased rainfall, increasing the river bed aggradation problems and activating landslides.	
Kathmandu	Mahankal	A farmer managed system commanding an area of 50ha. The system was recently rehabilitated. A typical small hill system with water extracted from a small perennial khola and carried across the local hillside to a command area at a lower elevation. Crops grown are monsoon paddy followed by a mixture of wheat, oilseed, potato and vegetables. The flow in the dry season falls to some 20 lps. The command area is terraced across the hill side. This results in it being exposed to storm damage during the monsoon season.	Current 10min intense rainfall events that occur once in every 5 years are projected to take place in the future once every 2 years. These intense rainfall events will increase landslide risks particularly where the main canal crosses steeply sloping land Landslides have regularly occurred along the main canal alignment with it being totally destroyed in places and having to be rebuilt.	Recent rehabilitation works have reinstated the canal alignment across a previous land slide zone. There were no drainage or bioengineering inputs associated with this work, making the remedial works still vulnerable to further damage in the future. There appeared to be little enthusiasm by the local water user group members to undertake any regular maintenance works to regularly remove debris entering the canal
Dolakha	Rampa	An existing farmer managed system, commanding 70ha, rehabilitated in 2012. The water source is the Kuthali Khola with a catchment area of 12km^2 being fragile in nature and threats from landslides. It is functioning well though some design aspects and the quality of	Normal river flows are predicted to increase by 25% in the July/august period only whilst in the winter period they could decrease by 20%. 1: 100 year floods are predicted to increase in size by 10% which will increase bed load entering through	Increased flash floods could result in the priority of the river channels upstream of the diversion weir changing with flows passing down through another channel With the 1:50 year one day rainfall intensity predicted to increase by 67%

District	High Risk System	Salient Features	Principal Climate Threat	Why high risk?
		construction of some components was poor. The siting of the diversion weir and headworks on one side of a bifurcation of the main khola channel raises concerns that flows may bypass the main canal intake site during low flows. Alternatively flash floods may result in future flows being diverted to pass down the other side of the bifurcation. The main canal passes under several cross drainage channels and at these super passages the configuration is such that it will constrict flood flows potentially damaging these structures.	the intake though the existing sediment basin and flushing sluice if properly operated should be able to cope with this. However flash floods are predicted to increase in frequency with a 30 minute storm event that now occurs every 50 years to happen every 5 years by 2050..	by 2050, floods in the cross drainage channels crossing the main canal could result in the existing super passage structures being inadequately sized to pass these predicted flood flows. Resulting damages could well interrupt irrigation water reaching the command area
Panchthar	Subhang	A farmer managed irrigation scheme commanding a net cultivable command area of 250ha. It was rehabilitated in 1993/94 The design is a typical hill irrigation scheme. The main canal intake is a free intake The total length of the main canal is 6.12 km with about half lined by stone masonry. Some sections of the main canal appear inadequate to carry the design discharge due to sediment deposition. In areas where major seepage has occurred HDPE	1:100 year flood events are predicted to increase by 50% and mean flows in the monsoon by 33%. Sediment problems entering the man canal will continue to increase unless gates are provided at the existing free intake site and a sediment basin and flushing structure provided The 1:50 year one day rainfall intensity is predicted to rise by some 80% induce further landslide events unless bioengineering works	The present design and construction of the system and its components are inadequate. O & M activities are performed by the water user group on an ad-hoc basis with minimal funds. Advanced technical capabilities are not readily available within the department of irrigation or water user group to raise the existing system capacity to achieve more climate resilient designs due to inadequate budgets.

District	High Risk System	Salient Features	Principal Climate Threat	Why high risk?
		pipes have been used or the canal has just been cut into the face of the landslip zone. These problems result in the system being not now operational and requiring rehabilitation.	associated with upslope drainage works are installed in the more critical areas along the main canal alignment.	

3.4 Department of Urban Planning and Building Construction

A summary of high risk projects identified for the urban planning and building construction sector is provided in Table 3-3.

Table 3-3 High risk projects identified for the urban planning and building construction sector

District	Components (Assets)	Risks / Vulnerability
Dolakha	Charikot town core	Intense and prolonged rainfall, flooding, landslides due to insufficient drainage and non-compliance with National Building Code resulting in destruction of homes and businesses.
	Singati Riverside Settlement	Intense and prolonged rainfall, flooding, landslides, and flash flooding due to location near confluence of two rivers; likely destruction of homes and market area since flooding and loss of lives has occurred in the past.
Kathmandu	Bagmati UN Park	Intense and prolonged rainfall, flooding and flash flooding and erosion / destruction of bridges, damage to historic temples, informal settlements, informal agricultural plots and the UNICEF water supply system adjacent to the Bagmati River.
	Pathivara Informal Settlement	Intense and prolonged rainfall, flooding and flash flooding and possible destruction of low income homes adjacent to Dhobi Khola.
Banke	Gabar Village-Churia Hills	Intense and prolonged rainfall, flooding and drought; flooding and possible destruction of homes and infrastructure.
	Nepalgunj-/Salyani Bag	Intense and prolonged rainfall, flooding and prolong pooling of water resulting in damage to homes and infrastructure.
Chitwan	Souraha Settlement	Intense and prolonged rainfall, flooding and damage to homes and disruption of tourist economy.

District	Components (Assets)	Risks / Vulnerability
	Bharatpur Solid Waste Site	Intense and prolonged rainfall, flooding and damage to waste site and spreading of pollution to downstream areas.
Mustang	Jomson Town and Airport	Intense and prolonged rainfall, flooding / flash flooding of town and nearby airport, resulting in destruction of homes / businesses and disruption of tourist economy.
	Marpha, Tukuche, Lete, Kagbeni and Tiri riverside settlements	Intense and prolonged rainfall, flooding / flash flooding, debris flow and sedimentation, landslides resulting in damage in homes and businesses.
Myagdi	Kali Gandaki Riverside Settlement (Beni)	Intense and prolonged rainfall, river flooding, flash flooding, sedimentation, landslides resulting in destruction of homes and businesses
	Lower Beni Bazar Road	Intense and prolonged rainfall, river flooding and pooling resulting in destruction of homes and businesses
Panchtar	Yasok Market Center	Decreased rainfall during dry season resulting in drought conditions.

3.5 Department of Water Supply and Sanitation

A summary of high risk projects identified for the water supply and sanitation sector is provided in Table 3-4 and Table 3-5.

Table 3-4 High risk water supply system infrastructure assets identified

Water Supply Infrastructure Asset	Reasons why the component is at high risk from climate change	High risk locations
Source – Springs, Streams and Rivers	Drying-up of source and less recharge of groundwater in the catchment is a common issue throughout Nepal and may be exacerbated by higher temperatures and changing rainfall patterns.	Springs in the following districts are at high risk: Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar Streams and rivers in the following districts are at high risk: Kathmandu, Chitwan, Mustang and Achham
Intake Structure	Increased likelihood of intense rainfall and flash floods will lead to collapse of intake structures.	Flash floods are well known to occur in hilly regions, therefore intake structures in the following districts are at high risk: Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar.

Water Supply Infrastructure Asset	Reasons why the component is at high risk from climate change	High risk locations
Transmission and Distribution Pipelines	Failure of highly exposed transmission and distribution pipelines due to landslides. Increased in temperature can also expand pipeline cracks in existing systems.	In hilly regions the existing transmission and distribution pipelines are laid along the historic landslide zones resulting in increased exposure and frequent failures which are likely to increase in number and severity. Therefore the pipelines in the following districts are at high risk: Achham, Banke, Dolakha, Kathmandu, Mustang, Myagdi and Panchthar
Storage Reservoirs	Collection of sediment from rainfall runoff in storage reservoirs can be a serious issue; particularly if sediments with organic matter reach residents. Increased incidence of high intensity rainfall events with climate change may increase the risk of such events.	Flash floods are well known to occur in hilly regions where large flows with high velocity can lead to over-topping and the collection of large volumes of solid particles and organic matter in storage structures. Reservoirs in the following districts have been identified as high risk: Dolakha and Kathmandu
Water Pumping Stations	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance of sediment collecting and clogging pumps and interrupting water supply.	In terrain like Banke, Chitwan and Kathmandu districts, where there is a need for lifting and gravity systems, pumping stations will be especially prone to impacts.
Water Treatment Plant (WTP)	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance of sediment collecting in the plant systems leading to overburdening and deterioration of water quality.	Relevant in flat and hilly terrain found in Chitwan, Dolakha and Kathmandu districts

Table 3-5 High risk sanitation system infrastructure assets identified

Sanitation System Infrastructure Asset	Reasons why the component is at high risk from climate change	High risk locations
Collection System (sewage pipes)	Failure of highly exposed collection systems due to landslides is a major potential climate change impact that could result from increased numbers of high intensity rainfall events.	In hilly regions the existing collection system are laid along historic landslide zones with frequent failure and disruption. Systems affected by landslides are likely to increase as will

Sanitation System Infrastructure Asset	Reasons why the component is at high risk from climate change	High risk locations
	Increases in temperature can also expand pipeline cracks in existing system.	the frequency and severity of damage. Collection systems in Chitwan and Kathmandu districts will be at high risk.
Sewage Pumping Stations	Increased temperature may increase the sensitivity of existing equipment and eventually lead to damage. In addition, increased rainfall will increase the chance of sediment collecting and clogging pumps and causing overflows from pumping stations.	In terrain like Chitwan and Kathmandu districts, where there is a need for lifting and gravity systems, pumping stations will be especially prone to impacts.
Septic Tanks/Pit Latrines	Increases in temperature may increase disease vectors. Increased incidence of high rainfall events may lead to overflows from septic tanks through the streets and pollution of groundwater and nearby streams. Frequent overflows from septic tanks causes public health and hygiene issues.	Relevant in all districts where septic tanks/pit latrines are constructed using improper design & construction techniques in densely populated communities.
Sewage Treatment Plant (STP)	Climate induced strain on STP such as increase in temperature can affect the biological treatment process and also enhance the corrosion within the STP and pipe systems. Increased incidence of high rainfall events may also lead to excess sediment deposits and system breach.	Relevant in flat and hilly terrain found in Chitwan and Kathmandu districts.

3.6 Department of Local Infrastructure Development and Agricultural Roads

A summary of the high risk projects identified for the roads and bridges sector (local roads) is provided in Table 3-6.

Table 3-6 High risk projects identified for the roads and bridges sector (local road network)

Districts	Assets	Description of Assets	Risk/vulnerability
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.	The road section is highly vulnerable to increasing intensity and frequency of extreme rainfall events leading to more landslides which may wash away the road.
Kathmandu	Kageswori Chakrapth (Ring Road)	The construction works of the road started in June 2011 and completed in 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.	The bridge is highly vulnerable to increasing intensity and frequency of extreme rainfall causing damage to bio-engineering works and slope failure.
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, construction and monitoring.	The bridge has been shown to be very highly vulnerable to bridge collapse from increased scouring. It is also highly vulnerable to increasing intensity and frequency of extreme rainfall events causing damage to bank protection works.

Districts	Assets	Description of Assets	Risk/vulnerability
	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.	The road is very highly vulnerable to increasing intensity and frequency of extreme rainfall events causing road damage and obstructing vehicle and pedestrian traffic.
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.	Increasing frequency and intensity of rains mean that such incidents will occur more often.
	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 landslides 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.	Increasing intensity and frequency of extreme rainfall events will lead to road damage, slope failure and toe wall collapse.

Districts	Assets	Description of Assets	Risk/vulnerability
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. Indian Government is the main financer and DDC/DoLIDAR is the implementing agency of the bridge.	The bridge is very highly vulnerable because the vertical clearance design is not sufficient, and increased scour depth will likely lead to foundation and bank protection works failure. In addition it is highly vulnerable to the river overtopping and damaging the approach roads.
	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.	The protection works are very highly vulnerable to increased scour and impact causing wall failure because the foundation depth is not sufficient.
Banke, Accham and Panchthar	Assets assessed in Banke, Accham and Panchthar districts were found to have only medium vulnerability to climate change and are therefore not considered high risk		