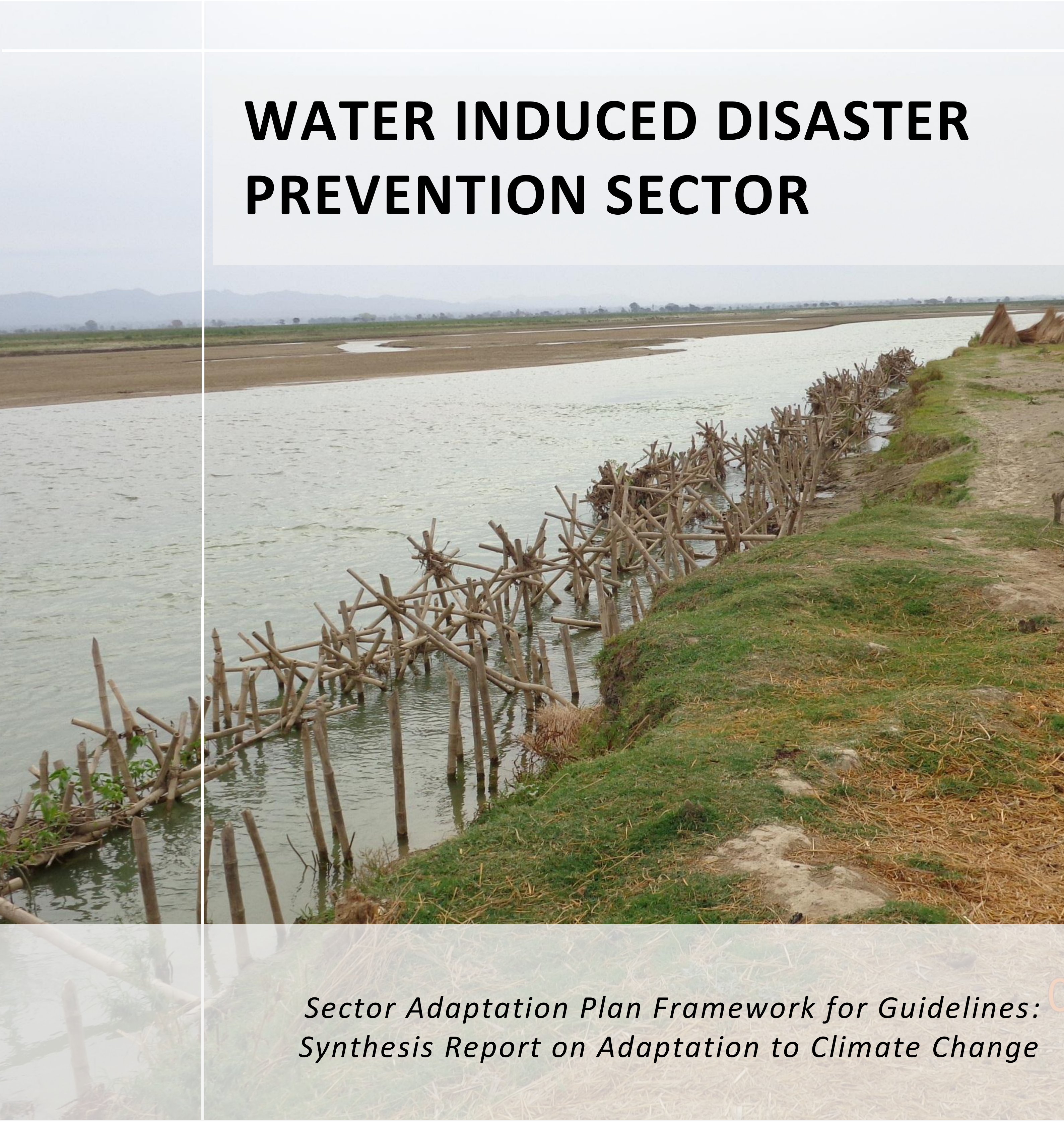
TA 7984-NEP: MAINSTREAMING CLIMATE CHANGE RISK MANAGEMENT IN DEVELOPMENT

1 Main Consultancy Package (44768-012)

WATER INDUCED DISASTER PREVENTION 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

The Nepal Himalayas comprise a geologically active zone where instability due to tectonic activity and ongoing erosion is everywhere apparent. The impacts of these Water Induced Disasters (WIDs), in terms of lives lost and livelihoods disrupted, tends to fall most heavily on the poor in Nepal. Climate change threatens to increase both the frequency and intensity of extreme weather events. The result in the decades to come may be an increase in the burden of weather-related disasters: events that can threaten the sustainability of development processes and undermine progress toward poverty reduction.

The Department of Water Induced Disaster Prevention (DWIDP) is responsible for all protection works to avoid or mitigate disasters such as inundation caused by large floods and landslides. In view of the direct relationship between Climate Change and WIDs the activities of DWIDP are very sensitive to changing climate. The Department must promote programs to increase awareness in climate change issues, improve access to credible, accurate and relevant information and expand its resources to implement response measures. Mainstreaming climate change risk management in the activities of DWIDP is therefore imperative for the sustainability of its already implemented and planned infrastructural assets.

The Director General assisted by three deputies heads the department, which has 9 sections, 7 Division offices and 5 Sub-division offices spatially distributed over the country and field offices of Peoples Embankment Programmes (PEP).

One of the major tasks of DWIDP is to plan, design and implement measures to mitigate or avoid impacts of WIDs such as landslides or flooding. Major assets of the Department include the river training works along the Koshi-, Bagmati-, East Rapti-, West Rapti-, Bakra-, Mahakali-, Lakhandei-, Ratu-, Lal Bakaiya- and Kamala Rivers.

Baseline studies were carried out in 5 Districts representing different physiographic. The main purpose was to get a better understanding of their present performance and their expected performance in future when impacts of Climate Change are more evident. An essential aspect of such studies also was to get better ideas as to how the various protection works could be made more resilient to climate change impacts.

The activities of DWIDP at the District level mainly fall under the categories “Water Induced Disaster Mitigation Works” and “Disaster Prevention Program”. These categories include emergency works, control works and long-term mitigation works identified in the Master Plans to cope with floods, landslides and debris flows.

The Disaster Prevention Program comprises:

- Disaster Prevention Program based on specific studies and
- People's Embankment Program (PEP)

The activities of DWIDP at the District level mainly fall under the categories “Water Induced Disaster Mitigation Works” and “Disaster Prevention Program”. These categories include emergency works, control works and long-term mitigation works identified in the Master Plans to cope with floods, landslides and debris flows.

The People’s Embankment Program is limited to the implementation of river training works in the Terai region. The protection works are aimed at the reduction of flood and inundation problems in low lying areas, the reclamation of land in the flood plain, the generation of employment, and the protection of lives and properties.

Every year DWIDP through its division, sub-divisions and field offices implement protection works at several locations in the districts. These may be extensions/additions to previous works or new ones. Apart from the major protection works there are many small protection works spread throughout the districts and usually consisting of smaller gabion works. For the baseline survey protection works were selected based on one of the following criteria:

- Protection works of National strategic importance

- Protection works of District strategic importance
- Protection works that has been impacted by past extreme events
- Protection works located in the areas prone to past extreme events
- Protection works of importance to women (because it e.g. reduces workloads, increases mobility, or supports women's livelihoods)
- Protection works of importance to poor or marginalized groups (e.g. Dalit, Ethnic groups)

Vulnerability assessments were made for prioritized assets of DWIDP in the pilot districts. Main assets are the structures to protect roads, bridges, irrigation systems, croplands, settlements, schools etc. from water-induced disasters. Most of these assets are located along riverbanks or floodplains. Others are located on unstable slopes. All these structures have a very high exposure to the climate change threats. Apart from that the components of these control or protection structures are highly sensitive to increased rainfall intensities and/or resulting floods. Thus, the impact of climate change is very high for most of DWIDP's assets. The present adaptive capacity of DWIDP to cope with the climate threats is considered medium in view of budget constraints and limited technical staff for design and construction supervision. Vulnerability of the river training works and other protection works at selected sites is high to very high under the present rainfall and flood conditions.

Based on the vulnerability assessment and further discussions with concerned department staff, a number of adaptation measures have been identified for the assets of DWIDP. The measures aim to reduce climate risk to an acceptable level and to also take advantage of any positive opportunities that may arise.

Climate change is one of the greatest challenges of our times. In the (not so distant) future, it will affect both the frequency and severity of WIDs if no adaptive measures are taken. Although in part driven by the necessity to take adaptive measures this situation also opens opportunities for the improvement of DWIDP's assets through:

- Strengthening of critical assets;
- Enhancement of design and construction practices;
- Reform of existing policies and guidelines; and
- Planning of Emergency Management Systems.

In view of the strong climate change impacts on WIDs it seems unavoidable to re-evaluate the existing practices, activities, and policies within DWIDP. The following are major conclusions on the present conditions.

- Although the government has given a mandate to DWIDP to deal with WIDs, the department is working with very limited manpower and has only 7 Division and 5 Sub-division Offices to cover the 75 Districts of the country. The present institutional capacity of DWIDP is clearly not sufficient to cope with WIDs.
- There is no guideline for prioritizing the protection works requested to the Division Offices by the different communities. Also, there are no proper guidelines and norms for the design and construction of these protection works. In practise the available budget is more or less evenly spread over the numerous requests. This results in a less than optimum use of the budget.
- In part because of the lower costs, gabion boxes filled with stones are about the only units being used in river training works and landslide mitigation works, although other more expensive options might have been more effective. Often there appears a shortage of gabion wire, supposed to be supplied by DWIDP for the control works.

- The budget constraints for the plan preparation of river training works in many cases seriously limit the quality and the level of detail of such plans. In many cases there appears insufficient budget to implement the works proposed in the Master Plans.

- Glacial lake outburst floods are one of the WIDs that endanger the country but up till now all activities related to GLOFs are dealt with by other institutions.

- Efficient implementation of preparedness activities has often been hampered by the lack of coordination between and within government and non-government organisations. This lack of coordination has in some cases led to a duplication of work by different organizations including DDCs and VDCs.

- Disaster management often includes learning by doing. To make such practice effective there should be a feedback mechanism. The Division Offices neither have such mechanism nor do they have any record keeping in their archives. There is no practice of monitoring, evaluation, and maintenance of assets.

- The present Monitoring Section in DWIDP only keeps track of the budget spending and the progress of works. It seems that much more attention should be paid to monitoring and evaluation of all protection structure.

- Hazard maps of the most susceptible areas have not yet been prepared for all categories of natural disasters such as floods, landslides, and earthquakes. In the absence of such maps, plans and programmes to mitigate natural hazards cannot be effectively prepared and implemented. As a result, more lives and property are being lost every year than could have been avoided.

- During design and implementation of river training works there is no practice of an integrated basin approach. Protection works are carried out without considering impacts on other areas or impacts from other developments.

- There is no set of consistent guidelines available at DWIDP for river training works. What is available are copies from textbooks and other institutions abroad, most of which is rather old and prepared at the Department of Irrigation prior to the establishment of DWIDP.

- Review of structures in the field revealed many shortcomings, which are related to improper design. In part this may be caused by budget constraints.

- Impacts of WIDs can be largely mitigated through community mobilization. It is a common belief in the communities that structural measures are the only effective means of protection against the impacts of disasters. The role of the community and the importance of non-structural measures are often very much under-estimated.

The study recommend following policy and institutional reforms to enhance the activities of DWIDP:

- It is recommended to promote the establishment of community groups that are prone to WIDs at various levels to more actively involve these stakeholders in the planning and type of protection measures.

- It is recommended to shift the focus of protection works somewhat more to the prevention of landslides and debris flows in the upper catchments in order to reduce their negative impact on downstream river training works.

- It is recommended to promote the organisation of communities that are prone to WIDs at different government levels in order to achieve a more active involvement of these communities in the planning and type of protection measures.

- It is strongly recommended to set up a Study and Design Unit in DWIDP with permanent senior and junior staff to strengthen DWIDP’s capability and knowledge base with respect to Disaster Mapping, Master Plan preparation, Design of Protection Works, and mainstreaming of climate change impacts on design and construction of protection works.

- It is recommended to include all activities related to GLOFs in DWIDP to concentrate all expertise related to WIDs in one pool of experts.
- It is recommended to give DWIDP the authority to approve Master Plans for river training works and landslide prevention works in order to get budgets approved for their implementation.
- It is recommended to enhance the scope of the present Monitoring section at DWIDP to also include Maintenance and Evaluation of protection works in this section enhanced by a GIS-based Management Information System.

ACRONYMS

ADB	Asian Development Bank
AP	Adaptation Planning
CC	Climate Change
cm	Centimeter
CCA	Climate Change Adaptation
^0C	Centigrade
DDC	District Development Committee
DWIDP	Department of Water Induced Disaster Prevention
EIA	Environmental Impact Assessment
FEWS	Flood Early Warning System
GLOF	Glacial Lake Outburst Flood
GON	Government of Nepal
km	Kilometer
LDOF	Landslide Dam Outburst Flood
m	Meter
M&E	Monitoring & Evaluation
MoSTE	Ministry of Science, Technology and Environment
NAPA	National Adaptation Programme of Action to Climate Change
NGO	Non Government Organisation
NPR	Nepali Rupees
O&M	Operation & Maintenance
PEP	Peoples Embankment Program
RCC	Reinforced Cement Concrete
TA	Technical Assistance
VA	Vulnerability assessment
VDC	Village District Committee
WID	Water Induced Disaster
%	Percentage

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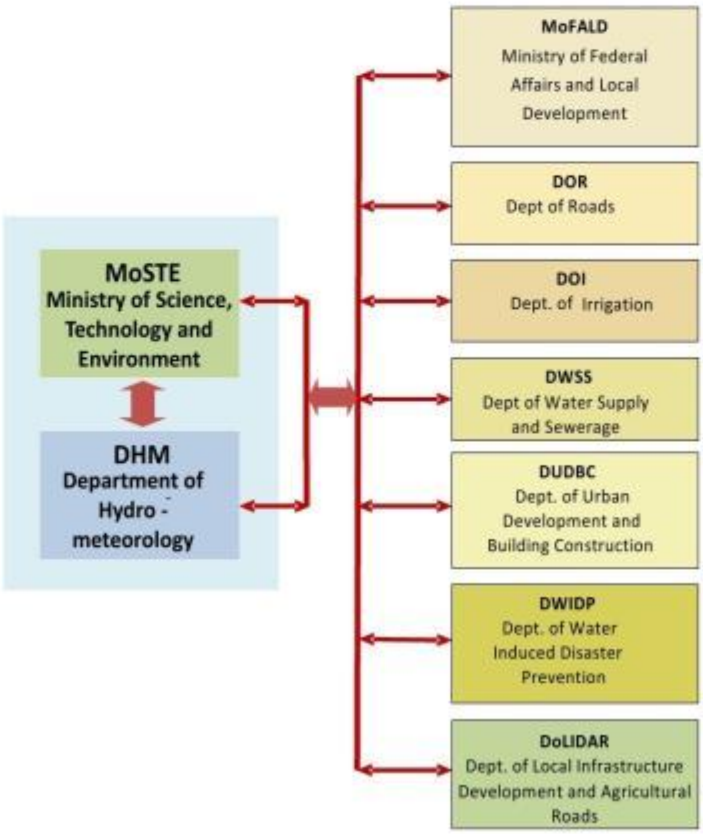
1 INTRODUCTION

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.

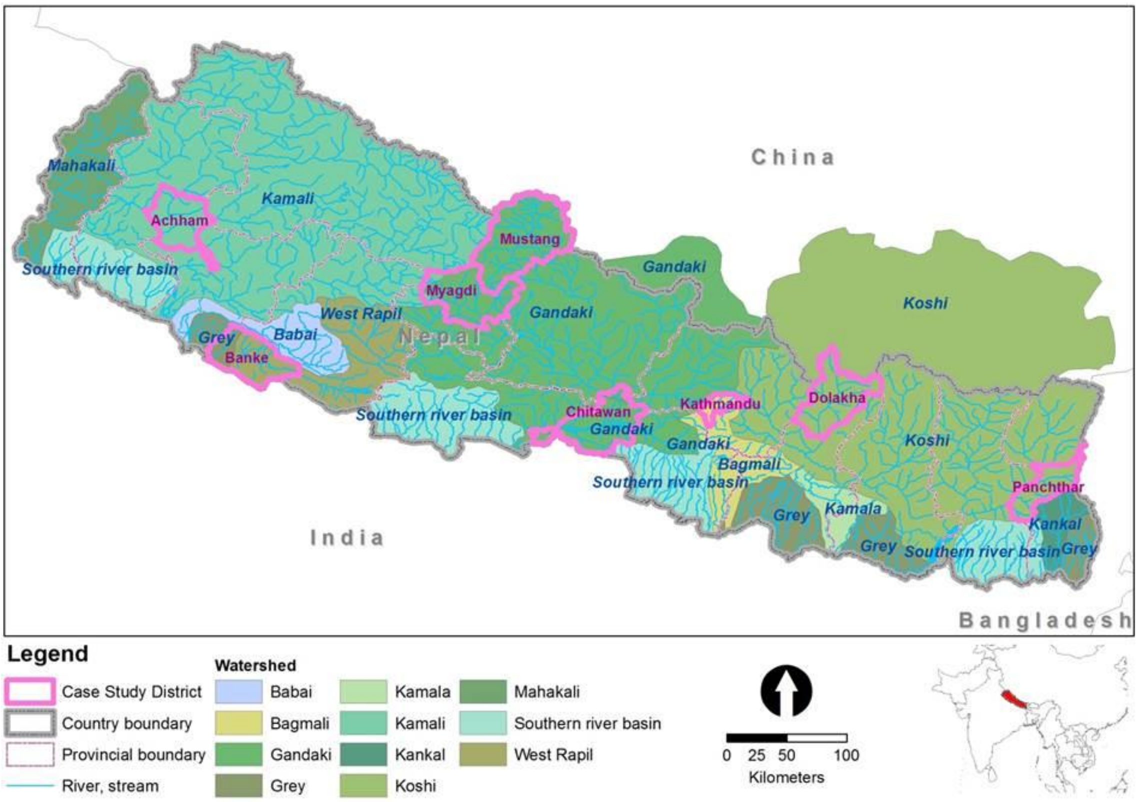


Figure 2 Target districts for developing an approach to infrastructure vulnerability assessment and adaptation planning

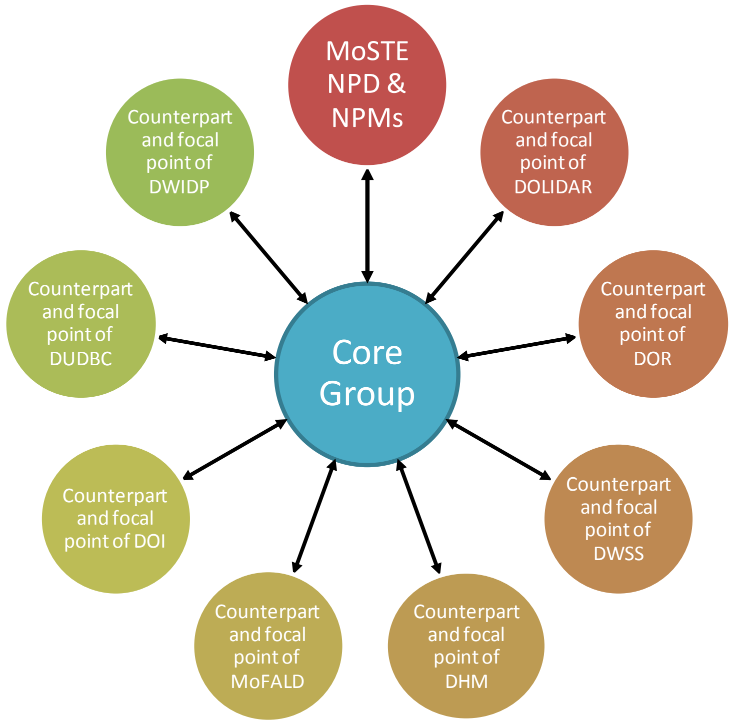


Figure 3 Infrastructure sector department climate change core group

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 Water Induced Disaster Prevention Sector Synthesis Report was prepared with Department of Water Induced Disasters Prevention (DWIDP) 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 Water Induced Disasters Prevention sector experts presented and discussed the synthesis conclusions and reform priorities. The government staff closely involved in the Water Induced Disasters Prevention sector consultations and in the preparation and commentary on this report and the various linked Water Induced Disasters Prevention sector district reports, climate change threat assessments and institutional analyses are listed in Annex 1.

2 WATER INDUCED DISASTERS IN NEPAL

The Nepal Himalayas comprise a geologically active zone where instability due to tectonic activity and ongoing erosion is everywhere apparent. These factors, combined with peculiar meteorological conditions where the rainfall and river flow vary tremendously in both time and space, make the landscape extremely vulnerable to floods, landslides, slope failures, debris flows and river bed migration (ICIMOD,2007). The impacts of these Water Induced Disasters (WIDs), in terms of lives lost and livelihoods disrupted, tends to fall most heavily on the poor in Nepal (NPC,2011).

Climate change threatens to increase both the frequency and intensity of extreme weather events. At the same time the increased population pressure causes deforestation, cultivation of marginal land, and encroachment of flood plain areas. These activities increase both the severity of water related disasters and the vulnerability of especially the marginalized people.

The result in the decades to come may be an increase in the burden of weather-related disasters: events that can threaten the sustainability of development processes and undermine progress toward poverty reduction.

The Department of Water Induced Disaster Prevention (DWIDP) is responsible for all protection works to avoid or mitigate disasters such as inundation caused by large floods and landslides. In view of the direct relationship between Climate Change and WIDs the activities of DWIDP are very sensitive to changing climate. The Department must promote programs to increase awareness in climate change issues, improve access to credible, accurate and relevant information and expand its resources to implement response measures. In addition, current engineering design practices should be modified since many are based on the magnitude of events that occur at specific return periods, based on the statistics of historic records. However, these statistics are no longer valid for future conditions in view of climate change. Mainstreaming climate change risk management in the activities of DWIDP is therefore imperative for the sustainability of its already implemented and planned infrastructural assets.

The present report summarizes the activities carried out so far within the scope of the project. These include the findings of surveys carried in a number of representative districts, vulnerability assessments (VA) of prioritized assets in these districts, adaptation planning (AP) of the same assets, and recommendations. The main focus of this report is on mainstreaming climate change risk management in DWIDP. This is the process of integrating the impacts of CC into the various activities of DWIDP with respect to policy, design and construction of protection measures, and related measures to reduce and avoid damage from climate related risks.

3 DEPARTMENT OF WATER INDUCED DISASTER PREVENTION (DWIDP)

3.1 INSTITUTIONAL SETUP

To mitigate or avoid Water Induced Disasters (WID) the Water Induced Disaster Prevention Technical Centre (DPTC) was established under the then Ministry of Water Resources in 1991. To further strengthen the capability of the government and the communities to cope with water induced disasters, a Disaster Mitigation Support Programme (DMSP) started in 1999.

To institutionalize the objectives and achievements of the DPTC, the Department of Water Induced Disaster Prevention (DWIDP) was established in 2000 under the Ministry of Irrigation. The Department is the focal agency for all water induced disaster mitigation works. The River Training Division of the Department of Irrigation was transferred in 2002 to DWIDP to deal WIDs by a single entity under the Ministry of Irrigation.

The Director General assisted by three deputies heads the department, which has 9 sections, 7 Division offices and 5 Sub-division offices spatially distributed over the country and field offices of Peoples Embankment Programmes (PEP). Figure 4 and Figure 5 show the organogram and the districts covered by Division and Sub-division offices, respectively. The total staffs of DWIDP include 231 persons.

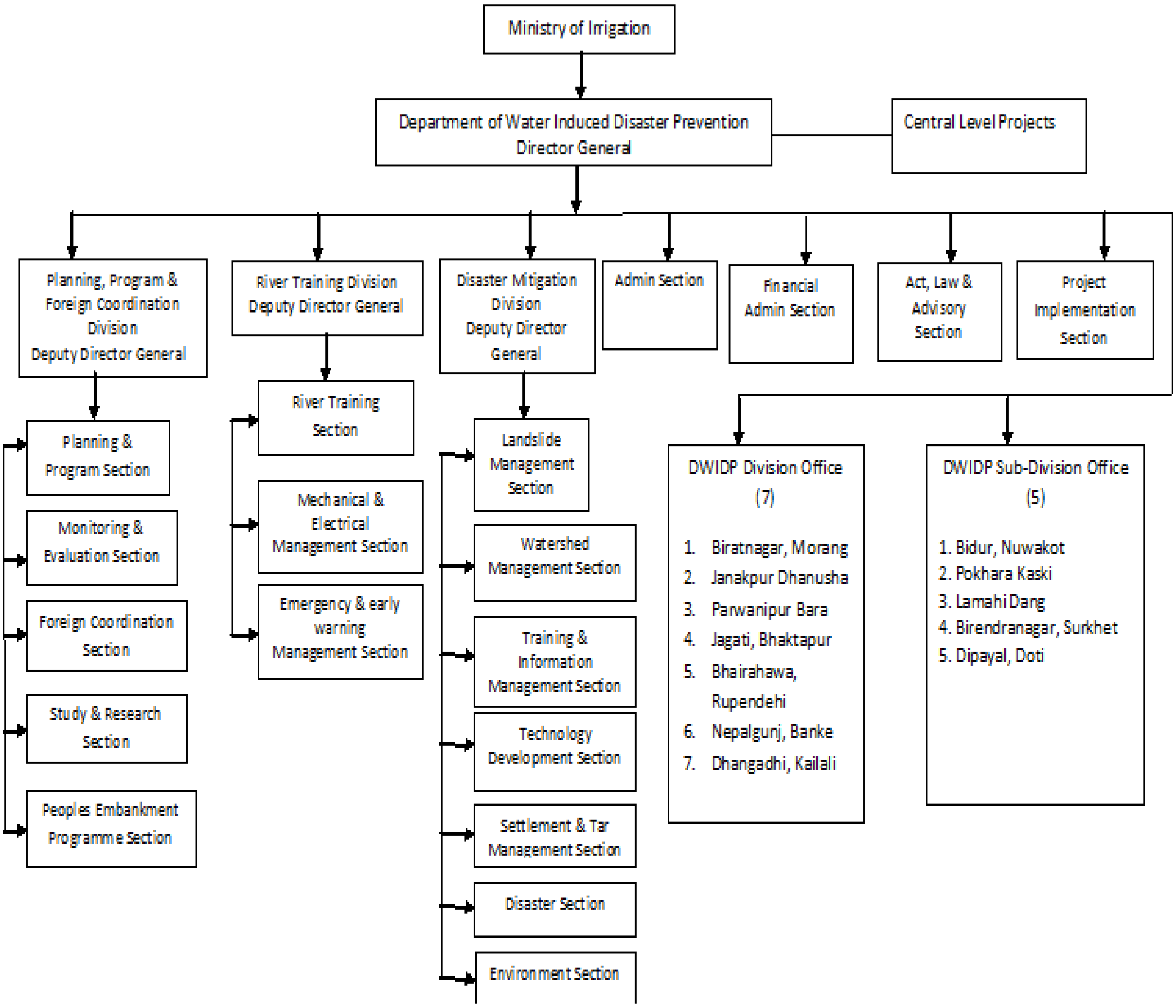


Figure 4 Organizational structure of DWIDP

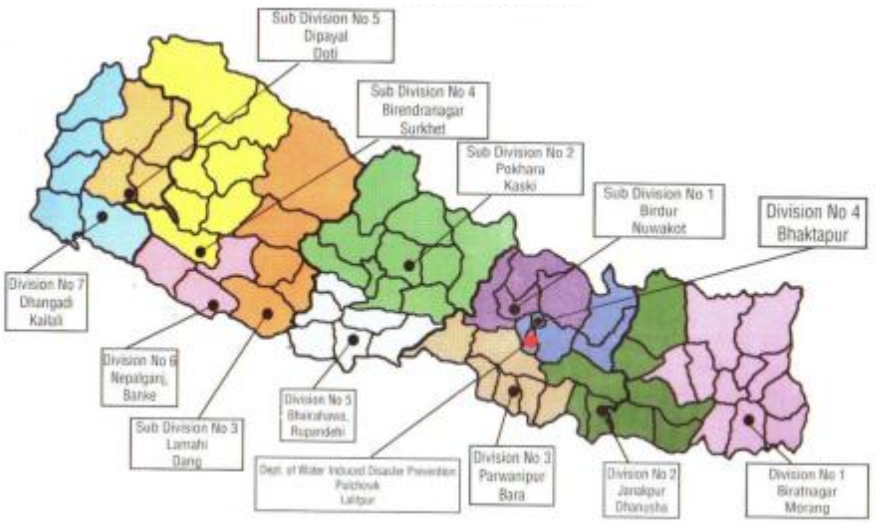


Figure 5 Division- and Sub-Division offices of DWIDP

3.2 TASKS

One of the major tasks of DWIDP is to plan, design and implement measures to mitigate or avoid impacts of WIDs such as landslides or flooding. Major assets of the Department include the river training works along the Koshi-, Bagmati-, East Rapti-, West Rapti-, Bakra-, Mahakali-, Lakhandei-, Ratu-, Lal Bakaiya- and Kamala Rivers.

DWIDP is supposed to prepare flood and landslide hazard maps for all river basins in Nepal. Up till now hazard maps for 11 basins are available. Although GIS and related modeling tools have been used to prepare these maps, they appear not consistent and they do not use similar standards. The Department is presently planning to prepare flood hazard maps for the lower reaches of 25 southern rivers of Nepal.

Based on the hazard maps Master Plans are to be prepared and following their approval the designs of river training- and other protection works are made and implemented. For the most vulnerable basins these Master Plans have already been prepared. DWIDP plans to implement these plans with the help of the People's Embankment Program (PEP) in the following areas:

- Kankai , Ratuwa, Mawa and Biring rivers in Jhapa district
- Rato river in Mahottari district
- Lakahandei and Jhim rivers in Sarlahi district
- Aurahi and Jallad Rivers in Dhanusa District
- Narayani river in Chitwan and Nawalparasi districts
- Danav Tinau in Rupendehi district
- West Rapti river in Dang and Banke districts
- Mohana, Dhoda and Mahakli rivers in Kanchanpur district
- East Rapti in Makawanpur and Chitwan district
- Karnali river in Bardiya and Kailai district

For engineering design of river training works some guidelines are developed in Nepal. The detailed designs in many cases include only some elements of the guidelines. Because of the lack of provision of code, most of these designs are inconsistent.

4 DISTRICT BASELINE STUDIES

4.1 SELECTED DISTRICTS

Baseline studies were carried out in 5 Districts representing different physiographic zones (see Figure 6). The main purpose was to get a better understanding of their present performance and their expected performance in future when impacts of CC are more evident. An essential aspect of also was to get better ideas as to how the various protection works (and specifically the protection works of more than local significance) could be made more resilient to climate change impacts.

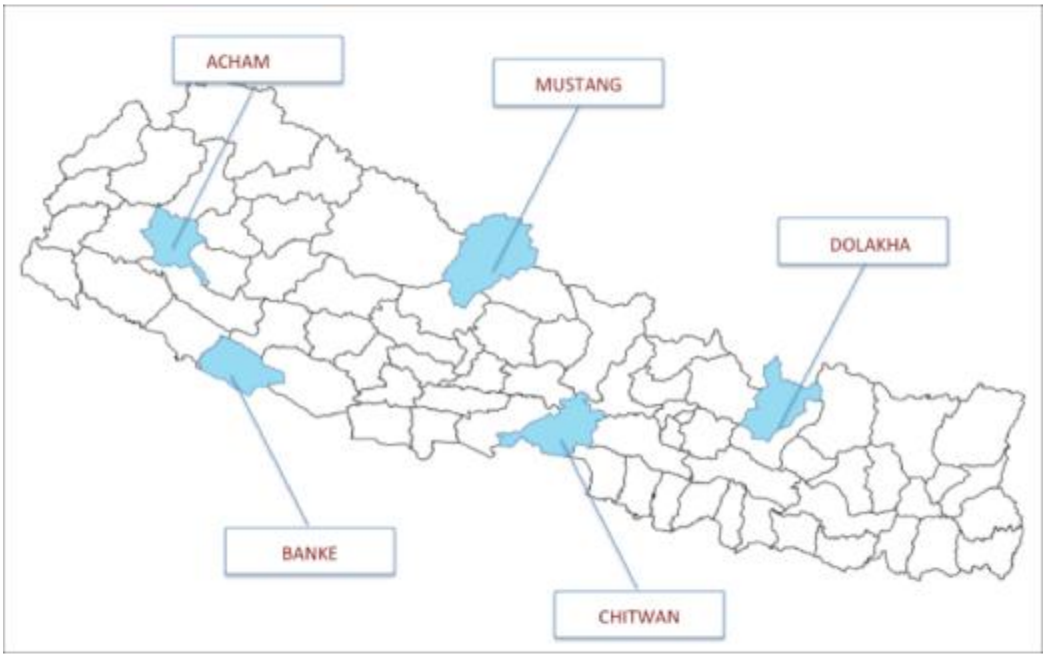


Figure 6 Selected Districts for Base Line Assessments

4.1.1 *Protection Works*

The activities of DWIDP at the District level mainly fall under the categories “Water Induced Disaster Mitigation Works” and “Disaster Prevention Program”. These categories include emergency works, control works and long-term mitigation works identified in the Master Plans to cope with floods, landslides and debris flows.

The Disaster Prevention Program comprises:

- Disaster Prevention Program based on specific studies and
- People's Embankment Program (PEP)

The Disaster Prevention Program is the continuation of ongoing projects related to disaster prevention works and the preparation of Master Plans for various rivers.

The People’s Embankment Program is limited to the implementation of river training works in the Terai region. The protection works are aimed at the reduction of flood and inundation problems in low lying areas, the reclamation of land in the flood plain, the generation of employment, and the protection of lives and properties.

4.1.2 *Selection of Protection Works for more detailed Reviews*

Every year DWIDP through its division, sub-divisions and field offices implement protection works at several locations in the districts. These may be extensions/additions to previous works or new ones. The annual budgets made available for the districts depend on the category to which they belong:

Table 1 Budget allocations for districts based on district type

Type of District	Annual budget (Million NPR)
Himalayan (Dolakha and Mustang)	2.5
Mountain (Achham)	4.5
Terai (Banke and Chitwan)	7.5 *

*The Terai districts get additional funding for the PEPs.

Apart from the major protection works there are many small protection works spread throughout the districts and usually consisting of smaller gabion works. For the baseline survey protection works were selected based on one of the following criteria:

- Protection works of National strategic importance;
- Protection works of District strategic importance;
- Protection works that has been impacted by past extreme events;
- Protection works located in the areas prone to past extreme events;
- Protection works of importance to women (because it e.g. reduces workloads, increases mobility, or supports women's livelihoods); and
- Protection works of importance to poor or marginalized groups (e.g. Dalit, Ethnic groups).

The list of selected sites and types of protection works in different districts is given in Tables 2-6.

Table 2 Selected sites and protection works in Chitwan District

Site	Chitwan District	Type of protection works	Remarks
1	Bank protection along left bank of Narayani River	Dyke, Spurs and Revetments	Structure vital for loss of cultivated land and houses of marginalised people, protection of community forest, recreational Parks and inundation
2	Bank protection along right bank of East Rapti River at Lothar and Kasara	Dyke, Spurs and Revetments	Strategic structure to protect heavely populated area and agriculture area. This area experienced a devastating flood and inundation in 1993.
3	Bank protection along left bank of Riu Khola River at Ayodhyapuri	Dyke, Spurs and Revetments	Strategic structure to protect heavely populated agricultural area. This area experienced devastating floods and inundations in 2000, 2001, 2010. The cloud burst during June 2013 eroded the bank of newly constructed dykes which were not protected by gabion lining

Table 3 Selected sites and protection works in Acham District

Site	Acham District	Type of protection works	Remarks
1	Bank protection along left bank of Budhiganga River in the vicinity of the airport	Dyke, and Revetments	Structure vital for protection of cultivated land and houses of marginalised people plus protection of airport
2	Protection at the confluence of Lungreligad and Budhiganga rivers near Baidyanath	Spurs and Revetments	Strategic structure to protect important temple area and agriculture land.

Site	Acham District	Type of protection works	Remarks
	temple.		
3	Bank protection along left bank of Budhiganga River at Sisnephat	Dyke, studs and Revetments	Strategic structure to protect and agriculture area and irrigation canal. This area experienced devastating inundation in June 2013 had washed away newly planted crops and damaged the protection works

Table 4 Selected sites and protection works in Dolakha District

Site	Dolakha District	Type of protection works	Remarks
1	Bank Protection along Charrange Khola	Toe Walls	Small slips along the right bank of the Charrange Khola are retreating very fast threatening the houses and roads uphill. The right bank is protected properly with surface and sub-surface drainage networks along with bio-engineering measures during the construction of the Lamasangu – Jiri road.
2	Milti Khola River Training	Revetments and spurs	DWIDP has been implementing the river training works for the last 6 years. Excessive bank erosion and cases of collapse of the structures due to the huge erosive power of the sediment laden river. The river carries huge debris during flood. Due to large amounts of deposited sediment the river changed into a braiding river with a widened bed during last 10 -15 years.
3	Bhirkot land slide and debris flow site	Landslide protection works and gully protection works	Vital structures to protect Narayani Higher Secondary School. The 2012 huge debris flow event caused extensive damage to the school building and other premises.

Table 5 Selected sites and protection works in Banke District

Site	Banke District	Type of protection works	Remarks
1	Bank Protection along Man Khola River at Naudast Ward No. 2	Spurs and Revetment	Vital structures to protect cultivated lands and houses
2	Bank Protection along Man Khola River at the confluence with Duduwa River at Phattepur Teteria, ward no. 5	Spurs and Revetment	Severe bank erosion threatened many houses
3	Bank Protection along Man Khola Rivers at Manpur Sohanpur – 9 Simalghari	Revetments	Collapse of Structures
4	Bank Protection along West Rapti River at Holiya - 9	Porcupine Works and other bio-engineering emergency works	Area is highly vulnerable to inundation and bank erosion, populated communities, example of use of light structures and bio-engineering measures to reclaim eroded banks, planned site for the

Site	Banke District	Type of protection works	Remarks
			construction of a high embankment
5	River Training along West Rapti River at Phattepur VDC, Dhalaiya	Spurs and Revetment	To protect the Irrigation Canal built in 2009 and the site where spurs collapsed that were constructed 9 years back
6	Emergency carried out to protect Bridge over West- Rapti River at Sindhaniyaghat	Strengthening of the guide bank	In August 2012 the excessive bank erosion triggered the outflanking of flow away from left guide bank
7	River Training along West Rapti River at Lalpur	High Levees, Spurs and Studs	Major asset of the district carried out under People's Embankment Programme (PEP)

Table 6 Selected sites and protection works in Mustang District

Site	Mustang District	Type of protection works	Remarks
1	Protection along Kaligandaki River at Kagbeni and Tiri	Spurs and Revetments	Strategic structure to protect important temple area and agriculture land.
2	Bank protection along right bank of Kali Gandaki River at Jomsom Airport region	Revetments	Structure vital for protection of airport and other infrastructures of the town
3	Bank protection Kali Gandaki and Tukuche Rivers at Tukuche	Dyke, Studs and Revetments	Strategic structure to protect an agriculture area and a settlement

4.2 DESCRIPTION OF TYPICAL HAZARDS AND PROTECTION WORKS

4.2.1 *Bank Protection Works along the West Rapti river at Holiya (Banke District)*

Many of DWIDP's activities are related to riverbank protection and the prevention of inundation. If no proper protection measures are taken the consequences may be high in terms of loss of lives, destruction of infrastructure, houses, agricultural lands, etc.

In the absence of proper river training works along the West Rapti river near Holiya village, river banks were regularly breached causing inundations of the adjacent farmlands. In 2013 the area was flooded twice. During this second flood in that year the low road embankment along the river was breached and an area of some 100 ha was flooded. This caused much damage, not only due to the flooding but also because of a layer of sand deposited on the crop area.

The protection works carried out by the Division office consisted mainly of light engineering systems with bioengineering works such as porcupines, bamboo stakes, and sand bags (Figure 7).

Figure 7 Bamboo porcupines and bioengineering works along right bank of West Rapti river near Holiya

However, these were by far not robust enough to withstand larger floods. In the absence of proper training works and embankments the annual flooding will continue and much valuable agricultural areas will be destroyed. This is illustrated in the satellite pictures in Figure 8 (source: Google Earth) taken in 2003 and 2007 where a significant shift occurred in the West Rapti river near the Holiya village.

Figure 8 Migration of West Rapti river channel between 2003 and 2007 (Banke district)

In Figure 9 the location of the right bank of the West Rapti is shown to have shifted over a distance of about 1 km in 7 years.

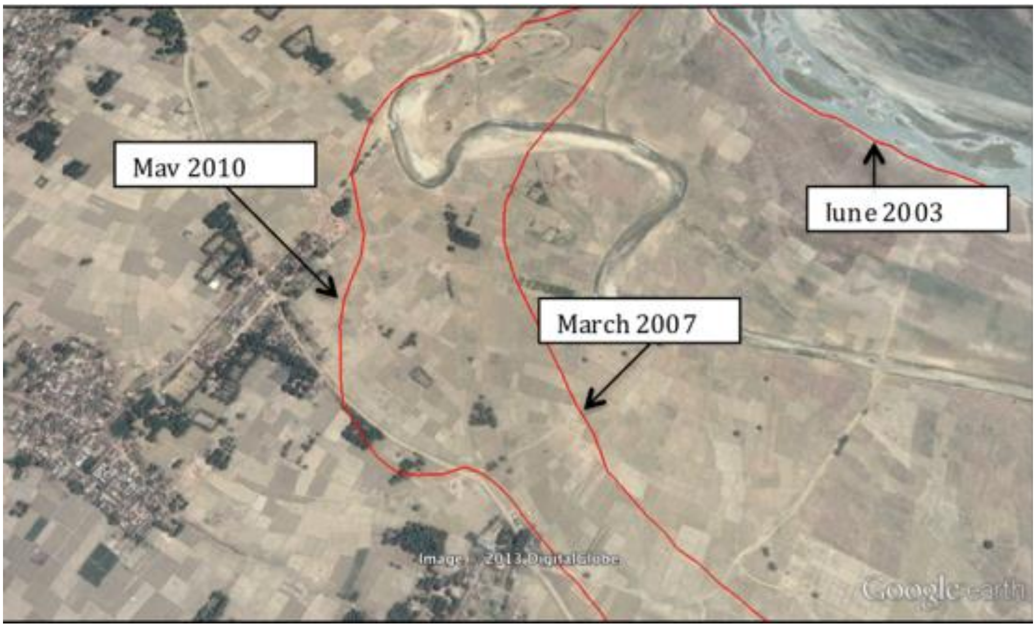


Figure 9 Migration of West Rapti river as indicated by satellite images (Source: Google Earth)

4.2.2 *River Training Works along Man Khola River at Naudasta (Banke District)*

A series of gabion spurs of 3 m height were constructed to divert the flow away from the outer bank of the lateral shifting Man Khola river at Naubasta Ward No 2. In a 12-year period the river shifted about 120 m towards the East forming a sharp bend (Figure 10). This was mainly caused by large sediment deposition just upstream by the tributary joining the Man Khola at the right bank. The resulting bank erosion affected some 200 households. Nine years ago the Division Office constructed a number of spurs (Figure 11). Most of these are damaged because the spur spacing and the lengths of the launching aprons appears inadequate while there is no return wall embedded in the structural system.

Due to budget constraints and the lack of long term planning, the efforts of the DWIDP division with the participation of the local people seem not adequate to control the damage. Some revetment was installed between the collapsed spurs to stop further bank erosion.

Based on the recent Master Plan the DWIDP will maintain the existing system and implement additional protection structures as proposed. For the sustainability of the countermeasures integration with a bio-engineering measures is necessary. In the Master Plan design of the spurs and revetments no consideration is given to the flow dynamics in the river bend. Also the use of geotextiles as filter media is not included in the design.

Figure 10 Man Khola river at Naubasta in 2003 and 2011

Figure 11 Bank protection works Man Khola river at Naudasta

4.2.3 *PEP embankment along the West Rapti river at Lalpur*

The embankment section at Lalpur was constructed along the outer left bank of the West Rapti River, where the river was threatened by bank erosion and inundation (Figure 12).

Figure 12 West Rapti river at Lalpur in 2003 and 2012

The project applied a combination of revetment and studs to protect the toe and divert the river flow away from the bank and to encourage sediment deposition. To protect the toe of the embankment at the upstream reach where the system of revetment and studs are not provided the project had implemented a long sloping spur. This stretch of the West Rapti River is wide (more than 150m), with a wide flood plain (more than 10 times the river width). The river, which has a sinuous shape and is locally braided has irregular point bars and lateral bars.

The physical components of river training works (levees, revetment and studs, see Figure 13) are of a permanent nature and designed to encourage sediment deposition to form a toe berm and avoid bank erosion. However, substantial erosion of the spur tip, outflanking of the spur key and excessive overtopping of the crest of the spur was observed. This resulted in the erosion of the bank immediately downstream of the spur. In addition the lack of vegetation growth and the sand mining activities in the riverbed are responsible for lateral migration of the thalweg of the river threatening the protection measures.

Figure 13 PEP river training works at Lalpur

4.2.4 *Bank protection works along left bank of Budhiganga River at Sisnephat*

This is the site of an irrigation area fed by the Budhiganga River (see Figure 14). The Department of Irrigation built a gabion revetment in 2009 along a 700m outer bend stretch of the river to protect the command area. During a flood in 2011 a significant length was damaged since these structures do not have a launching apron to resist the scouring of the riverbed. The Sub-Division office of DWIDP then rehabilitated this system by adding height to the structure since at many occasions the flood level overtopped the bank and inundated the cropped area. The system then functioned like an embankment (dyke) to protect the command area.

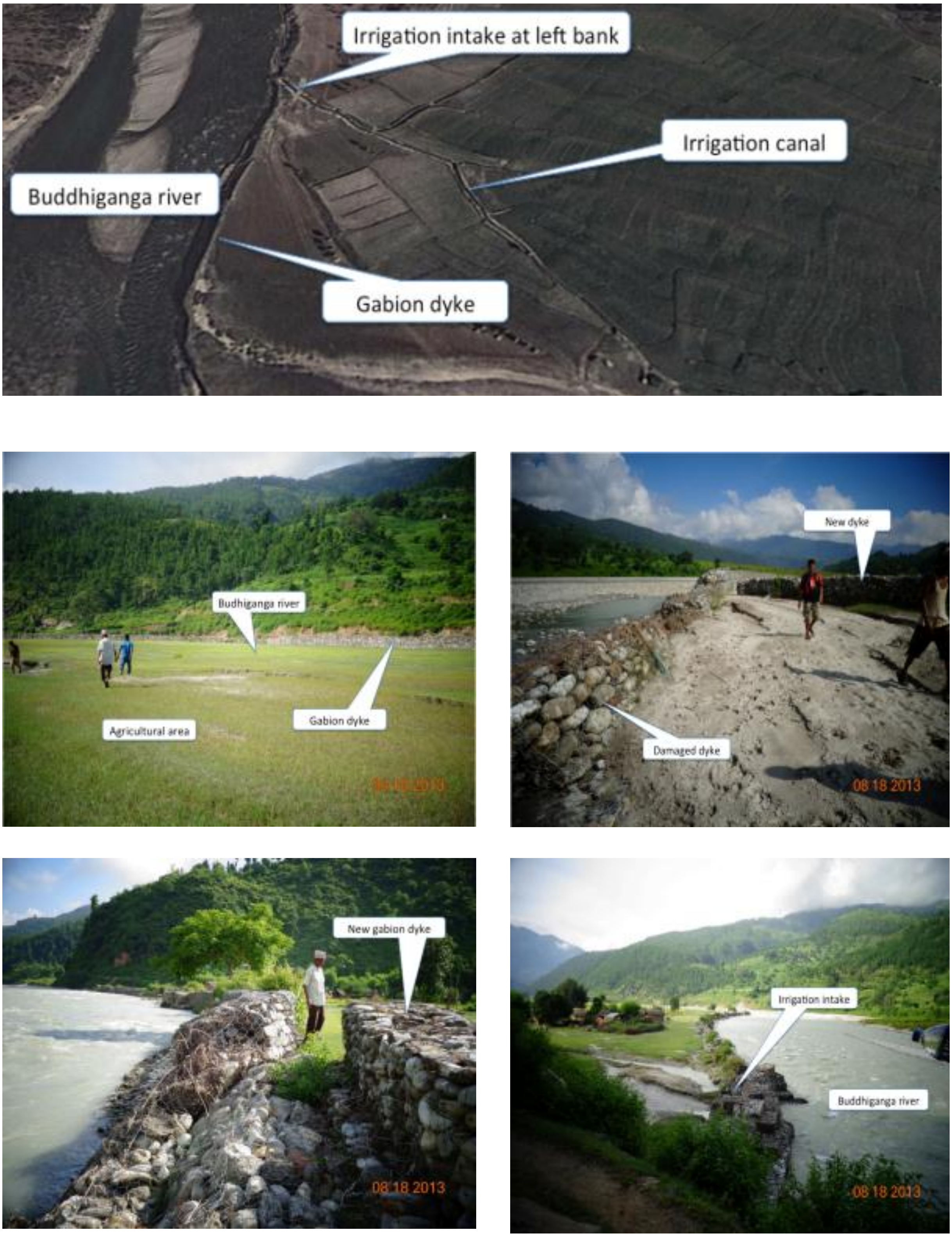


Figure 14 Bank protection works along Budhiganga river at Sisnephat

However the three meter long launching apron and the height of the dyke are not sufficient. During the flood of 2013 some portion of the system was again washed out and the area was inundated severely with huge deposits of sandy soil. The young crops planted a month before were either washed away or wilted because of this adverse condition and the area was left fallow for that year. Protection works along Kaligandaki River at Kagbeni and Tiri

This site, which is located at the confluence of Kag Khola River with Kaligandaki River, is an important destination for pilgrimage in Nepal. The Kagbeni settlement lies on the banks of Kag Khola. The

Kaligandaki and Kag Khola rivers constantly erode the banks threatening the collapse of settlements, Gumbas and temple.

The Sub-Division office of DWIDP implemented gabion revetments along the left bank of the Kag Khola to control the erosion. However, the design of the structures and the materials used are not resilient enough to counter the erosive power of Kag Khola, which is steep and carries coarse sediment. As a result those revetments are already in the verge of collapse. Currently the District Development Committee (DDC) has been implementing RCC revetments starting from the right bank of Kag Khola near the junction to upstream of the Kaligandaki river along the left bank to protect the settlements and Gumbas (see Figure 15).

Figure 15 Overview map Kali Gandaki and Kag Khola rivers

Also, DWIDP implemented revetment and spurs to protect valuable agriculture land along the left bank of Kali Gandaki River downstream of the confluence. However, the orientation, height and other structural elements of the spur are not properly designed and they are severely damaged. An additional length was put in place to strengthen the collapsed one. That portion is again not keyed and oriented in such a way that if flood level overtopped the crest, it directly hits the bank (Figure 16).

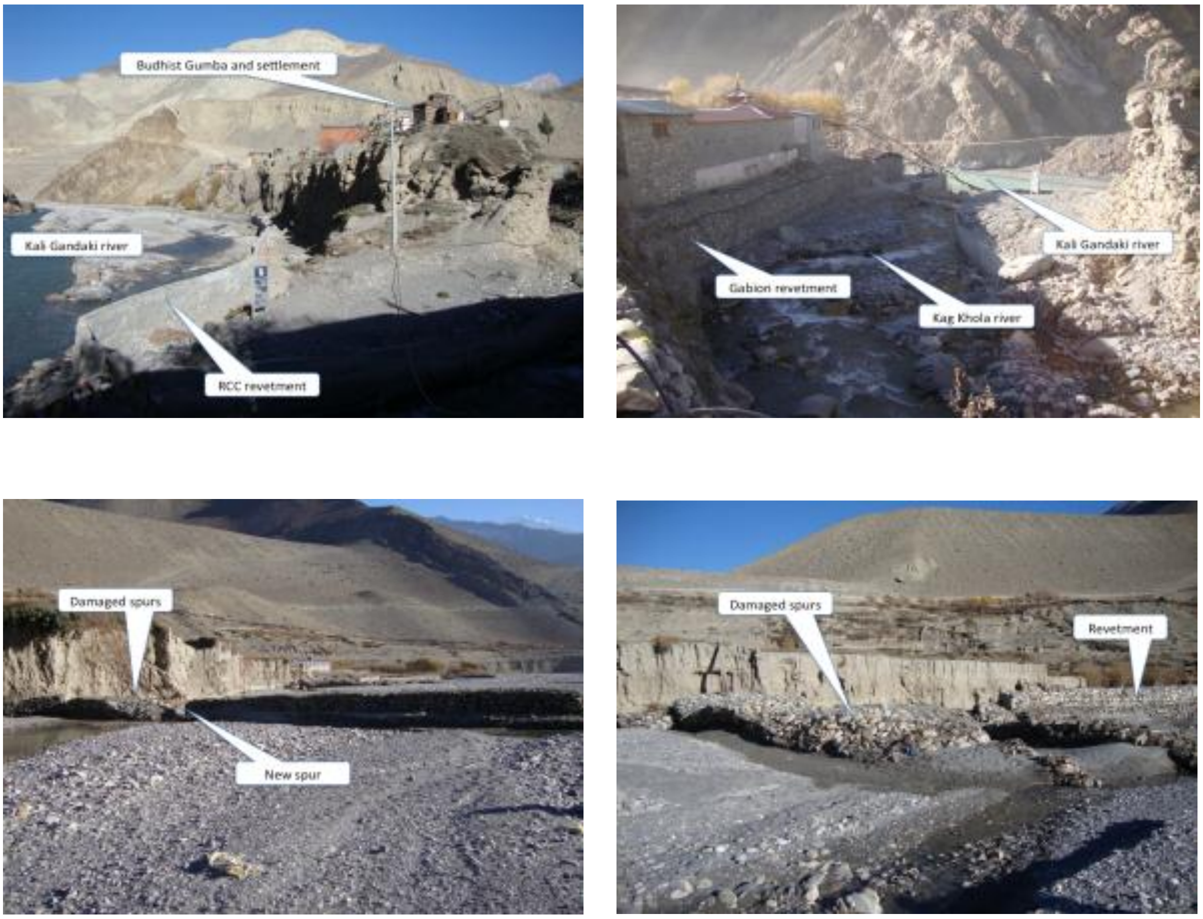


Figure 16 Bank protection works at the confluence of Kag Khola and Kali Gandaki rivers at Kagbeni (upper) and along the left bank of the Kaligandaki river d/s of the junction (lower photos)

5 CLIMATE CHANGE THREATS AND IMPACTS ON WIDS

5.1 CLIMATE THREAT PROFILE MODELLING

Studies done by the National & International Hydrological Modelling 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.

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. Additional parameters computed included river water levels, floods, erosion, sediment concentration, slope stability/land slide risk and irrigation demand.

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 occurrence and magnitude of the above climate threat parameters are presented in Climate threat profile documents.

5.2 POTENTIAL IMPACTS ON WIDS

For each of the five districts where case studies were undertaken for the DWIDP sector, district climate profiles were prepared from the model outputs. The principal climate change threat profiles as they affected the systems were evaluated under the following headings:

Changes and Shifts in Climate Indicators:

- Increase in design floods (1 in 100 year flood discharges);

Changes and Shift to Meteorological and Hydrological Events:

- Flash floods;
- Storms 1 in 10 year 10min intense rainfall and 1 in 50 return period 24hr rainfall events; and
- Landslides.

The significances of the above parameters to the protection works are:

- 1 in 100 year flood events are used to provide safe designs for the dykes, spurs and revetments;

- 1 in 50 year 24hr rainfall events are used for designing flood flows in spurs, revetment ,check dams and surface drainage works in ungauged catchments (Also indicates the likelihood of high sediment loads associated with flood events); and
- 1 in 10 year 10min rainfall events are used for identifying potential damaging storm events and assessing soil erosion and landslide risks from flash floods.

In summary it can be concluded that as a result of climate change there will be an increased likelihood of WIDs including: GLOFs, landslides, LDOFs, debris flow, riverbank erosion, and lateral river migration.

5.3 IMPACTS ON RIVER TRAINING WORKS

With regard to river training works it is concluded (see Section 7.1) that already in the present situation there are many shortcomings, which mainly result from improper designs and lack of funds. In order to withstand the future climate conditions these shortcomings should not only be corrected but the design standards should also be adjusted to account for:

- higher rainfall intensities
- higher design floods and design water levels
- higher sediment concentrations

6 VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING

6.1 VULNERABILITY ASSESSMENT

Vulnerability assessment (VA) is a tool to identify potential risks to assets (protection works/structures) for specific threats. It will provide the decision-makers with an early warning signal about the need to monitor potential changes. Thus, at an early stage threats are detected and measures can be taken to reduce negative impacts. VA also identifies gaps in existing information and the necessity to collect such information.

The current VA process followed for DWIDP assets is to better understand the status of existing protection measures and facilities under the prevailing conditions and to understand the most dominant factors that influence their vulnerability. This helps the decision-makers with options to evaluate and modify existing policies and to implement measures to improve the design of counter measures. Specifically, the VA is aimed to:

- Assess the vulnerability of existing protection measures to CC threats, and its impact on development options, human well-being and the environment;
- Identify the potential impacts of climate change on DWIDP's protection structures and assess their current adaptive capacity;
- Create a knowledge base of scientific data and information on extreme weather events and responses by the catchments.
- Evaluate the impacts on landslides, debris flows and river morphology;
- Develop the knowledge, policy options; and
- Identify gaps in data and research and recommend needs for further studies.

6.1.1 *Method used*

The VA method followed to assess the vulnerability of hydraulic structures is widely used and tested in several parts of the world. Figure 17 outlines the process.

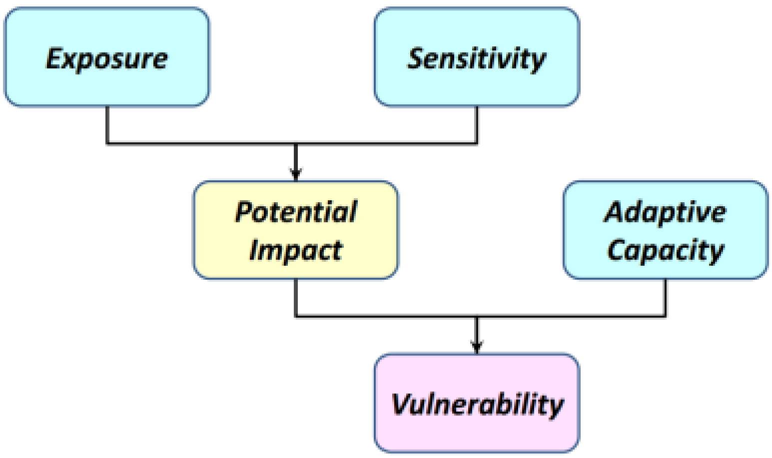


Figure 17 Flow chart of Vulnerability Assessment

EXPOSURE refers to the extent to which an asset comes into contact with a climate threat or the consequences of a climate threat. The exposure also takes in to account the critical aspects such as the location of asset, intensity, duration and frequency of the climate threat towards the asset and the magnitude of the event.

SENSITIVITY is the degree to which an asset is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., increases in flood water levels). It is the *extent to which* a system is affected by climate change. It takes into account the age of the structure, materials used in the construction and its quality, levels of maintenance, any design considerations that protects the asset from any extreme climatic events.

Impact: Once the exposure and sensitivity are determined, the severity of the impact is estimated using the guiding matrix as shown in Table 7.

Table 7 Matrix to determine impact of climate change

		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*

ADAPTIVE CAPACITY refers to the ability of a system to accommodate or cope with climate change threats with minimal disruption. This takes into account the range of available adaptation technologies and the funds that are available to meet such technologies, local skills and knowledge base, management responsiveness and relevant policies that make such adaptation to happen and the locally available materials for such adaptation.

***VULNERABILITY*:** Based on the impact and adaptive capacity, the vulnerability of the asset for the CC threat is estimated using the guiding matrix shown in

Table 8.

Table 8 Matrix to determine Vulnerability to climate change

		Impact				
Adaptive Capacity		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
	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

6.1.2 *Summary of results*

Vulnerability assessments were made for prioritized assets of DWIDP in the pilot districts. A brief overview of the results is given below.

Main assets are the structures to protect roads, bridges, irrigation systems, croplands, settlements, schools etc. from water-induced disasters. Most of these assets are located along riverbanks or floodplains. Others are located on unstable slopes. All these structures have a very high exposure to the climate change threats. Apart from that the components of these control or protection structures are highly sensitive to increased rainfall intensities and/or resulting floods. Thus, the impact of climate change is very high for most of DWIDP's assets.

The present adaptive capacity of DWIDP to cope with the climate threats is considered medium in view of budget constraints and limited technical staff for design and construction supervision. These aspects are discussed below in some detail.

DESIGN

There are no proper guidelines and norms for the design of the protection works. The gabion revetments and the spurs are designed using estimates adopted for average riverine condition. The designs hardly consider the river morphology i.e. the shape of the river channels and how they change over time in relation to erodibility of the bed and banks, vegetation, sediment transport and composition, etc. Estimates of e.g. scour depth, reduction in critical velocity, and increase in acting shear velocity are needed to design structures that can withstand the more extreme flood conditions. In particular, the installation of spurs is mostly done without considering the bend dynamics. As a result the spacing of spurs is either insufficient or the spurs are not properly oriented with respect to the thalweg. Insufficient length of the launching apron and lack of return wall for keying into the bank are other reasons for structure failures or improper functioning of the protection works. Furthermore, there is no practise of integration of bio-engineering measures with the physical structures to increase the sustainability of the structures.

OTHER ISSUES

Apart from the shortcoming in design the following issues appear to affect the vulnerability of the structural protection works:

- 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
- There is insufficient attention for interventions in the upper catchments to reduce erosion and sediment transport. Besides, more attention should be given to landslides control works in the upper catchments
- In the implementation of river training works there is no practise of an integrated basin approach
- There is no practice of monitoring and maintenance of protection works.
- Because of the difficulties in acquiring land the waterways of the river have been constricted much in most of the stretches where the PEP has intervened with the construction of levees.

Considering the design aspects and other issues discussed above it is concluded that the vulnerability of the river training works and other protection works is high to very high under the present rainfall and flood conditions. A summary of the scorings of DWIDP's assets based on the surveys in the different pilot districts is given in Table 9.

Table 9 Summary vulnerability assessments in the pilot districts

Threat	Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability Score
Increased rainfall Larger floods Higher sediment transport	Very High Very High High	Medium Medium Medium	Very High Very High High	Medium Medium Medium	Very High Very High High

6.2 ADAPTATION PLANNING

The vulnerability of DWIDP protection works to climate change can be lowered by reducing the sensitivity to climate and weather conditions or by increasing the adaptive capacity of the system under consideration. The main objective of adaptation is to develop a more resilient system by taking proactive steps to prepare for the impacts of projected climate.

Adaptation is a collaborative process. Stakeholders and the communities should work together to develop strategies for adaptation. Adaptation planning can be done in a series of steps, each of which is relatively simple to accomplish:

1. Increase the public awareness of climate change and its impacts for the community
2. Increase the community's technical capacity to prepare for climate change.
3. Incorporate climate change preparedness into policy decisions.
4. Increase the adaptive capacity of the community's systems (built, natural and human).
5. Strengthen the physical system
6. Strengthen community partnerships to reduce vulnerability.

The overall aim of the adaptation plan is to increase resilience in the short- and long-term by various measures.

6.2.1 *Adaptation Measures*

Based on the vulnerability assessment and further discussions with concerned department staff, a number of adaptation measures have been identified for the assets of DWIDP. The measures aim to reduce climate risk to an acceptable level and to also take advantage of any positive opportunities that may arise.

The adaptation measures are categorized in short- and long-term measures to address immediate requirements at a reasonable and available level of funds and human resources. Table 10 explains the significance of CC impacts on the overall protection system and on individual components. Relevant adaptation options and the justification of their priority are also explained in the Table.

Table 10 Priority listing of adaptation measures

Threats	Impacts	Significance			Adaptation options	Priority adaptation		
		Likelihood	Seriousness	Significance	Listing of the adaptation options in addressing each of the most significant impacts – focus on structural and bioengineering options	Feasibility	Effectiveness	Priority
SYSTEM • Increased rainfall intensity • Higher floods • Higher sediment loads	1. Erosion of embankment slopes	M	VH	VH	1. Bioengineering works (grass planting) on the embankment slopes	VH	H	VH
	2. Overtopping of the embankment				2. Increase of embankment height	L	H	M
	3. Toe erosion (embankment/ revetment)				3. Extension of revetment length or installation of bamboo porcupines or studs	M	H	H
	4. Damage to tip of spur				4. Extension of launching length	L	H	M
	5. Undermining of the key of the spur				5. Installation of return wall	M	VH	VH
	6. Excessive over topping of the spur crest				6. Add height and transform sloping spurs to level ones	M	VH	VH
EMBANKMENT • Intense rainfall • Flood levels	1. Erosion of embankment slopes	L	M	M	1. Bioengineering works (grass planting) on the embankment slopes	VH	H	VH
	2. Overtopping/breaching of embankment	L	VH	H	2. Increase in embankment height	L	H	M
	3. Toe erosion	M	H	H	3. Extension of revetment length or installation of bamboo porcupines or studs	M	H	H
REVETMENT • Floods • Higher sediment loads	1. Failure of launching apron because of increased scour	M	M	M	1. Extension of launching length or installation of bamboo porcupines or studs	M	H	H
	2. Failing of launching apron because of damage to gabion	L	M	M	2. installation of bamboo porcupines or studs	M	H	H
STUDS • Floods	1. Failure of Launching apron because of increased scour	M	M	M	1. Extension of launching length or installation of bamboo porcupines or studs	M	H	H
	2. Failing of launching apron because of damage to gabion	L	M	M	2. installation of bamboo porcupines or studs	H	H	H

SPUR • Floods • Higher sediment loads	1. Damage to tip 2. Undermining of the key 3. Excessive over topping of the spur crest	M L H	M H L	M M M	1. Extension of launching length 2. Installation of return wall 3. Add height and make sloping spur the levelled one	L M M	H VH VH	H VH VH

In Table 11 the adaptation measures for the short- and long term are mentioned.

Table 11 Adaptation measures for the short- and long-term

Short-Term Measures	Long-Term Measures
Increased O&M	Bioengineering works (e.g. grass planting) on the embankment slopes
Installation of bamboo porcupines	Integrated Watershed Management
Installation of a return wall	Adding height to spur and transfer sloping spur to level spur
Extension of the length of launching apron	Increase in embankment height

6.2.2 *Supporting adaptation measures*

To support the above adaptive measures, a number of supportive measures are required including:

- Development and/or refinement of guidelines on :
  - Design
  - Construction regulations
  - Operation & maintenance
  - Residuals management
  - Compliance inspections/ monitoring
  - Corrective Actions
  - Record keeping, inventory & reporting
- Regional planning, land zoning and land use control
- Watershed management
- Set_up of a Flood Early Warning System (FEWS)
- Preparation of Evacuation Plans
- Planning Emergency Relief
- Community based disaster management and crisis management
- Financial assistance & funding

6.2.3 *Learning from global good practices*

Based on global practices the following approaches seem relevant for informing the application of the adaptation measures described above to the specific conditions in Nepal.

Integrated Flood Management

Integrated Flood Management (IFM) is part of Integrated Water Resources Management (IWRM), which is defined as a process which promotes the coordinated development and management of water, land and related resources in a river basin, to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Thus, the objective in IFM is not only to reduce the losses from floods but also to maximize the efficient use of flood plains with the awareness of flood risk, particularly where land resources are limited.

Integrated Flood Management in particular looks at the river basin as an entity. This is important since measures taken upstream often also have an impact downstream. Sustainable development is based on the participation of users, planners and policymakers at all levels. The participatory approach should be open and transparent, should require the decentralization of decision-making, and should have the involvement of stakeholders in planning and implementation. Representatives of all the upstream and downstream stakeholders need to be involved.

Adaptive Flood Management

The climate will continue to change in the future. However, no climate change projection will ever be free from uncertainty. It is therefore essential to build a resilient society that can adapt to such a changing and uncertain climate in a sustainable way. Under such conditions the flood policies to address these uncertain risks has to be based on a robust but flexible approach. Adaptive flood management has been widely recognized as the approach to deal with uncertainties, wherein decisions are made as part of an ongoing science-based process. It involves planning, acting, monitoring and evaluating applied strategies, and incorporating new knowledge as it becomes available into management approaches.

Level of protection

Depending on the severity and frequency of flood damages protection measures can be taken. However, absolute protection from flooding is technically not feasible and economically not viable. Therefore, flood management has to provide strategies in case floods occur of a magnitude in excess of the design flood for which protection measures are taken. Such strategies are usually combinations of structural and non-structural measures.

Since floodplains are largely occupied by the weaker sections of the population resettlement programs and other floodplain policy measures must be assessed with respect to their overall effect on the livelihood opportunities of populations at risk. This is also relevant in urban areas where the poor are often living in shelters on flood prone areas near the rivers.

Community Based Disaster Management (CBDM)

The disaster management capacity of communities has recently become more important since it is realized that:

- climate change impacts are manifested locally;
- vulnerability and adaptive capacity are realized locally; and
- adaptation action is best observed at local levels.

Communities have limitations as to their response to disasters and assistance from the government sector is crucial. Therefor it is necessary to identify social strengths and weaknesses and understand how the community works in order to design interventions that will suit the needs of the community. Any intervention should take community governance into account, with a focus on building trust between partners in a joint venture.

The social factors that need to be identified may include the degree of awareness that the community members have for the necessity for disaster management; the response to disasters in the past; the state of community governance in terms of decision-making, communication, and resources (financial, environmental, and technical resources, social capital, and community organizations).

Coordination mechanisms

Coordination is needed at various levels. At the government level, including the central policy makers and the local governments, coordination is the key to mainstreaming adaptation in development policies. This coordination clearly needs to be strengthened.

Other coordination mechanisms are those between the government and those at risk of flooding with various forms of self-help and mutual help:

- public help or government efforts to manage disasters, which should be strengthened;
- self-help or efforts by individuals, businesses and other entities on their own; and
- mutual help or efforts by local communities, businesses, and organizations to help one another.

Stakeholder Participation

It is essential that a representative range of stakeholders is involved in the decision-making process of flood management, especially those who are directly affected by the floods and including women who are usually the primary providers of child and health care and commonly experience a disproportionate share of the burdens of recovering from floods.

Basin Strategy for Flood Control

It is important to recognize that there is no option but to live with floods that increase in frequency and severity due to climate change. To cope with this situation flood embankments would have to be raised. In urban and densely populated areas the height of embankments should be able to withstand design floods that are expected to occur at specific return periods. The choice of return period should be determined in relation to the risk of flooding and related damage. In the Netherlands for example the design floods for rivers entering the country have a return period as high as 1250 years.

In many less densely populated agricultural areas the flood protection measures will be at a much lower level due to limited financial resources. In these areas the flood protection will be more aimed at protection against more the frequent floods through levees to protect agricultural areas. In addition road levels could be raised to serve as a secondary levees and evacuation routes whereas built-up areas could be created for the location of houses. In these agricultural areas vulnerability should be reduced through disaster preparedness and flood emergency responses, including the set -up of a crisis management framework where communities strengthen their disaster management capacity supported by local governments and NGOs.

The acceptance of inundation in less densely populated upstream areas will to some extent relieve the situation more downstream because of the temporary storage of floodwater in the inundated area.

Spatial Planning

Implementation of appropriate measures at an early stage of development are much more efficient and cost effective in comparison with measures to catch up later on. The following spatial planning measures seem essential for climate change adaptation.

Risk zoning and development control

Zones where severe damages by floods or landslides risks are predicted should be used as agricultural field, recreational area or other non-residential functions. In these zones the construction of houses should be prohibited.

However, it is almost impossible to prohibit the construction of houses in flood prone areas where urbanization has already progressed. In such case the construction of houses could be permitted when utilizing reinforced concrete for the structures that can resists flood levels, and that have an upper floor to be used for evacuation at high flood levels. This is especially relevant in areas with landslide risks. Alternatively, it may be possibly to seek consensus between to designate risk zones where no houses should be built. In other areas, where housing is permitted, disaster education, evacuation drills, and early warning systems are needed in case of calamities.

In the upper steep catchment areas forests have an important function in the prevention of erosion and surface runoff. Deforestation in these areas would drastically increase the magnitude of floods and sediment transport. Any developments in these areas that affect the forested area should therefore be avoided.

Rainwater infiltration areas and flood control ponds

Wherever possible, especially in urban areas, new developments should be combined with measures to mitigate the negative impact of the developments. With respect to storm runoff there should be a focus on rainfall infiltration areas and flood retention ponds.

Green belts

To promote a better urban environment and at the same time to promote rainfall infiltration, green belts should be designated at an early stage of urbanization. In particular forests play a major role in the prevention of floods and the preservation of water resources. However, also agricultural areas and parks can play an important role in creating such green belts.

Legal Frameworks

In many cases legal frameworks and control systems have been established after devastating disasters. Although most people understand the purpose of these regulations in the aftermath of a disaster, those that are contradictory to their interest tend to be disregarded with the passage of time. Therefore, when establishing a new law, a clear level of restriction that has to be adhered to in practice needs to be prepared at the same time to ensure the effectiveness of the law and regulations.

A control system should describe the reason for the regulation and the consequences for not adhering to the regulation in a way that is understandable to all levels of the population. In case of a permit system, unclear criteria to obtain such permit often cause problems of governance. Permits, such as those related to climate change adaptation, need clear objective criteria to ensure the issuing of permits to everybody under the same conditions.

The central government passes the new legal frameworks to local governments. However, there often appears a clear bottleneck in their implementation. This has to do with lack of capable staff and the fact that the contents are not always clearly understood even if they are related to disaster management to save lives.

When central and local governments advertise a position for disaster management, capacity building of new staff will be essential. Discussions about impacts of climate change on flooding within the scope of Community Based Disaster Management (CBDM) will serve a good opportunity to both train officers and to raise awareness within the community. Concrete activities of CBDM include settlements watching, evacuation drills, preparation of leaflets, visiting and taking care of vulnerable people and distribution of foods when necessary.

6.2.4 *Adapting to take advantage of the benefits of climate changes*

Climate change is one of the greatest challenges of our times. In the (not so distant) future, it will affect both the frequency and severity of WIDs if no adaptive measures are taken. Although in part driven by the necessity to take adaptive measures this situation also opens opportunities for the improvement of DWIDP’s assets through:

- Strengthening of critical assets;
- Enhancement of design and construction practices;
- Reform of existing policies and guidelines; and
- Planning of Emergency Management Systems.

Table 12 outlines the climate change threats and corresponding adaptive measures by which those threats can be converted into opportunities in addition to building some adaptive capacity within the authorities, staff and the end-users in DWIDP system.

Table 12 Opportunities created by adaptive measures

CC Threat	*Adaptive Measure*	*Opportunities created*		
		Infrastructure	***Authorities***	***End-user***
Increased flood frequency and severity	Rehabilitation and upgrading of the system of River Training works	Better and more sustainable structures can be built.	Better training in O&M of the more robust systems	Benefits through the enhanced system: more security for women and marginalised people in the community.
Increased rainfall intensities High sediment transport	Watershed management and bio-engineering on embankment slopes	More sustainable land use and protection of river training structures More sustainable structures can be build	Improved soil and water conservation Better training in design, O&M of more robust systems	Less loss of fertile soil, improved eco-systems and biodiversity Removes flooding and bank erosions and ensures better living standards

6.2.5 *Negative Impacts of other autonomous developments*

Table 13 shows some negative impacts of a number of autonomous developments on WIDs and measures to mitigate these impacts.

Table 13 Negative impacts of a number of autonomous developments and mitigation measures

Autonomous developments	Impacts	Mitigation measures
Uncontrolled rapid urbanization	Increase in flood volumes and flood peaks	Better control of urban development and adherence and land-use planning
Deforestation	Increase in surface runoff, erosion, flood magnitude, and sediment transport	Establish community forest protection act and encourage/promote community awareness programs, educate the community to protect the environment.
Road construction	Triggering of landslides and erosion thereby increasing sediment discharges in the river.	Well planned construction with measures to control road drainage and erosion
Sand and gravel mining	Adverse effects on the river morphology and bank protection works	Introduce and implement operation guidelines and standards and enforce the law

6.2.6 *Monitoring and Evaluation*

Monitoring and Evaluation (M&E) is vital to make the adaptation process as effective and efficient as possible. M&E should take place at both the national- and the community level and at both levels the institutional and individual competences should be assessed.

The M&E process proposed aims at:

- National level: focus on the process of mainstreaming and up-scaling of the climate change adaptation and disaster risk reduction in the responsible institutes
- Community level: assessment of individual community level knowledge, attitudes and skills.

Table 14 specific indicators have been proposed for M&E. Due to resource constraints it may not be possible to include all these indicators. In that case a selection of indicators should be considered.

Table 14 Indicators for Monitoring and Evaluation

Adaptation measure	Monitoring focus	Frequency	Institutions involved	Organizational Indicators	Technical Indicators
Increased O&M	Institutes and community capabilities and participation in O&M Improved functioning of system	Annual	DWIDP and Users Committees	Definition of O&M roles Annual O&M funds allocated Availability of skills, training and knowledge	% of damage to assets Types of breakdown or issues Prevention of bank erosion and inundation
Installation of bamboo porcupine works	Functioning of structures	Annual	DWIDP and User Committees	Availability of skills, training and knowledge Annual funds allocated	% of damage to assets Prevention of bank erosion and inundation
Increase in height of embankment and bio-engineering slope protection	Success in growth of grasses and shrubs Settlement of embankment	Quarterly	DWIDP and User Committees	Availability of skills, training and knowledge for bio-engineering works	% of embankment slope area without erosion Free board during peak flows
Integrated watershed management	Sediment discharge of the river Vertical and horizontal stability of river stretches	Annual	DWIDP	Sediment monitoring Availability of skills, training and knowledge Annual O&M funds allocated	% of damage to assets Prevention of bank erosion and inundation

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Living in a 'Zero Victim' environment from disaster is a fundamental human right of the people of Nepal and it is the responsibility of the DWIDP to implement measures to prevent Water Induced Disasters.

In view of the strong climate change impacts on WIDs it seems unavoidable to re-evaluate the existing practices, activities, and policies within DWIDP. The following sections are focussed on a number of major conclusions on the present conditions.

7.1.1 *Institutional and Financial Capacity*

Although the government has given a mandate to DWIDP to deal with WIDs, the department is working with very limited manpower and has only 7 Division and 5 Sub-division Offices to cover the 75 Districts of the country. The present institutional capacity of DWIDP is clearly not sufficient to cope with WIDs.

The engineering staffs (main technical man power) posted for DoI and DWIDP are categorized under sub-group Irrigation within civil Engineering group of Engineering service by the government of Nepal during their appointment. This has resulted in a regular circulation of Engineering staff between the DoI and DWIDP. This hampers the establishment of a strong design and implementation unit in DWIDP staffed by experienced river morphologists, civil engineers, hydrologists, (hydro-) geologists, etc., specialized in design and construction of river training works and landslide protection works. As a consequence, there also is not a pool of junior professional staff that is gradually trained in these aspects.

There is no guideline for prioritizing the protection works requested to the Division Offices by the different communities. Also, there are no proper guidelines and norms for the design and construction of these protection works. In practise the available budget is more or less evenly spread over the numerous requests. This results in a less than optimum use of the budget.

The rules for construction contracts to be awarded by DWIDP allow the by-passing of time consuming tender procedures for contract values of less than 6 million NRs. Such contracts are often awarded to User Groups when they have the proven capabilities to undertake such works. This possibility was created to increase employment in the districts. In this respect one of the conditions is that no machinery and equipment may be used and that all work has to be done by manual labour. In practise this often results in lower efficiency and quality of the construction works.

In part because of the lower costs, gabion boxes filled with stones are about the only units being used in river training works and landslide mitigation works, although other more expensive options might have been more effective. Often there appears a shortage of gabion wire, supposed to be supplied by DWIDP for the control works.

The budget constraints for the plan preparation of river training works in many cases seriously limit the quality and the level of detail of such plans. In many cases there appears insufficient budget to implement the works proposed in the Master Plans.

Glacial lake outburst floods are one of the WIDs that endanger the country but up till now all activities related to GLOFs are dealt with by other institutions.

7.1.2 *Coordination among agencies*

Efficient implementation of preparedness activities has often been hampered by the lack of coordination between and within government and non-government organisations. This lack of coordination has in some cases led to a duplication of work by different organizations including DDCs and VDCs. In general the disaster preparedness is more focussed on ad hoc actions after the disaster occurred.

Water Resources User groups are already well established at different levels, including the national level. A similar organisation of communities that are prone to WIDs could result in a more active involvement of these communities in the planning and type of protection measures.

The Local Governance Act has some provision for a DDC to award licenses for sand and gravel mining. However such licensing appears not always justified in view of serious consequences for downstream river training works.

7.1.3 *Monitoring and Evaluation*

Disaster management often includes learning by doing. To make such practice effective there should be a feedback mechanism. The Division Offices neither have such mechanism nor do they have any record keeping in their archives. There is no practice of monitoring, evaluation, and maintenance of assets.

The present Monitoring Section in DWIDP only keeps track of the budget spending and the progress of works. It seems that much more attention should be paid to monitoring and evaluation of all protection structure.

7.1.4 *Hazard Mapping*

Hazard maps of the most susceptible areas have not yet been prepared for all categories of natural disasters such as floods, landslides, and earthquakes. In the absence of such maps, plans and programmes to mitigate natural hazards cannot be effectively prepared and implemented. As a result, more lives and property are being lost every year than could have been avoided.

A problem with available hazard maps is that different models and different standards were used as well as different degrees of detail. In many cases, flood hazard maps are prepared by delineating areas that were prone to flooding in the past.

With regard to real-time modeling, there are only few possibilities because of data transmission problems and the incapacity to use global meteorological data.

One of the tasks of DWIDP is to prepare Master Plans for river training works and landslide prevention works. However, there is confusion with respect to the authority that is reviewing and approving the draft Master Plans. As a result, the procedure to allocate budget to carry out the works proposed in the Master Plans is not clear.

7.1.5 *Integrated basin approach*

During design and implementation of river training works there is no practice of an integrated basin approach. Protection works are carried out without considering impacts on other areas or impacts from other developments. Furthermore, the effectiveness of control structures largely depends on the dynamics of river morphology but the links are not properly studied at the design stage. By far the largest part of DWIDP's budget for protection works is for river training works. It is recommended to reserve a larger portion of this budget to the prevention of landslides and debris flows in the upstream areas since the sustainability of river training works largely depend on sediment transported by the river.

The regulation with respect to Water Induced Disaster Planning has already been prepared but not yet approved, hampering the smooth functioning of the sector activities.

7.1.6 *Design Manuals and Guidelines*

There is no set of consistent guidelines available at DWIDP for river training works. What is available are copies from textbooks and other institutions abroad, most of which is rather old and prepared at the Department of Irrigation prior to the establishment of DWIDP.

7.1.7 *Quality and effectiveness of control structures observed in the field*

Review of structures in the field revealed many shortcomings (see Section 6.1.2), which are related to improper design. In part this may be caused by budget constraints.

7.1.8 *Non – Structural Measures*

Impacts of WIDs can be largely mitigated through community mobilization. It is a common belief in the communities that structural measures are the only effective means of protection against the impacts of disasters. The role of the community and the importance of non-structural measures are often very much under-estimated.

7.2 RECOMMENDATIONS

The Government of Nepal has attached high priority to the reduction and prevention of disasters as this is also linked to poverty reduction.

There is now a good policy basis for disaster risk management at the national level. There also are extensive legal regulations for construction, environmental protection, forest conservation and watershed management. The implementation of the Water Induced Disaster Management Policy in 2006 by DWIDP was another important step forward to disaster risk reduction.

In 2010, the government published the National Adaptation Programme of Action (NAPA) to Climate Change, which is a strategic tool to assess climate vulnerability, and systematically respond to climate change threats by developing appropriate adaptation measures. However, there are still large gaps in the legal framework and the institutional capacity to implement the proposed framework. Those policies therefore need to be backed with legislation and resources to ensure an effective and efficient implementation of Climate Change Adaptation (CCA) measures. Another option could be to extend the existing EIA legislation to include Climate Change Adaptation (CCA) criteria.

Similarly the legal mechanisms of community based forest and water management ‘user groups’ to encourage conservation, sustainable exploitation, and hazard reduction could be combined into community based CCA to strengthen the legal basis and coordination of such projects. Following are the policy and institutional related recommendations to enhance the activities of DWIDP.

POLICY

In view of the many problems related to the impacts of sand and gravel mining on downstream river training works the licencing for sand and gravel mining should in future be carried out in close coordination with DWIDP.

The condition that no machinery and equipment may be used when DWIDP contracts for protection works are awarded to User Groups should be amended when this condition results in lower quality of the works.

The regulation with respect to Water Induced Disaster Planning should be approved as soon as possible to guarantee a smooth functioning of the sector activities.

It is recommended to promote the establishment of community groups that are prone to WIDs at various levels to more actively involve these stakeholders in the planning and type of protection measures.

It is recommended to shift the focus of protection works somewhat more to the prevention of landslides and debris flows in the upper catchments in order to reduce their negative impact on downstream river training works.

INSTITUTIONAL

It is recommended to promote the organisation of communities that are prone to WIDs at different government levels in order to achieve a more active involvement of these communities in the planning and type of protection measures.

It is strongly recommended to set up a Study and Design Unit in DWIDP with permanent senior and junior staff to strengthen DWIDP’s capability and knowledge base with respect to Disaster Mapping, Master Plan preparation, Design of Protection Works, and mainstreaming of climate change impacts on design and construction of protection works. For this purpose, it is also recommended that the government of Nepal creates WID as new category of sub group under Civil engineering group of engineering services in Nepal for the recruitment of technical manpower.

It is recommended to include all activities related to GLOFs in DWIDP to concentrate all expertise related to WIDs in one pool of experts.

It is recommended to give DWIDP the authority to approve Master Plans for river training works and landslide prevention works in order to get budgets approved for their implementation.

It is recommended to enhance the scope of the present Monitoring section at DWIDP to also include Maintenance and Evaluation of protection works in this section enhanced by a GIS-based Management Information System.

Table 15 illustrates recommendations for reforms within the sector that would increase the feasibility and reliability of the adaptation measures to address the issues discussed in Section 7.1.

Table 15 Recommended reforms

Category	Proposed Reform
Policy	• Determine goals and priorities for climate change adaptation planning • Define clear roles and jurisdiction for the effective implementation of adaptation planning • Establish effective legislation and regulatory controls
Institutional	• Establish effective institutions adaptation planning related to CC threats • Develop responsibilities and authority for local authorities with respect to CC adaptation planning • Introduce appropriate management of protection works and emergency planning • Build CC adaptation planning capacity • Extend lower cost adaptation planning services through community participation
Social	• Orient CC threats and adaptation planning to the real needs of people, including the poor, women and children • Raise people's awareness of CC threats and adaptation planning problems and priorities • Mobilise community participation in water induced disaster management
Financial	• Establish practical and transparent cost accounting and budgeting system • Mobilise adequate capital investment resources • Raise sufficient revenues for recurring expenses – ensure adequate O&M • Improve the efficiency of the costs for AP
Technical	• Update Design Manuals and Guidelines • Establish Early Warning Systems • More closely monitor the river morphology • Prepare Hazard maps, Master Plans and prepare Spatial Plans

ANNEX I: LIST OF GOVERNMENT OFFICIALS PARTICIPATING IN TIFFIN TALK AND ROUND TABLE MEETINGS

S.N	Name	Position/Organization
1	Mr. Kamal Regmi	Director General, DWIDP
2	Mr. Rama Nanda Yadav	Director General, DWIDP
3	Mr. Narendra Bdr. Lama	Deputy Director general. DWIDP
4	Mr. Bidya Sagar Mallik	Deputy Director general. DWIDP
5	Mr. Noore Mohammad Khan	Deputy Director general. DWIDP
6	Mr. Nibas Chandra Shrestha	Senior Divisional Engineer, DWIDP
7	Mr. Arvind Kumar Gupta	Senior Divisional Engineer, DWIDP
8	Mr. Rabin Nath Babu Shrestha	Senior Divisional Engineer, DWIDP
9	Ms. Manju Sharma	Sociologist/DWIDP
10	Mr. Madan Mohan Jha	Senior Divisional Engineer, DWIDP
11	Mr. Ramu Mishra	Senior Divisional Engineer, DWIDP
12	Mr. Shanmukhesh C. Amatya	S.D Hydrologist, DWIDP
13	Mr. Chandra Bhusan Dutta	Senior Divisional Engineer, DWIDP
14	Mr. Kaushal Jha	Senior Divisional Engineer, DWIDP
15	Mr. Vijay Chandra Khatiwoda	Senior Divisional Engineer, DWIDP
16	Mr. Shree Kamal Dwivedi	Senior Divisional Engineer, DWIDP
17	Mr. Atma Ram Raj	Senior Divisional Engineer, DWIDP
18	Mr. Binod K. Chapagain	Senior Divisional Engineer, DWIDP
19	Mr. Pradeep K. Manandhar	Senior, Divisional Engineer, DWIDP
20	Mr. Rajeshwar Yadav	Senior, Divisional Engineer, DWIDP
21	Mr. Ashok Raj Gautam	Engineer, DWIDP
22	Mr. Kendra Bahadur Shrestha	Engineer, DWIDP
23	Mr. Keshab Prasad Sitaula	Engineer, DWIDP
24	Mr. Suresh Basnet	Engineer , DWIDP
25	Mr. Shyam Krishna Pande	Engineer, DWIDP
26	Mr. Upendra Regmi	Engineer, DWIDP
27	Mr. Ramesh Acharya	Engineer, DWIDP

S.N	Name	Position/Organization
28	Mr. Ishwor Mani Pokharel	Engineer, DWIDP
29	Mr. Ramesh Adhikari	Engineer, DWIDP
30	Mr. Kamal B. Dhakal	Engineer, DWIDP
31	Mr. Thal Bdr. Tamang	Engineer, DWIDP
32	Ms. Yojana Neupane	Engineer, Geologist, DWIDP
33	Mr. Padam Raj Devkota	Hydrologist Engineer, DWIDP
34	Mr. Bishwaraj Maraseni	Section Officer, DWIDP
35	Mr. Gopal Sharma	Engineer, DWIDP
36	Mr. Santosh Aryal	Sub- Engineer, DWIDP
37	Mr. Subash Baniya	Sub-Engineer, DWIDP
38	Mr. Yam Neupane	Engineer, DWIDP
39	Mr. Ram Dev	Engineer, DWIDP
40	Mr. Sundar P. Sharma	SCO, DWIDP
41	Mr. Himalaya P.	Engineer, DWIDP
42	Mr. Shib Nandan Pd. Shah	Engineer, DWIDP
43	Mr. Trailokya Man Shrestha	Engineer, DWIDP
44	Mr. Khil Nath Dahal	SDHG, DWIDP
45	Mr. Yadav Sigdel	Engineer, DWIDP

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