Study Team

Steering Committee
Rajendra Khanal, IUCN Nepal
Banshi Moktan, CETD Nepal
Arjun Niraula, APEC Nepal
Deepak Paudel, Lead Consultant

Fulltime Technical Team
Deepak Paudel, Watershed Management and Climate Change, Hydrologist
Prakash Karn, Environmental Economist
Dambar Singh Pujara, GIS
Sanjeeb Dhungal, Social Data Management
Sachin Shrestha, Social Data Management

Thematic Team
Dil Kumar Limbu, Biologist
V.N. Jha, Livestock Management
Sharmila Ranabhat, Gender & Social Inclusion

Management Logistic Team
Indira Kandel, Meteorologist
Rajendra Rimal, Field Coordinator
Kedar Neupane, Logistic Management & Field Coordinator
Keshab Rijal, Logistic Management & Field Coordinator
Balandu Hamal, Logistic Management & Field Coordinator
Ananda Shrestha, Logistic Management & Field Coordinator
Rajendra Mishra, Gauge Reader
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## Acronyms and Abbreviations

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<th>Description</th>
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<tbody>
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<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>amsl</td>
<td>Above Mean Sea Level</td>
</tr>
<tr>
<td>APEC</td>
<td>Association for Protection of Environment and Culture, Biratnagar</td>
</tr>
<tr>
<td>BISEP-ST</td>
<td>Bio-diversity Sector Program for Siwaliks and Terai</td>
</tr>
<tr>
<td>BS</td>
<td>Bikrum Sumbat</td>
</tr>
<tr>
<td>CARE Nepal</td>
<td>Cooperation for American Relief Everywhere</td>
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<tr>
<td>CBDPP</td>
<td>Community Based Disaster Preparedness Program</td>
</tr>
<tr>
<td>CBS</td>
<td>Central Bureau Statistics</td>
</tr>
<tr>
<td>CCA</td>
<td>Climate Change Adaptation</td>
</tr>
<tr>
<td>CETD</td>
<td>Centre for Environment and Tourism Development, Dharan</td>
</tr>
<tr>
<td>CFUCs</td>
<td>Community Forest Users Committee</td>
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<tr>
<td>DD</td>
<td>Drainage Density</td>
</tr>
<tr>
<td>DDC</td>
<td>District Development Committee</td>
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<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
</tr>
<tr>
<td>DFID</td>
<td>Department for International Development</td>
</tr>
<tr>
<td>DHM</td>
<td>Department of Hydrology and Meteorology</td>
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<tr>
<td>DIWC &amp; WSMC</td>
<td>Dharan Integrated Watershed Conservation and Water Supply</td>
</tr>
<tr>
<td>DNP</td>
<td>Dharan Nagar Palika</td>
</tr>
<tr>
<td>DoMG</td>
<td>Department of Mines and Geology</td>
</tr>
<tr>
<td>DRR</td>
<td>Disaster Risk reduction</td>
</tr>
<tr>
<td>DoSCWM</td>
<td>Department of Soil Conservation and Watershed Management</td>
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<tr>
<td>EVA</td>
<td>Economical Valuation Analysis</td>
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<tr>
<td>FAO</td>
<td>Food Agricultural Organization</td>
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<td>FGD</td>
<td>Focus Group Discussion</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GIS</td>
<td>Geographical Information System</td>
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<td>GoN</td>
<td>Government of Nepal</td>
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Chapter 1

Introduction

1.1 Background

Sardu watershed is a major source of drinking water for Dharan Municipality. The watershed is important not just as a source of drinking water but also provides provisioning services like food, fodder, fresh water and energy to upstream and downstream areas. Apart from the above mentioned services it also provides ecosystem services like supporting services (nutrient cycling, soil formation and primary production), regulating services (climate regulation, flood regulation, diseases regulation and water purification) and cultural services (aesthetic, spiritual, educational, recreational service). The importance lies in not just contributing to the ecological and livelihoods requirements of Dharan city and surrounding villages but also to the development of the entire eastern region of the country.

However in the recent years, the inhabitants of Dharan Municipality have been facing water shortage. It has been reported that the people residing within the watershed have also been facing scarcity of environmental services, particularly in food production, fodder, potable and irrigation water supply. As a result, upstream and downstream people who receive benefits through the natural services provided by the watershed have started blaming each other for the reduction in the benefits and services. For example, a case of displacement from the upstream of the watershed occurred in 1976. It was assumed that the upstream people had heavily encroached on the water sources and polluted the watershed. As a result, the local indigenous inhabitants (209 families) were relocated from the watershed to Bayarban Village Development Committee (VDC) in Morang District.

The problems regarding the encroachment of water sources and overexploitation of watershed services by people living upstream have led to scarcity of drinking water downstream particularly in Dharan city. This has now become a great challenge for the entire watershed region. The root causes of the problem have been identified as:

• Lack of authority to conserve the natural resources in the watershed area;
• Lack of adequate knowledge about conservation of the resources; and
• Lack of integrated programs for sustainable development of the watershed area.

In order to address such issues, IUCN Nepal, has been playing a major role in the conservation of natural resources in the region as well as other parts of the country. IUCN along with Association for Protection of Environment and Culture (APEC), Biratnagar, a member organization of IUCN and Center for Environment and Tourism Development (CETD), Dharan, a local partner organization initiated a study of Sardu Watershed Plan by assessing environmental services available in the area. The main focus of the study was the sustainable conservation of natural services provided by the watershed through the mechanism of Payment for Ecosystem Services (PES).
This study was conducted under the project funded by Department for International Development (DFID). The project aimed at achieving improvement of governance through changes in legal and policy frameworks at the national and sub-national levels that empower local communities and institutions in decision making processes and through strengthened land and resource rights that increase accountability and transparency in decision making structures.

The study was based on Sardu watershed to maintain single line policies and regulations incorporating vulnerable groups having fair and equitable access to natural resources in general, and community forestry and watershed management systems in particular. During the course of implementation, several output documents had to be produced that would benefit the local stakeholders as well as influence the policy level decision-makers.

1.2 The Need for the Study

As mentioned above, the local government played a vital role in displacing the local communities from upstream of the watershed in 1976 to make Dharan and surrounding areas water secured. Although the present system has been able to achieve water sufficiency in the city and in providing other services to the communities within the watershed for the last 25 years, new issues and challenges for the management of natural assets have emerged in recent years. Some of the major issues are:

- Rapid population growth;
- Overexploitation of the natural resources;
- Human intervention on lands in the name of different developments being carried out without any environmental impacts studies;
- Poor knowledge of agriculture practices;
- Very limited farm land;
- Low productivity of the land;
- Lack of appropriate technologies;
- Poor farming practices;
- Dependence on firewood for energy; and
- Rapid in-migration on flood zones.

Likewise, Soil and Watershed Conservation Act, 1982 emphasizes only on controlling mechanism in ad-hoc basis that too if the government feels that the condition of watershed is sensitive. In this regard, the act does not address the sustainable management of natural resources in a win-win approach. So far as the government prioritization of watershed management is concerned, the district (Sunsari District) where the studied watershed lies is not under government priority as the district fell on good watershed condition during the 1980s. Since then the condition of the studied watershed has been deteriorating but the classification of watershed prioritization has not been amended and the act and other related policies has not addressed such changes.
Government of Nepal had adopted the watershed management through participatory approach during 1990s and the approach is still being followed in the country. The approach has not been able to address the issues of natural resources management and community development. However, the planning was widely based on local people’s participation yet the watershed was not given priority by the local government and concerned stakeholders. Further, a systematic study of the watershed problem had not been carried out previously, although there have been some analysis of the status of the watershed in terms of water quality and land use practices after 2000. The finding of these studies highlighted poor quality of water in Sardu River and poor productivity of land in the region. In addition, with the development of market economy; local government, local consumers and Dharan civilians have been facing water scarcity as well as shortages of other natural resources.

Based on these analyses, it seems that many areas remain to be understood properly for sustainable watershed management. Trends in changes of environmental services, in regard to their values and consumption by local communities living in and around the watershed needs to be understood properly. Besides these, approach and efforts to promote sound soil conservation and watershed management practices at grassroots of rural and urban societies and way of linking upstream and downstream needs to be identified for sustainable watershed management. Hence, this study has the following objectives.

1.3 Objectives of the Study

The overall objective of the study was to prepare a report of a collaborative and participatory watershed conservation plan and draft mechanisms for cost and benefit sharing as well as forming linkages between upstream and downstream of the Sardu watershed.

The specific objectives of the assignment were:

- To assess economical valuation of watershed services particularly water and forest;
- To develop a mechanism for the application of the PES scheme in the watershed for good governance, management and for sustainable conservation of the watershed;
- To find out conflicts among stakeholders on management of Sardu watershed and its possible solutions; and
- To prepare a watershed management and conservation plan based on the land capability in order to increase water supply for drinking and agriculture and to maintain a natural system within the watershed area.

1.4 Scope of the Study

The following scopes were undertaken in the study:

- Workout the economic valuation of watershed services, particularly the direct use values of water and forest and get benefit cost ratio for the development of the watershed;
- Workout services providers, potential buyers and intermediary’s environmental services;
• Develop a mechanism of cost and benefit sharing for upstream and downstream resource users;
• Design elements of payment mechanism and recommend a model of PES mechanisms for upstream conservation initiatives and downstream water availability for drinking water, agriculture in the watershed;
• Assess legal and regulatory framework for the mechanism of PES;
• Prepare a baseline information about the watershed and socio-economic situation of the communities in the watershed;
• Review the relevant literatures regarding PES mechanism and valuation of services and conservation measures;
• Delineate watershed boundary and compute the area;
• Carry out digitization of different features of the watershed and classify the land classes;
• Carry out the land capability classification;
• Obtain the average slope of the watershed and classify the lands into different slopes;
• Develop drainage map and compute drainage and drainage density of the watershed;
• Estimate and observe the runoff of the Sardu River;
• Workout the existing land cover and land use patterns of the watershed and compute the land coverage;
• Delineate the area of existing land use and proposed land use with proper management and conservation measures;
• Estimate soil loss and sediment yields before and after conservation measures;
• Recommend control measures for watershed management;
• Determine the existing condition of socio-economical profiles of the watershed;
• Workout the climatic situation of the watershed: annual, seasonal and monthly trends of maximum and minimum rainfall and temperatures;
• Prepare a draft report of watershed conservation plan by incorporating the outcomes of the economic valuation of the services and PES mechanism;
• Carry out a consultation meetings with concerned stakeholders for the discussion on the draft report; and
• Prepare the final report of the conservation plan and other several reports of economic analysis;

1.5 Methodology

In brief, the tools adopted in the study were: Local Ecological Knowledge Assessment (LEK) using household survey and sampling; Participatory Vulnerability Assessment (PVA) using transect walk and FGDs; Public Ecological Knowledge (PEK) assessment using FGDs and consultative meetings; Hydrologist ecological knowledge assessment (HEK) using measurement and rational formula; Land use cover and land system analysis (LULSA) using
Participatory Geographical Information System (PGIS); Economic Valuation Analysis (EVA) using total economic value framework and market price for those services which are traded in the market and the opportunity cost of time for not traded in the market; PES mechanism strategy using national and international practices and local context potential assessment; and Rapid Biological Assessments (RBA). The following steps were carried out in the study.

1.5.1 Desk Work: Literatures Review, Watershed Delineation, Mappings and Preparation of Questionnaires

Several published and unpublished reports, journals and texts books from different sources like IUCN Nepal, International Center for Integrated Mountain Development (ICIMOD), Department of Soil Conservation and Watershed Management (DSWM), Water and Energy Commission Secretariat (WECS), websites and the others relevant information were reviewed to conceptualize the principles of watershed management and conservation, conservation measures and land capability, water and soil conservation, economic valuation of watershed services including use and non-use, methodology for the Payment for Environmental Services (PES) scheme etc. Documents of government policies and strategies, legal instruments like regulation, acts and International legal systems in distribution of natural resources were also considered in the literature review. The secondary data related to demography and the physical, environmental and economic development, and natural resources and environmental services were collected from the concerned municipality and Village Development Committee (VDC) profiles. The collected information/data were compiled and reviewed.

Similarly, topographic maps (Sheet Nos. 2687-02C, 2687 01D at a scale of 1:25000) compiled from 1: 5000 scale aerial photography taken in 1992 and field verification carried in 1995 and published in 1996 by the Survey Department, Government of Nepal, were used to get the topographical data and information about drainage, land use, land cover, trails, buildings/houses, build up areas and other infrastructures, forest lands and agricultures lands etc.

Watershed boundary was delineated on topographical maps at a scale of 1:25 000 on the basis of the principle of surface water divide with an outlet ridge-line using Geographical Information System (GIS). The base map of Sardu was prepared by incorporating major land features like boundary, rivers, buildings and ward and VDC boundaries (Figure 2.1). Structural and semi-structural questioners were developed to extract primary data related to social, natural and environmental status from the field (Annex 1).

Besides the literature reviews the following works were also carried out during the desk work:

- Preparation of different thematic maps like drainage map, existing land use map, DEM map, slope map, land classes map, etc.;
- Preparation of questionnaires for the Focus Group Discussion (FGD) and Households Surveys to be used during the field study;
- Preparation of a work plan for the overall study and household survey sampling and methodology. Here, a study team including representatives from IUCN, CETD and
APEC was formed and likewise part time sub-consultants in different subjects were also involved in the study and they were led by the lead consultant;

- Collecting secondary information regarding the hydrological and meteorological data from the Department of Hydrology and Meteorology (DHM); and

**1.5.2 Field Work: Thematic Map Verification, Sampling, Household Survey, Multi-stakeholder Consultations and Interviews of Key Informants**

**Transect Walk**

Delineated watershed boundary was verified in close consultation with local stakeholders and communities. The corrections were made on the base map based on the transect walk in the field. During the verification, sensitizations about the methods followed for the demarcation of the watershed boundary were also carried out among the local organizations and political parties. As a result, the local people including reporters and journalists became aware about the watershed and its process of delineation.

**Sampling**

The household survey was carried out in three regions: upstream, midstream and downstream. The watershed has been divided into these regions on the basis of availability and uses of resources and on the basis of land system of the watershed.

Upstream includes ward 7 of Bishnupaduka VDC, Bhedetar market and Panchkannya VDC. The upstream from where Nepal Water Supply Corporation (NWSC) gets its water is also rich in flora and fauna. The population density is comparatively lower in upper region than in other regions. The total household number in the region is about 144.
Likewise, midstream also lies in upland and it covers wards 2, 1, 6 (partially) and 5 (partially) in Bishnupaduka VDC and physiographically the region lies mostly under the Siwalik area. Total household number in the region is about 331 and the potential water sources are high. But the region is vulnerable to landslides and erosions and it has more agriculture lands than any other regions of the watershed.

Downstream region lies in the lowland of the Dhahran municipality and comprises of wards 13, 16, 11, 17 & 18. This region is at risk of flood and bank cutting. About 2434 households are there in this region. It should be noted that complete areas of ward nos. 13, 16, 11, 17 and 18 are not included within the Watershed.

Several discussions amongst the study team including the local enumerators of this study, local organizations and scholar from Louisianan University were carried out to determine the sampling size for the household survey and to finalize the draft of structural questionnaires. On an average, 25% of the total households (564 HHs) including 33.8% in upstream, 23.3% in midstream and 18% in downstream of the watershed were taken for sampled household size. After identifying these three clusters (upstream, midstream and downstream) and the household numbers within each cluster, random sampling method was used to identify the sampled households. After having the first sampled households, 2nd sampled households were selected by skipping specific number and this was done till the end of desired sample size. The same process was applied in each cluster to identify each sampled households. 16 enumerators were involved in the survey of the households. The household survey questionnaires were tested by involving the enumerators and the questionnaires were finalized after consultation with them. All the enumerators were given orientation classes to familiarize themselves with the questionnaires and also to help them understand the context of the study.
Focus Group Discussions (FGD), Key Informants Interviews and Multi-stakeholders Discussions

Focus group discussions were carried out to identify the issues, problems and their causes and consequences. The FGDs were done during the field visits amongst Bhedetar and Tamkham communities in upstream, Bhanjayang, Karkichhap communities in midstream and with Rai tole, Phusere, and Devitole communities in downstream. The discussions mainly focused on the resources availability, its distribution and management among the communities living in the regions. The checklist prepared for the FGDs has been attached in the annex 1.

The interviews with key informants were carried out separately. The key informants involved in the discussions were political parties, VDC secretariats of Bishnupaduka and Panchkannya, Executive Officer of Dharan municipality, Federation of Nepalese Chamber of Commerce and Industry (FNCCI), Dharan, Civil societies, Nepal Journalist Association, Dharan, Community Forest Users Committee (CFUCs), Water Users Committee, Army Engineer Unit, Dharan, Police office, Hotel Association, Academic institutions etc.
1.5.3 Office Work: Data Entry, Processes, Analysis and Report Preparation

The household survey data and information were firstly compiled and checked. All the variables were coded and entered into the Statistical Programme for Social Survey (SPSS) program. Before coding and entering the data, the data managers were given orientation to help them understand the context of the study. Final tables were obtained after analyzing the entered data using SPSS.

Likewise, the inputs obtained from field verifications on base map, land use change map and other thematic maps were entered into the GIS and the final maps were acquired on respective themes.

Stakeholder Consultation Meetings and Report Preparation

Stakeholder consultation meetings were carried out on the discussions of inception and progress reports. The discussions basically concentrated on the delineation of watershed and the issues of the watershed management. The inputs obtained from the discussions were incorporated into the report. The write-up on the gender and social inclusions and biodiversity issues were collected from respective part time consultants. After compilation of the reports, including the economic valuation of the services, final report was prepared and submitted.

1.6 Expected Outcome

The expected outcome of the study is a report describing Watershed Conservation Plan and PES mechanism for the conservation of the Services of the watershed.

1.7 Sardu Watershed Management Plan: Vision, Mission, Guiding Principles and Objectives

The Sardu Watershed Management Plan has been made with a vision, mission and specific objectives while incorporating the general principles of the watershed management. This plan is based on interactive research of Sardu watershed and is expected to be implemented through the proposed PES mechanism. By providing opportunities for close involvement in the research, the local stakeholders assumed ownership of the programme and understood and adopted the findings. The vision of the plan was to find the reflection of feelings and experiences about importance of the watershed.

1.7.1 Vision

“The vision for Sardu watershed management plan is one of a healthy ecosystem with excellent water quality and quantity, sound environment with good relationship among stakeholders and healthy communities with sustainable economies that respect the cultural and social values of the communities served.”

1.7.2 Mission

The plan offers a common understanding about the importance of Sardu watershed in integrating activities for conservation and development through people’s participation and collaboration among concerned institutional and social actors to ensure sustainable management of ecosystem services.
Evidently, the watershed has been visualized as the “Heart for Dharan City” and promoting it as an amalgamation of environmental services along with the concept of community development through collaborative approach would go a long way in maintaining ecological sustainability of the watershed.

1.7.3 Objectives of the Plan

The following were the objectives of the plan:

- To maintain the integrity of the ecosystem in the watershed while making development decisions;
- To integrate watershed services into community development and soil conservation;
- To adopt collaborative and participatory approach for the promotion and development of environmental services; and
- To maintain a linkage between upstream, midstream and downstream communities for sustainable watershed management.

1.7.4 Principles of Watershed Management

- The Sardu Watershed Management Plan is viewed not only as a product but also as a part of an ongoing process. As new information/issues are obtained, the plan can be revisited and refined where necessary;
- The authorities, the concerned stakeholders including the local community leaders must be fully committed to sincerely introduce and execute programs that are directed towards the benefit of the people living in and around the watershed region;
- Although the integration of environmental and socio-economic issues was initiated more than a decade ago through Service Economy, Environment and Democracy (SEED) approach, the actual implementation, particularly in economy, environment and democracy sector has not been yet institutionalized in local level planning. Hence, development decisions are required to balance the distribution of socio-economic benefits while maintaining the integrity of the watershed ecosystem. Based on the fundamentals of development, this plan is guided by collaborative approach with active participation of upland and lowland communities. This approach includes variety of partners (upland, lowland communities, Dharan citizens, experts, concerned authorities, etc.) in a variety of roles that are generally related to the goals of environmental conservation and sustainable use and equitable sharing of resource and benefits;
- Nation’s knowledge and other local knowledge can be used in implementing the plan; and
- The institutional condition of the watershed management is weak. Conflicts are likely to arise for acquiring watershed services and mainly for water consumption. If such situations arise, all the concerned stakeholders should be carried in a single platform by building partnership and all the issues related to watershed services should be discussed through the platform to attain a viable solution for all.
Chapter 2

Study Area: Sardu Watershed

2.1 Introduction

This chapter deals with the study area mainly in two aspects: bio-physical profiles and socio-economic profiles. Physiography, geomorphology, climate, drainage, hydrology and vegetation of the study area are highlighted in this chapter.

2.2 Physiography

Sardu Watershed is located between $26^\circ 45' 57.7"$ to $26^\circ 52' 30.95"$N and $87^\circ 12' 20.43"$ to $87^\circ 19' 20.20"$E in Sunsari district of the eastern development region of Nepal (Figure 2.1). The watershed has expanded from the foothills of Mahabharat range in Northern region (Chiuribas hills in central part, Bhedetar in eastern part and Silket hills in western part) to Coniferous forest range in the Southern region. The area covers 39.35 sq km and comprises of mid-hills, Siwalik and Terai in the district. Its elevation ranges from 150m amsl at the point where tributaries of Sardu River meet in Charkosejhhadi (Coniferous forest) in the south to 1580m amsl at Chiuribas hill point in the north. The watershed’s maximum north-south and east-west aerial distances are 15.2 km and 4.9 km respectively. The longest length of the main channel of Sardu River (max length of travel of water) is about 17 km.

Wards 7, 1, 2, 5, 6 and 4 of Bisnupaduka VDC and ward 9 of Panchkannya VDC and wards 11, 13, 16, 17, 18 of Dharan Municipality lie within the watershed. Dharan is the nearest city of the watershed. The salient features of the watershed are attached in annex 2.

The watershed is palm shaped. The compactness coefficient and the form factor are 1.81 and 0.024 respectively. The overland flow phase is predominant over the channel flow. Upstream of the watershed (above 1000m amsl) is confined but it is free when the river passes across the Dun valley and Siwalik and alluvial plain regions. Hence, the flow in the main channel is dependent on the land use practices. The size of the watershed is determined by its coverage area which is equivalent to 39.35 sq km. The average slope of the watershed is about 8.4% based on the date computed using Digital Elevation Model (DEM) in GIS environment. This is significant from conservation point of view.

Quantitative analysis has been carried out for the evaluation and for assessing the morphological characteristics of the watershed. The estimation in the report is based on the topographical map of 1996 that was pictured in 1992 by Department of Survey, Government of Nepal.

2.3 Geology

A distinct geological characteristic is found in the upper and lower reaches of the watershed. Upper catchment of the watershed is occupied by quartz biotic schist and feldspar
biotic schist with consolidated quartzite and phylite limestone. Middle catchment comprises of poor consolidated sediment, alluvial complex and older alluvium. Active alluvium and older alluvium are present in the south of the watershed. Loamy skeletal is the texture of the upstream of the watershed. Likewise, the texture of the middle reaches of the watershed is sandy, loamy and contains boulders, whereas downstream of the watershed/lower reach encompasses sandy and loamy/boulders.
2.4 Climate, Drainage Network and Hydrology

The basic parameters of the hydrology are precipitation, humidity and runoff. The other parameters affecting the hydrology of watershed are drainage networks, vegetative covering and physiographic characteristics. Drainage pattern is a major factor influencing erosion and runoff patterns in the watershed. In general, high drainage density affects runoff pattern.

2.4.1 Climate

Since the elevation of the Sardu River is less than 1580m amsl, the watershed experiences two climatic classes: warm temperate climate above 1000m amsl and sub-tropical monsoon climate below 1000m amsl. The upstream of the watershed experiences warm annual average temperature ranging 15-20 °C whereas mid stream and downstream regions experiences subtropical climate of annual temperature exceeding 20 °C. There are four distinct seasons with respect to precipitation: dry pre monsoon (Mar - May) characterized by thunderstorm in the subtropical region; wet monsoon (June - Sept) with heavy precipitation; Post monsoon (Oct - Nov) with relatively moist air and winter (Dec - Feb) with dry air.

Temperature

Climatic station is not available within the watershed. The station in Dharan bajar of Index 1311, (located at about 2 km east from the watershed at an altitude of 440m amsl) is the nearest climate station to the watershed. It has been used for temperature assessment in the study, though it has no long term temperature data records.

The mean monthly average temperature at the station is 24.3 °C. The mean maximum and minimum temperatures are 29.6 °C and 19.6 °C respectively. The temperature record shows that normally May is the hottest and January the coldest month of the year. The highest normal and the lowest normal temperature at the station are 36.1 °C and 6.0 °C respectively (Figure 2.2).

Rainfall

The watershed is rain fed run-off; therefore precipitation on the watershed determines the water availability in the river system. In this context, the study assessment of rainfall trends of the watershed is considered as a major parameter to determine the run-off generation in the river system of the watershed. Given that none of the meteorological stations are located within the watershed, the nearest station is Dharan bajar of Index 1311, located at about 2 km east from the watershed at an altitude of 440m amsl. The rainfall data at this station was used for assessing the rainfall trends in the watershed (Figure 2.3).
watershed; data from stations that were located near the periphery of the watershed were used. Five meteorological stations including four precipitation stations and one climatology station were selected for the hydrologic study of the watershed. The daily data records of a year of the selected stations were taken from the Department of Hydrology and Meteorology (DHM), Government of Nepal. The average annual and monthly rainfalls at the selected stations of indices are 1311, 1308, 1309, 1316, 1312 and 1823 are presented in the figure 2.4. Equivalent depth of average rainfall in the watershed was estimated using arithmetic mean of rainfall recorded in the selected stations.

From the estimation, the average annual rainfall of the watershed is about 1823.9 mm of which about 80% of the total rainfall (1455.7 mm) occurs during the monsoon season (June to September) and 20% (368.2 mm) during the rest of the year.

Rainfall analysis shows that about 80% of the total annual rainfall occurs during the monsoon period (June to September), 2% during the winter period (December to February), 12% in pre-monsoon (March to May) and 6% in post monsoon (October to November).

2.4.2 Drainage Networks and Drainage Density: Sardu River System

Sardu River originates in the foot hills of Mahabharat at an altitude of 1580 m amsl. Within the watershed the total length of the main channel of the river is 17.17 km. The river flows through the Siwalik (3.32 km), inner valley (6.20 km) and alluvial plains (7.58 km) and finally across the outlet at an altitude of 150 m amsl. Its major tributaries are Khardu Khola, Chhotimorang khola, Lampate Khola, Chirubas Khola, Khani Khola and Sulikot Khola. These rivers originate in the foothills of Mahabharat zone and Siwalik. The other tributaries are Timure Khola, Simle Khola, Tamakham Khola, Kalimati Khola, Machhamara Khola and Pakuwa khola. The source of Kavre khola and Chunpole khola lies in the Shiwalik zone. In recent years, many other gullies and rain-fed streams have sprouted in the river system.

The Sardu watershed is drained by more than 497 streams and rivers including distributaries with a total length of 142.85 km (Table 2.1). The stream order, tributaries and rivulets of Sardu River were classified and their respective lengths were computed by using GIS on topographic map (1:250000). The computed lengths of the streams are presented in the table 2.1. The

<table>
<thead>
<tr>
<th>Stream Order</th>
<th>Number of Streams</th>
<th>Length in Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>278</td>
<td>76383</td>
</tr>
<tr>
<td>2</td>
<td>122</td>
<td>31029</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>16242</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>3660</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>15538</td>
</tr>
<tr>
<td>Total</td>
<td>497</td>
<td>142852</td>
</tr>
</tbody>
</table>
Sardu River is a fifth order river (Figure 2.6). The first order river plays a very significant role in deteriorating the watershed due to erosion.

The drainage density (DD) of the entire watershed is 4.54 km per km². The density of the major catchments Sardu and Khardu are significant for supplying drinking water to Dharan municipality. Drainage density of Sardu is 5.57 km per km² which is greater than of Khardu (4.85 km per km²). It means that the Sardu catchment is more susceptible to erosions in comparison to khardu catchment with respect to stream networks.
The general slope of Sardu River is 8.4% and is distributed from North to South with varying topographic units. It is 24.74% in the Siwalik (above 600m amsl), 4.84 % in the fan zone (300-600 m amsl) and 2.05 %( <300m amsl) in the alluvial plain.

**Hydrology: Prediction of Design Peak Runoff Rate-Discharge**

Sardu watershed is not a river gauged basin. Therefore, peak discharges for various return periods were estimated at the outlet of the watershed using empirical relations. Further, rational method was used to estimate the peak discharge for the return periods of 10 years, 25 years and 50 years. Water & Energy Commission Secretariat (WECS) approach which was modified by the Department of Hydrology and Meteorology was also used for the estimation of peak flood runoff for the different returns periods of 2 years, 10 years, 25 years and 50 years. The computed results are presented in the figure 2.7.

Figure 2.7 shows that the peak discharges estimated by using WECS approach at the outlet (150m amsl of the watershed) ranges from 54 cumecs to 239 cumecs for the return periods of 2 years to 50 years. The figure also shows that the peak discharges, estimated by using the rational approach at the outlet ranges from 318 cumecs to 397 cumecs for the return period ranging from 10 years to 50 years.
2.5 Socio-economic Profile and Responses

2.5.1 Demography and Population Projection

There are around 2909 households in the watershed. The distributions of the households’ in accordance to the upstream, midstream and downstream regions are 144, 331 and 2434 respectively. Total population in the watershed is about 11,319 comprising of 49% male and 51% female. Population density is the highest downstream with 669 persons per sq km, second is midstream with 116 persons per sq km and upstream has a density of 90 persons per sq km. On an average, the family size is about 5.3 persons/HH in the watershed. There are more than 22 ethnic/castes groups in the watershed (Table 2.2).

Table 2.2: Caste/Ethnic Distribution by Regions in the Watershed

<table>
<thead>
<tr>
<th>Ethnic/Castes</th>
<th>Upstream</th>
<th>Midstream</th>
<th>Downstream</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rai</td>
<td>63%</td>
<td>31%</td>
<td>30%</td>
<td>33%</td>
</tr>
<tr>
<td>Tamang/Sherpa/Bhote</td>
<td>17%</td>
<td>57%</td>
<td>12%</td>
<td>18%</td>
</tr>
<tr>
<td>Brahmin/Chhetri/Thakuri</td>
<td>4%</td>
<td>3%</td>
<td>19%</td>
<td>16%</td>
</tr>
<tr>
<td>Dalit(Sarki/Damai/Kaami)</td>
<td>1%</td>
<td>13%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Gurung/Limbu/Magar</td>
<td>13%</td>
<td>5%</td>
<td>11%</td>
<td>10%</td>
</tr>
<tr>
<td>Newar</td>
<td>4%</td>
<td></td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Terai Caste (Yadav/Kurmi/Kayastha/Kanu/Rajvar)</td>
<td>2%</td>
<td></td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Gharti Bhujel</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Others (Tharu, Sunuwar, Majhi and Sanyasi)</td>
<td></td>
<td></td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The distributions of the population by their religions and in accordance to the regions are given in the figure 2.8. There are basically only four religions followed by the people in the watershed. Most people are Hindus (69%), followed by Buddhists (14%), Kirats (14%) and Christians (4%).

The literacy rate among male and female is 81% and 71% respectively. These figures are very good in comparison to the national average of 59.6%. Average percentage of girls’ up to 15 years going to school is comparatively greater than those of boys. But the tendency of leaving school by girls is higher than that of boys, as a result, the percentage of male having SLC
or above (14.8%) is higher than that of female (12%). But the percentage of higher education even of male is not satisfactory. Poverty is the main cause of poor education status in the watershed. Both male and female are compelled to quit their desire of higher education because of poverty. Male usually go to nearest city (mostly to Dharan city) as well as abroad for labours works and female are engaged in household works.

During the 1990s, nearly 22 %, 27%, and 4% of households form hills and mountain districts had migrated downstream (left bank of Sardu River-into flood zones-Dharan city), midstream and upstream of the watershed respectively. The migrated population mainly came from Bhojpur, Dhankuta and Khotang districts. The other districts from where people had migrated are Sunsari, Morang, Taplejung, Terahathum, Udayapur, Solukhumbu, Jhapa, Panchthar etc. There are more than 15 driving factors that had compelled people to migrate into the watershed. Nearly 28% population said that they migrated due to better facilities and livelihoods in Dharan city. Only 14% people stated natural disasters and Maoist insurgency as the cause for their migration. Migration trends in lower and middle part of the watershed have been increasing; thereby encroachment towards flood zone in the left bank of Sardu has enhanced and forest areas have been cleared for the settlements and agriculture use in the uphill of middle and upper parts of the watershed.

**Population Projection**

It has been projected that by the year 2025 with a growth rate of 1.97% in upland and 4.43% in lowland, the population would reach approximately 20,287 within the watershed. The break up in accordance to the three regions would be approximately 926 in upstream, 1,936 in midstream and 17,425 in downstream. The population growth in downstream is expected to be comparatively higher than in up and midstream regions (Figure 2.10). This is because most of the opportunities and facilities in terms of living standards and livelihoods are better in the municipality region which lies in the downstream. Likewise, the population projected by the year 2030 is approximately 2,77,365 in the municipality.

![Figure 2.10: Population Projection within the Watershed by 2025](image-url)
Institutions

There are significantly lower number of social organizations and institutions in the watershed as compared to other similar watersheds. Their involvement in the conservation of the watershed is also not substantial.

There are 7 community forest organizations in the watershed, namely, Nametar Community Forest (covering Khardu catchment); Nisan Saranga Community Forest (covering Chhotimorang and Nisane Catchments); Sagunri Community Forest (covering Sardu and Kalimati catchments); Karkichhap Community Forest (covering forest around Karkichhap); Gaundhara Community Forest (covering Pakuwakhola and Machhamara catchments); Jalkannya Community Forest (covering Khare Khola and Machhamara Catchments); and Bhaldunga Community Forest (covering Kavre, Chunpole and Kholepani Khola Catchments). The first three community forest organizations lie in the upstream of the watershed and the rests are in mid and downstream regions. All these community forests had not been handed over to the communities by the government till this study was conducted. Some of them were under the process of being handed over to the communities but few of them were still in the process of registration. Due to lack of resources to strengthen their capacities to conserve, the forest areas have been exploited and have steadily decreased over the years. However, they have begun conservation practices on their own efforts.

Likewise, the 13 water user groups existing in the area are Khanepani Upabhokta Samiti; Water User Committee, Dharan 11 and 17; Gauritole Water User Committee, Dharan 13; Kalikhola Water User Committee; Sumnima and Naulobast Water User Committee; Jorsokhuwa Water User Committee; Loktantrik Basti Water User Committee; Water Management Coordination Committee, Dharan 11; Ganatantra Water User Committee, Dharan 13; Water User Committee, Dharan 16; Shree Kalikhola Water User Committee, Dharan 16; Phokland Water User Committee, Dharan 17; and Koloni Marga Water User Committee.

2.5.2 Economic Activities, Production and Food Sufficiency

General

Wage labour, agriculture (including livestock), overseas work and self employment through trades are the major sources of livelihood in the watershed. The major source of sustenance of 42% family is wage labour, agriculture 23%, self employment 14%, foreign employment 13% and 8% other sources. Furthermore, agriculture and livestock is the main source of livelihood for 92% family in midstream region of the watershed. Incomes from labour works are major source of livelihoods for nearly 33% population in upstream and for 48% population in downstream.
Per capita incomes of the people in upstream, midstream and downstream are NRs. 3,480/-, NRs. 11,683/- and NRs. 12,669/- respectively. These figures are comparatively lower than the national per capita income of the year 2007/08 (US $470/-) (US $1= approx NRs. 70/-). These figures show that people’s income in downstream is more than in midstream and upstream. Incomes from private jobs and daily wages notably contribute to the increment of the total income of the communities in downstream region. Meanwhile, per capita income of midstream communities is 3 times higher than that of upstream communities. Livestock productions and overseas work significantly contribute to the midstream income (Annex 4).

**Land Holdings and Production**

So far as the land distribution in the watershed is concerned, only 51% families on average have their own lands for agricultural farming and of these, 77% families live in upstream, 66% in midstream and 46% families in downstream regions. Further, the irrigated land (Khet) in the watershed is only 27 ha, whereas non-irrigated land (Bari) is about 83 ha. 3 ha of the irrigated land fall in the upstream region, 14 ha in the midstream region and 11 Ha in the downstream region.

Annual average household's production is about 103 kg and 99 kg of vegetable and fruits in upstream and midstream regions respectively. The agriculture productions including cereal productions are listed in the tables in detail and are presented in annex 3.

Food production (cereal crops) in the watershed is trivial and is not meeting the requirements of the existing population. In addition, total food available in the watershed is only 77.5 mt per year but the food requirements for upland people (2452) at the rate 223 kg person (DSCO, 2006) is 547 mt per year. The food is deficit by 85% in the watershed. This is because of low productivity of land, insufficient land for cereal crops production, conventional farming practices, lack of irrigation facilities etc. Although the land availability for cereal production is very limited in the watershed, the production can be increased by conservation farming practices along with the use of modern techniques, technologies and practices. So, high value crops, nitrogen fixing crops, and agro-biodiversity should be promoted in the watershed rather than cereal crops.

**Livestock and Fodder Status**

The number of goats in the watershed, particularly in the uphill regions (upstream and midstream) is substantial. It means that the people in uphill depend on goat business for their income generation. Currently the average number of livestock is about 17 per HH but it was 26 per HH five years ago.

The livestock density is higher in upstream than in the midstream and the highest lies in the downstream regions (Table 2.3). But the annual livestock production is comparatively more in midstream (NRs. 9984/- per HH) than in the upstream regions (NRs. 985/- per HH).

<table>
<thead>
<tr>
<th>Livestock Types</th>
<th>Livestock in No.</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream</td>
<td>Midstream</td>
</tr>
<tr>
<td>Cattles</td>
<td>605</td>
<td>602</td>
</tr>
<tr>
<td>Buffalos</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Goats</td>
<td>1445</td>
<td>1548</td>
</tr>
<tr>
<td>Total</td>
<td>2090</td>
<td>2160</td>
</tr>
<tr>
<td>Livestock Density</td>
<td>241</td>
<td>155</td>
</tr>
</tbody>
</table>
It was noted that open grazing system takes place in entire regions of the watershed. Because of open grazing, particularly in upstream region, the region is prone to soil erosions. So far as the fodder status within the watershed is concerned, annual fodder requirements (in terms of Total Digestible Nutrient - TDN) for existing livestock heads of 4910 is 1231 mt but the availability is 2323 mt. Though there is surplus of fodder, the production of resources from the livestock is not significant in quantity. This is mainly due to lack of proper knowledge about livestock management and its benefits.

**Infrastructures**

Road networks in downstream is comparatively better than upstream and midstream (Figure 2.13). Every cluster in downstream has access to road networks and one can reach Kosi Highway within an hour (in Panchkanny VDC). Dharan-Dhankuta road connects VDCs located in the north and south of the downstream region. But, very few villages of Bishnupaduka have access to motorable earthen roads. The topography in Bishnupaduka VDC is not suitable for the construction of roads by using heavy machinery equipments. Yet, rural earthen road networks are being constructed haphazardly without undertaking any precautions to control erosion and landslides. Few examples of such constructions are roads from Dharan municipality to Bhanjyang in Bishnupaduka, from Dharan (Phusre) to Tamakh in Bishnupaduka, and from Bhedetar to Dhankuta through Chiuribas Danda. Meanwhile, several roads have emerged from Kosi Marga to different villages in Panchkanny VDC without any EIA or IEE studies. As a result the watershed faces real dangers of soil erosions and mass landslides during heavy rainfall.

The toilet facilities are not satisfactory in the watershed. Although almost 85% households have toilet facilities in the upstream region, only 23% are pakki (with safety tanks) and remaining are pit toilets. About 15% households have no toilet facilities. Meanwhile, only 60% families in midstream have toilet facilities and 40% use open space as toilets (Figure 2.12). Likewise, 76% family has toilet facilities in downstream and the rest use open spaces. There is a high possibility of surface water contamination in the Sardu River due to inadequate quantity and quality of toilet facilities.

Nearly 57% households have access to drinking water supplied by community-led management and the rest have access to drinking water that is managed by the water corporations in downstream region of the watershed. About 77% households in the upstream region and 92% households in the midstream region have public taps.

Only 6% households have access to grinding mills in the upstream region. About 35% households have access to these mills in midstream region.
Figure 2.13: Settlements with Access to Road Networks

Legend
- Highway
- District road
- Cart track
- Major trail
- Minor foot trail
- Track on river bed
- Watershed boundary

Source: Toposheet 1995
2.5.3 Energy Consumption and Fuel Wood Demand Projection

Fuel wood is the main source of energy for the people in the watershed. People spend 4-5 hrs a day to collect one bundle of fuel wood (about 40 kg - locally called Bharï) from the forest, whereas only 1-2 hours was needed to collect the same amount of fuel wood a decade ago. The sources for fuel wood have been decreasing in the recent years and this is mainly due to increase in population and lack of alternative sources of energy in the region. The fuel wood consumption rate (on average 1030 kg) is highly greater in the watershed than national per capita consumption rate (402.76 kg per year)\(^1\). The consumption rate of the upstream people is greater than the national rate by 120%. Likewise the consumption rate is larger than national rate in midstream by 408% (Figure 2.14). These figures indicate that consumption of fuel wood is one of the major causes of deforestation in the region. It also shows that forest quality is poor in the watershed in general and is worst in midstream region.

The projected fuel wood demand on the base of national per capita consumption rate in the next 15 years will be about 8,171 mt for a total population of approximately 20,287 (Figure 2.15).

\[\text{Figure 2.14: Fuel Wood Consumption within the Watershed Based on the Data Survey, 2009}\]

\[\text{Figure 2.15: Fuel Wood Demand Projection in the Watershed}\]

2.5.4 Awareness and Responses

Level of awareness and responses were assessed in Micro and Macro levels in view of sustainable watershed management. The awareness of and responses to negative changes differ greatly between the micro (farm/village communities) and macro (policy and plan makers and key stakeholders) levels\(^2\). Conservation practices to sustain watershed condition are of major concern in the watershed. In view of this, level of awareness and responses to negative changes found in the study were assessed by taking the perceptions of communities

\(^1\) IUCN, 2000
\(^2\) Purandara, 2006.
within the watershed at micro level and of major stakeholders at macro level (watershed beneficiaries in Dharan city).

**At Micro Level**

On the bases of conservation, only 35% people in upstream and midstream believe that the watershed is in good condition. Only 22% of the communities in downstream believe that the watershed condition has been maintained at a satisfactory level in the last 5 years. As per the perception of the communities and our field visits there is an urgent need for proper conservation plan and its implementation.

It was found that almost 72% people practice up-down ploughing for cultivation on the slope lands. Likewise, only 12% farmers use terrace cropping and just 6% people practice cropping by making water outlets to control rill erosions. Almost 91% of the communities still don’t know about the inter-cropping practices on slope lands in the upland regions (Figure 2.16).

About 56% people in the upstream region say that the availability of water has been decreasing in recent years due to severe deforestation but only 28% people residing in downstream region agree to this. This statement gives us various conclusions: Downstream communities lack knowledge about the relationship of conservation of water sources and water availability; communities in upstream are much more aware about the importance of forest in the region; loss of forest has seen significant in recent years and thereby communities within and outside the watershed are not only aware about the importance of conservation of watershed but are also conscious about the causes and consequences of deforestation. However, communities in the up-hill region (mostly in Bisnapaduka VDC) lack technical knowledge about conservation and at the same time they do not have any other option but to be dependent on fuel wood for their livelihood.

Community’s perception on importance of Sardu watershed gives us a clear picture on the importance and urgency for development of conservation plans. Responses on the importance of watershed in regards to its services were collected from the communities. For example, around 61% of the communities said that the watershed was essential for water services. Nearly 60% people stated that the watershed was valuable for resource like wood and fuel wood. About 53% believed that boulders/pebbles/stones were important services that were obtained from the watershed and 51% believed that the watershed was the main source for fodder. According to farmers, the other services that are being provided by the watershed are natural herbs, fruits, agriculture products, animals, grazing, fish, irrigation etc. (Details of bio-diversity services available in the watershed are given in the next chapter)

On an average, about 63% of the communities believed that severe impacts would happen on their livelihoods if prohibitory mechanism took place for the collection of the watershed services. For sustainability of the watershed, perceptions of the communities need to be transformed and a concept of a win-win relationship between supply of watershed services and community’s needs need to be built. Communities believe that this can be achieved through: Capacity development programs (responded by 50%), alternative energy and
capacity building for scientific agriculture frammings, control mechanism on the uses of services, replacement of settlements (responded by 33% people) from flood and crack zones and also from the areas where water sources are available. Community’s willingness to control negative changes that are occurring in the watershed is tabulated and presented in the table 2.4.

### Table 2.4: Tabulated Figures on Community’s Willingness for the Conservation of the Watershed

<table>
<thead>
<tr>
<th>What Would be Your Contribution for the Management of the Watershed?</th>
<th>Responded by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical contribution (Sram daan)</td>
<td>47%</td>
</tr>
<tr>
<td>Money</td>
<td>42%</td>
</tr>
<tr>
<td>Don’t know/can’t say</td>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What Role do You Play on the Upper Part to Conserve the source?</th>
<th>Responded by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not want to involve but need a sustainable mechanism with programs</td>
<td>80%</td>
</tr>
<tr>
<td>Do not want to involve at all</td>
<td>7%</td>
</tr>
<tr>
<td>Don’t know/Can’t say</td>
<td>16%</td>
</tr>
</tbody>
</table>

### At Macro Level

Responses through policy and planning to negative changes in the watershed had been initiated many years ago. For example, upland part of the watershed was prohibited for settlements after enacting the oral declaration in the legal documents (in Nepal Rajpatra). The declaration concerning the protection of the watershed area was declared by Late King Birendra Bir Bikram Shah Dev in 1976. In the following years, 209 houses were relocated to Morang district (for details please consult compiled documents in CETD, Dharan). The watershed supplies drinking water for about 85% of the total population of Dharan Municipality, however, in the recent years, public of Dharan municipality have been facing severe shortage of drinking water both in quality and quantity.

A few rules and policies are made for sustainable watershed management in the country, for example, Soil and Watershed Conservation Act, 1982 (section 1) defines the soil and watershed conservation. According to the act, “soil and watershed conservation means the work of protecting or saving any area from such natural disasters as floods, landslides and soil erosion, keeping the volume and flow of water in normal condition, for maintaining the purity of the flow of water without letting it get muddy. The act also focuses on declaration of protected watershed area (section 3).” But the act does not give a clear concept of the meaning of watershed. It only gives the definition of soil and watershed conservation and it does not address the concept of sustainable watershed management.

GoN has the following targets regarding environmental management for watershed and aquatic ecosystems (NWP, 2005):

- by 2027, a management plan nationally important watersheds and aquatic system are prepared and initiated;
- by 2007, water quality and wastewater quality standards are developed and enforced;
- by 2017, full-scale environmental protection and management protects are implemented in all priority watershed and aquatic ecosystems;
- by 2017, stakeholders’ participation in environmental protection and management is provided for;
- by 2027, quality of watersheds is increased by 80% in all regions; and
- by 2027, adequate water quality is attained for aquatic habitat, including fish, human consumption and recreation, in all rivers and lakes.
In order to address the above targets, National Water Plan recommends 10 major programmes for the sustainable watershed management (2002-2027). The activities are as follows:

- Improve environmental database system;
- Map important, critical and priority watershed and aquatic ecosystems;
- Develop water and wastewater quality standards and regulations;
- Implement water conservation education programme;
- Implement nationally important watersheds and aquatic ecosystems protections, rehabilitations and management programmes;
- Develop strategic environmental assessment in water resources management;
- Ensure compliance with environmental impact assessment;
- Promote community participation in the management of watershed and aquatic ecosystems;
- Enhance institutional capacity and coordination; and
- Develop watershed management policy.

The programmes mentioned above were made on the basis of watershed conditions district-wise prioritized by the Department of Soil Conservation and Watershed Management (Figure 2.17). According to the watershed condition map, watersheds that lie in the Sunsari District are under good condition (shown by green color on the map). The studied Sardu watershed was good condition in 1980s but the watershed has now been deteriorating in the recent years.

![District Wise Watershed Condition and Priority Map](Image)

*Figure 2.17: District Wise Watershed Condition and Priority Map (Source: DSCWM, 1983; adopted from FAO, 2004)*
With this view, stakeholders of Sardu watershed have shown positive responses to address the negative impacts on the watershed conditions. The negative impacts are reflected in quality and quantity of watershed services. The perceptions obtained from the watershed management organizations and multi-stakeholders gave a clear picture of people-nature relationship (Annex 5). In addition, for the sustainability of the watershed management, the relationship between the communities in the three regions play a great role in the conservation of soil and water without compromising the current needs of the livelihoods of local communities. The study also shows that the local stakeholders themselves can address their problems related to watershed management.

2.6 Conclusions

The average slope of the watershed is about 8.4%, which plays an important from role conservation point of view. It means, on average, the entire region of the watershed is not suitable for cereal. Sardu and Khardu of drainage density 5.57 km per km² and 4.85 km per km² respectively are major catchments of the watershed. The Shardu catchment is more susceptible to erosions in comparison to Khardu catchment in respect to stream networks.

Since the population density is higher in downstream (669 persons/km²) than in midstream (116 persons/ sq km) and lowest being in the upstream (90 persons/ km²), human encroachments in the low land is comparatively higher than in the upland regions. The midstream region of the watershed is comparatively more threatened than the upstream due to higher population density. Ethnically, upland is dominated by indigenous caste, particularly the Rai caste and the lowland has a mixed caste.

The average literacy rate (75.5%) in the watershed is higher than the national level (59.6%). But the overall higher education status is not satisfactory in the watershed. Average percentage of girls' up to 15 years going to school is comparatively greater than those of boys. But the tendency of leaving school by girls are higher than boys, as a result, the percentage of male having SLC or above (14.8%) is higher than that of female (12%). But the percentage of higher education even of male is not satisfactory. Poverty is the main cause of poor education status in the watershed. Both male and female have family obligations and cannot pursue higher education. Because of limited livelihood resources of the family they have to engage in work for income at an early age. Male usually go to nearest city (mostly to Dharan city) as well as abroad as labours. Whereas female are engaged in household works which usually involves collection of fuel wood and fodder and brewing local wine (Raksi called in local language). The viscous circle of poverty has been observed in the watershed.

Migration trend in the lower and middle part of the watershed has been increasing and thereby encroachment towards flood zone in the left bank of Sardu has increased. Likewise, forest areas were cleared for cultivation and settlements and this phenomenon was dominant in the midstream region. Due to lack of resources for strengthening the capacity of the Community Forest User Groups, the conservation of the forest areas has been very limited. However, they have begun conservation practices in their own efforts.
The watershed has food deficit of about 85%. This is because of the low land productivity, not sufficient land for cereal crops production, conventional farming practices, no irrigation facility etc. The production can be increased by conservation farming practices along with the use of modern farming techniques and methodologies. However, the land availability for cereal production is very limited in the watershed. So, high value crops, nitrogen fixing crops, and agro-biodiversity should be promoted instead of cereal crops.

The livestock density in the upstream region is higher than in the midstream and the highest in the downstream region. The grazing system is open feeding. As a result, the upstream zone is highly prone to soil erosion. The fodder is sufficient in the watershed but if open feeding continues then with time there will be a shortage of fodder. Likewise, the production from livestock is not significant in the watershed. This is due to the lack of knowledge of proper livestock management and its benefits.

The watershed is sensitive to soil erosions and also extreme rainfall that causes mass landslides in the regions. The severity is projected to be intensive mainly due to rural earthen road networks that are being constructed haphazardly without undertaking any precautions to control erosion and landslides. The existing topographical situation in Bishnupaduka VDC is not suitable for the constructions of roads using heavy machinery equipments. Yet, the road networks are being expanded without any Environmental Impact Assessment (EIA) being undertaken.

There is a high potential of contamination of surface water in Sardu River due to unsatisfactory quantity and quality of toilet facilities in the watershed.

The fuel wood consumption rate (on average 1030 kg) in the watershed is very high in comparison to the national figures of 402.76 kg. If alternative energy sources are not adopted by the communities, the fuel wood demand is expected to increase drastically in the watershed in next 15 years. The study shows that the existing consumption rate of fuel wood is one of major causes for the loss of forest from the region. It also shows that the forest quality is poor in the watershed in general and is worst in midstream region in particular. For the sustainability of the watershed, the multi-stakeholders perception at micro level will play a vital role in the conservation of soil and water without compromising the current needs of the local communities. The study also indicated that the local stakeholders themselves can address their problems related to watershed management.
Chapter 3

Physical Assessment: Land Use, Land Capability, Risks and Water Status

3.1 Introduction

This chapter deals with the physical features of the watershed in an analytical approach. Land capability and landform system for the watershed has been analyzed in this chapter. The land features have been classified as per the slopes of the terrains and are in order of the land use plan in the watershed. Existing land use system has been divided into ten types. Digital Elevation Model (DEM) has been used to classify the lands into five slope types. Soil loss from the watershed in an existing and proposed land use has also been estimated in this chapter. Climatic trends and risk factors that threat ecological services and approaches to disaster risk reductions are also examined in this chapter. In order to address the impacts of climate change, integration of climate change adaptation and disaster risk reductions are also evaluated. Likewise, existing water available in the watershed has been assessed in this chapter. Hydrograph for major tributaries of Sardu and Khardu Rivers has been estimated. Water demand in quantity and quality and its supply system are also reviewed and in addition, potential sources of water contamination in the watershed are also considered in this chapter.

3.2 Land Use Change and Land Capability

Environmental factors in the Sardu watershed are followed by the assessment of land use changes over the last three decades. Land capability within the watershed has also been assessed on the basis of their soil characteristics, drainage patterns, slope classes etc.

3.2.1 Landform and Land Systems of the Watershed

The landform system of the watershed has been assessed on the basis of land systems map of scale 1:50000. The map was prepared from the aerial photography taken in 1978/79 by the Department of Survey. The landforms on the three regions of the watershed on the basis of the land systems (the boundaries of the land systems were based on the ecological land units) are: Middle mountain region; Siwalik region; and Terai region (Table 3.1 and Figure 3.1). Accordingly the watershed includes land systems units 11, 12 (middle mountain); 4, 7, 8 (Siwalik); and 1, 3 (Terai).
Figure 3.1: Land System Classes for Sardu Watershed

Source: Land system map LRMP, 1978
The northern areas like Shikharbas, Bhedetar, Chiuribas and Tamakham falls on the middle mountain region. Climatically these areas have a warm temperate condition and lies between 1000m to 1485m amsl. Likewise, the Land Resource Mapping Project LRMP map places the study area in the middle part (west of Sardu River) and around Dharan city in the Siwalik region (300-1000m amsl). Similarly, the LRMP map places the southern part of the study’s area in the Terai region (150-300m amsl). The Siwalik and Terai region falls under subtropical climate.

In fact, physiographically, the above Middle Mountain Region land system has more characteristics of the sub-tropical zone than just warm temperate conditions. The landform characters of the upstream region of the watershed vary from moderately to very steeply sloping mountainous terrain (from less than 60% to above 60%). Likewise, active and recent alluvial and moderately to steep slopes hilly terrains (a wide slope ranging from 2-40%) are placed in the midstream region of active alluvial fan (erosion) whereas the landforms in downstream are active alluvial plain (depositional).

Three regions have been adopted to describe the watershed in this report. They are upstream, midstream and downstream. The upstream covers the northern areas that are described above. Likewise, the areas of ward numbers 1, 2, 5 and 6 of Bishnupaduka VDC are placed in the midstream region. The wards 13, 11, 16, 17 and 18 of the municipality and Bharaul regions within the watershed are placed under the downstream region.

The geology around the upstream is characterized by consolidated quartzite, phylite, limestone and schist in context of the surface erosion from the region. It widely varies from low to high degradation. The hazard of mass wasting in the region varies from medium to high zones. Likewise, the geology of midstream is poorly consolidated. Sediment, alluvial complex and older alluvium are largely found whereas from erosion point of view, the area is highly deposited zone in low-band and extreme erodible surface in upland zone and the area is also characterized by high hazardous wasting zone in highlands and net deposit in lowlands. In the downstream area, geologically active alluvium and older alluvium is found. The surface erosion in downstream is characterized by deposition and medium erodible surface.

### 3.2.2 Slope Classes of the Watershed

Slope map was made by using the DEM on the topographical map (DoS, 1996). Slope map of the watershed is shown in the figure 3.3.

<table>
<thead>
<tr>
<th>Slope Class in %</th>
<th>Cover Areas in Ha</th>
<th>Cover Areas in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>1414</td>
<td>36</td>
</tr>
<tr>
<td>3-15</td>
<td>565</td>
<td>14</td>
</tr>
<tr>
<td>15-30</td>
<td>123</td>
<td>3</td>
</tr>
<tr>
<td>30-60</td>
<td>880</td>
<td>22</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>966</td>
<td>25</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3935</td>
<td>100</td>
</tr>
</tbody>
</table>

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The topography of the watershed has been divided into 5 slope classes (Table 3.2). It shows that 36% of the total areas are under the regions that are inclined from slope class of 0-3%. Further, 14% of total area has a slope ranging from 3-15% and only 3% of total lands are under the slope up to 30%. A significant coverage (about 47% of total lands) is under the slopes greater than 30%.

Figure 3.2: DEM Map of the Watershed Based on Topographical Map of 1996
Figure 3.3: Slope Map of the Watershed Based on Topographical Map of 1996
3.2.3 Existing Land Use and Land Cover (LULC) and their Practices

Classification of the land use and land cover in the Sardu Watershed has been assessed using the GIS on the topographical map. The types of land use and land cover with their corresponding areas and general features in existing condition are assessed. A brief of the general features of the land types based on field observation is also presented in the table 3.3.

*Table 3.3: General Features of the Existing Land Use and Land Cover Types of the Watershed*

<table>
<thead>
<tr>
<th>Types</th>
<th>Area in ha</th>
<th>in %</th>
<th>General Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivation</td>
<td>804.60</td>
<td>20.45</td>
<td>Areas allocate to rain-fed crop production, mostly intension to cereal production in steep slopes</td>
</tr>
<tr>
<td>Built-up areas</td>
<td>11.43</td>
<td>0.29</td>
<td>Built-up areas expand to flood zones rapidly</td>
</tr>
<tr>
<td>Bush</td>
<td>371.57</td>
<td>9.44</td>
<td>Land covered by small trees, bushes and shrubs in highlands</td>
</tr>
<tr>
<td>Forest</td>
<td>2347.87</td>
<td>59.67</td>
<td>Hard wooden trees losses from the coniferous forest zones in downstream whereas mixed forest with mainly bushes and non-timber vegetations are observed in upstream forest zone.</td>
</tr>
<tr>
<td>Grass</td>
<td>105.63</td>
<td>2.68</td>
<td>In haphazard areas/no cultivated areas</td>
</tr>
<tr>
<td>Landslide</td>
<td>32.27</td>
<td>0.82</td>
<td>Mass wasting are frequent in river banks and soil erosion in midstream and upstream</td>
</tr>
<tr>
<td>Pond</td>
<td>0.14</td>
<td>0.00</td>
<td>Very insignificant ponds coverage</td>
</tr>
<tr>
<td>Sand and Gravel</td>
<td>261.53</td>
<td>6.65</td>
<td>Sand and gravel deposits in alluvial zones and are being rapidly and haphazardly extracted.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3935.03</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

About 21% of the total area of the watershed is under cultivation. From the total cultivated land, only 21% is in upstream and 35% in midstream. The remaining 44% lies in the downstream of the watershed. The cultivation practices are of conventional approach. A frequent tillage in steep slopes (>30%) is observed in the watershed. Ploughing up-down on the steep and very steep terrain slopes is frequent in the watershed. Cereal crops in hilly areas have also been cultivated by the communities but the productions of these crops are very poor.

Likewise, forest occupies 59.67% of the total area of the watershed. 35% of the total forest lies in the upstream, 16% in the midstream and 48% in the downstream region. The quality of forest in terms of timber and water holding tress are not sufficient in Sardu catchment in comparison to Khardu catchment. Forest in the midstream region of the watershed is poor in terms of its coverage and density. This is because the shifting cultivation practices is predominant in the region. Degradation of forest in midstream is mostly due to landslides in the region. In totality, the forest coverage in terms of quantity seems well but plants that control soil erosion and preserve water quantity are unsatisfactory in upstream and midstream regions. The forest coverage in downstream of the watershed is significant but the loss of timber trees from the region is of major concern.

Bush and grass coverage in the watershed accounted for 9.44% and 2.68% respectively. Further, a considerable portion (6.65%) of the watershed area comprises of bare ground with recent sand and gravel deposits. The coverage of sand and gravel has been increasing due to frequent flooding in the lowlands. Other land uses like built-up areas accounts for 0.29% of the total area and it mostly lies in the urban regions of downstream.
In accordance to the slope, land use type and land cover has been computed from the topographical map of 1996 and updated during the field visit in 2009 and the results are given in the table 3.4. About 21% of the total land is under cultivation. Only 18% of the total cultivated land lies within 0-3% slope which is suitable for the cultivation. Likewise, about 52% of the total cultivated land lies in the steep slopes (30-60%) and about 22% land being used for cultivation is very steep (greater than 60%) and this is not at all suitable for cultivation activities. In the land which is between 3-60% slope, conservation measure must be adopted before cultivation but we observed that no such measures had been taken.

### Table 3.4: Slope Wise Land Use and Coverage

<table>
<thead>
<tr>
<th>Slope Class in %</th>
<th>Agriculture</th>
<th>Built up</th>
<th>Bush</th>
<th>Forest</th>
<th>Grass</th>
<th>Landslide</th>
<th>Pond</th>
<th>Sandy</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>134</td>
<td>27</td>
<td>62</td>
<td>1008</td>
<td>14</td>
<td>7</td>
<td>0</td>
<td>150</td>
<td>1401</td>
</tr>
<tr>
<td>3-15</td>
<td>179</td>
<td>69</td>
<td>32</td>
<td>183</td>
<td>12</td>
<td>0</td>
<td>89</td>
<td>565</td>
<td></td>
</tr>
<tr>
<td>15-30</td>
<td>33</td>
<td>4</td>
<td>34</td>
<td>29</td>
<td>4</td>
<td>2</td>
<td>17</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>30-60</td>
<td>228</td>
<td>1</td>
<td>186</td>
<td>394</td>
<td>44</td>
<td>19</td>
<td>0</td>
<td>7</td>
<td>880</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>159</td>
<td>0</td>
<td>281</td>
<td>464</td>
<td>28</td>
<td>33</td>
<td>0</td>
<td>966</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>733</td>
<td>101</td>
<td>595</td>
<td>2079</td>
<td>101</td>
<td>62</td>
<td>0</td>
<td>263</td>
<td>3935</td>
</tr>
</tbody>
</table>

#### 3.2.4 Land Use Changes

Land use of the watershed has been assessed in the study using the land use map prepared in 1978/79 (LRMP) and Topographical Map 1996. The field verification was also carried out in 2009. The land use changes from 1978 to 2009 have been compared. The land use changes maps produced by GIS is shown in the figures 3.4, 3.5 and 3.6.

The area under agricultural use has decreased from 992 ha to 733 ha in the last 32 years. The decrease in cultivated land was due to various reasons like lack of irrigation facility in upland, low productivity of soil, cultivation on steep slope terrain, shifting cultivation practices, decreases in supply of agriculture laborer, lack of technology and knowledge about high values crops, etc.

The area under the forest cover had increased from 1998 ha in 1978 to 2348 ha in 1995 but it had decreased to 2079 ha in the year 2009. Clearly, the forest cover had initially increased and this might be due to the declaration of protected areas in upstream of the watershed in

### Table 3.5: Land Use and Land Cover Changes in the Watershed from 1978 to 2009

<table>
<thead>
<tr>
<th>Land use LRMP 1978</th>
<th>Land Use Topo 1995</th>
<th>Land Use Update 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Area in Ha</td>
<td>Percent</td>
</tr>
<tr>
<td>Agriculture</td>
<td>991.67</td>
<td>25.20</td>
</tr>
<tr>
<td>Built up</td>
<td>0.57</td>
<td>0.01</td>
</tr>
<tr>
<td>Bush</td>
<td>669.84</td>
<td>17.02</td>
</tr>
<tr>
<td>Forest</td>
<td>1998.30</td>
<td>50.78</td>
</tr>
<tr>
<td>Grass</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Landslide</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pond</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sandy</td>
<td>274.65</td>
<td>6.98</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3935.03</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Figure 3.4: Land Use and land Cover Changes in 1978
Figure 3.5: Land Use and Land Cover Changes in 1996
Figure 3.6: Land Use and Land Cover Changes in 2009
Then the forest cover was good upstream but the forest cover has decreased during the last 15 years (Table 3.5). The major causes for decrease in the forest cover during these 15 years were: the dense timber plants were cleared in upstream by forest smugglers (according to locals) during the politically transition period and also during Maoist insurgency; and forest products basically fuel wood, fodders and other forest related products have been haphazardly and excessively exploited in the recent years. A detail land use and land cover changes are shown in the table below.

During last 32 years the land use areas for cultivation, bush cover and sandy lands have decreased by 6.6%, 1.9 % and 0.3% respectively. Contrastingly, forest cover and grass covering have increased by 2.1% and 2.6% in the last 32 years. Whereas built-up and landslides areas have also increased during the same period (Table 3.6). In the table the – ve sign indicates the decline of land use types whereas the +ve sign signifies increase in land use types.

### Table 3.6: Aggregate Land Use Changes Over the Last 32 Years in the Watershed

<table>
<thead>
<tr>
<th>Land Use Types</th>
<th>Changes (between 1978-2009) in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>-6.6</td>
</tr>
<tr>
<td>Built up</td>
<td>+2.6</td>
</tr>
<tr>
<td>Bush</td>
<td>-1.9</td>
</tr>
<tr>
<td>Forest</td>
<td>+2.1</td>
</tr>
<tr>
<td>Grass</td>
<td>+2.6</td>
</tr>
<tr>
<td>Landslide</td>
<td>+1.6</td>
</tr>
<tr>
<td>Pond</td>
<td>0.0</td>
</tr>
<tr>
<td>Sandy</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

3.2.5 Soil Loss Prediction from the Watershed

Soil loss is a complex and dynamic process that transports fertile topsoil from the mountains and uplands and causes flooding in the downstream and flat areas. Soil erosion due to rainwater is a major concern in the study area. About 85% of total annual rainfall occurs in the monsoon season and soil loss is a major problem during this period. The critical factors that influence the soil erosion by water are: rainfall erositivity R, soil erodibility K, surface vegetation, surface conditions, topographic factor including slope steepness and length, cropping practices, and land management practices. In this regard the soil loss from the watershed has been predicted using Universal Soil Loss Equation (USLE).

The soil loss caused by water has been computed by putting all the depending factors for the estimation of the soil. Area weighted soil loss from the watershed has been computed and is equal to 65.39 ton/ha/yr. The computed figure lies within the range of national soil loss estimation rate (20-100 ton/ha/yr) for poorly managed slopping terraces. But when we compare the computed figure with the surrounding values estimated in other studies (Sherchan & Gurung, 1996 estimated soil loss from eastern region-Pakhribas Dhankuta Rain-fed Middle Mountain Region, Tiwari et al.2005 at 35 ton/ha/yr when agricultural land is under conventional tillage practices) it seems high. This shows that soil loss from Sardu watershed is almost double than that of Pakhribas Dhankuta rain-fed middle mountain region. This means that the Sardu watershed ecologically varies from flat region to poorly erodible region in the mid hills. Similarly, the conventional tillage cultivation practices are considerably observed in both lands; steep and high steep slopes.

The soil loss from the watershed can be reduced by improving the cultivation practices and increasing forest regions and discouraging shifting cultivation. For improving cultivation practices, contour cultivation on maize is expected to decrease soil loss from the land ranging

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5 CETD, 2009.
6 MoPE, 2001 Estimates of Soil Erosion at National Level
from slope 3-30%. Likewise, soil loss is also expected to decrease from the lands of slope 30-60% when brushwood check-dams and agro forest is adopted. The proposed land use with some correction on the land use practices is expected to decrease the soil loss rate by almost 32.74 ton/ha/yr in the watershed.

### 3.2.6 Land Capability Classification

Land capability classification is an internationally recognized means of land classification, used to evaluate the capability of land to support a range of land uses, on a long-term sustainable basis. Land capability is a fundamental requirement in order to achieve sustainable watershed management and conservation programs. Land capability is a prerequisite for planning, implementation and execution of soil and water conservation programs. Therefore, the assessment of the capability of the Sardu watershed is needed to conserve soil and water in the watershed.

In the context of land capability assessment, Tyagi, 2006 highlighted some important factors that determine the land capability. The factors are texture of the top soil, its effective depth, permeability of the top soil and subsoil, availability of nutrients, soil salinity, alkalinity and toxicity and land features like slope of the lands, erodibility, the degree of wetness and susceptibility to water logging etc. Meanwhile, Gurung, 2004 highlights the definition of land capability as defined by The Land Resource Mapping Project (LRMP). LRMP defined land capability as the inherent capacity of land to be productive under and sustain specific management methods (Carson, 1986).

In view of knowledge on the factors that determine the land capability, the land capability of the watershed has been carried out by assessing land features for example slope. Because of resource constraints, assessments by considering the other factors in detail were limited in this study. The land capability is represented in different classes of the lands with respect to suitability for cultivation. The slope of the watershed terrain is classified into five classes (Table 3.7) on the basis of Nepal’s context (LRMP, 1984; Sthapit, 1986c; and Sthapit et.al, 2006). The slope classes are: Class I (0-3%), Class II (3-15%), Class III (15-30%), Class IV (30-60%), and Class V (>60%). The land capability class indicates the general degree of limitation to use and the versatility of land use.

#### Table 3.7: Land Capability Classes and its Appropriate Use

<table>
<thead>
<tr>
<th>Class</th>
<th>Protection Measures</th>
<th>Land Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flood protection measures</td>
<td>Crops cultivation</td>
</tr>
<tr>
<td>2</td>
<td>Some leveling</td>
<td>Suitable for cultivation after terracing or contouring to control soil erosion and conservation measures with maintenance of ground is required for sustained forestry related usages</td>
</tr>
<tr>
<td>3</td>
<td>Terracing and drainage needed</td>
<td>Suitable for Agro-forestry and for fodder production when terracing is to be carried out.</td>
</tr>
<tr>
<td>4</td>
<td>Terracing and drainage essential</td>
<td>Suitable for fuel wood, fodder and timber production when a good, permanent vegetative cover is mentioned to minimize erosion</td>
</tr>
<tr>
<td>5</td>
<td>Unsuitable for Cultivation</td>
<td>Not suitable for any human activities. These lands are considered fragile causing extreme erosion hazard and are poor regeneration potential</td>
</tr>
</tbody>
</table>

---

Class I land has the following features:

- Land has a very gentle incline with a slope less than 3%;
- Soils are deep, not stony, well drained and has water holding properties;
- There are few limitations for arable agriculture or forestry and those are: flood protections measures are not present in the flood zone areas; controlling measures for sheet erosions are absent; and existing forest coverage needs to be increased;
- Erosion and bank cutting have been observed in the river banks; and
- Soil with physical and chemical deficiencies can be corrected economically.

Class II land has the following features:

- Lands are gently inclined and the slopes range from 3% to 15%;
- Soils are deep and well drained and has water holding capacity;
- When the land is used for arable agriculture, terracing or contouring is necessary to control erosion and to maintain it ground cover for sustained forestry related usages;
- Soils can be maintained in good tilt and productivity except if cereal crops are cultivated;
- The risk of erosion is high if cultivation is done without taking any measures and if the traditional crops use and forest use methods are still continued; and
- The risk of flooding is high in low lands and risk of mass land slides is also high at existing landslides zones.

Class III land has the following features:

- Lands are moderately inclined with slopes ranging from 15% to 30%;
- Land mass is very limited in the watershed (around 123 ha);
- Soil depths varies from 50cm to 100cm;
- Lands are suitable for agro-forestry and fodders production when terracing is done;
- Major soil conservations practices and careful management (drainage) is necessary;
- Limitations in terms of erosion hazards, physical handicaps like stoniness, internal drainage, soil structure and nutrient deficiency are present.

Class IV land has the following features:

- Slopes range from 30 to 60%;
- Lands are broken by gulley and surface irregularities;
- The degree of stoniness and other physical limitations prevent agricultural farming;
- Erosions hazards vary from moderate to severe;
- Terracing and drainage are essential for cultivation and forest use;
- Suitable for fuel wood, fodder and timber and a good, permanent vegetative cover is present to minimize erosion; and
- The land cover under this class is significant in quantity (around 880ha);
Class V land has mostly the following features:

- Lands are very steeps and the slopes are above 60%;
- Lands are rocky;
- Soil depth is less than 20cm and has poor nutrients;
- Lands are not suitable for any human activities like agriculture and buildings.
- These lands are fragile causing extreme erosion hazards and have poor regeneration potential;
- These lands needs to declared as protected;
- This class in upstream plays a major role in water generation;
- This class of land is unsuitable for grazing and should not be cleared for fodder;
- Conservation measures including re-vegetation or retention of existing vegetation cover should be adopted;

3.3 Climatic Trends and Risks to Disasters

3.3.1 The Context

Changing weather elements particularly precipitation, temperature, winds, humidity, solar intensity and cloud covering and visibility from normal patterns is termed as climate change. According to WMO recommendations, numerically averaging values of at least 30 years data of those weather elements needs to be taken into account when we talk about normal weather patterns. The change is the consequences of increasing global emissions causing climate variability in temporal and spatial variations and climatic extremes like hot days, cold nights, cold days, erratic rainfall, melting ice and increasing sea level. Such changes are causing severe hydro-meteorological disasters risk in a frequent manner particularly in developing countries like Nepal. In this context, the Fourth Assessment Report\(^9\) highlights that frequency of occurrence of more intense rainfall events is increased and that is causing severe climatic hazards like floods, landslides and mud flows in many parts of Asia. That reports also highlights that the number of rainy days and total annual amount of precipitation has also decreased. Likewise, Nepal Capacity Stocktaking Report on Climate Change highlights the climate variations and changes in Nepal due to global climate change impacts (MoEST, 2008).

Climate change, in disaster risks context, is an immense concern through two specifics:

a) Intensive climatic hazards with ambiguity and

b) Enhanced risk to livelihood assets and increasing vulnerability.

Climatic hazards particularly in the form of flood and drought have been frequently observed in the recent years. Rainfall duration and intensity and its frequency are the major factors to intensify the floods and droughts hazards.

\(^9\) IPCC, 2007
Similarly, climate change lowers the coping strength of humans, especially the poor and marginalized people both in urban and rural regions. Lowering coping strengths to disaster risk reduction is one of results of climate change on the resiliency system. The resiliency system encompasses sustainable livelihood assets including natural, financial, social, physical and human capitals.

Climate change also catalyzes risks related to hydro-meteorological disasters. Climate change has impacts on disaster risks directly and indirectly. Climate variability and climate extreme has direct impacts on disaster risk whereas climate change has indirect impacts on livelihoods assets. The following empirical relation shows the disaster risks with direct and indirect impacts of climate change.

\[
\text{Disaster Risk} = \frac{\text{Climatic Hazards (Direct Impact)} \times \text{Vulnerability (Indirect Impact)}}{\text{Coping Capacity}}
\]

3.3.2 Climatic Trends

**Rainfall Patterns**

The daily rainfall data recorded at the Dharan Bajar has been analyzed in the study in relation to the climate change impacts. The analysis showed that the normal rainfall had decreased during 1976-2008 by 12.85% in comparison to 1948 to 1975. The rainfall during monsoon was 1802.6 mm in 1976 - 2008 but was 2068.34mm during the periods of 1948-1975.

In general, the rainfall pattern has not significantly changed during the years 1975-2008, but the deviations from the normal rainfall are observed in alternative years. But after 1990 the rainfall pattern below normal has been more frequently observed. In particular, number of years which received below normal rainfall in all seasons is higher than above normal (Figure 3.7). It means the number of flooding years in monsoon season has comparatively decreased but the occurrence of uncertainty of flooding is high. This uncertainty would increase the flood disasters in flood zone regions and landslides in regions with slopes in the watershed. Further, the number of years with below than normal rainfall has increased in the last 33 years. As a result it has decreased the runoff yield in the Sardu River during the dry seasons.

**Temperature Patterns**

Temperatures recorded in the last 10 years at the station were analyzed to represent the temperature pattern for the watershed. But this data is not sufficient for the analysis of the temperature patterns because the data of the recorded temperatures are only available of the past 10 years and there is no other station in the area. The trends of temperature at Dharan
Station has been developed and shown in annex. According to the analysis, the hot days of temperature >29.8 °C has decreased but the decreasing trend is not significant. The data of cold days were not observed during the last 10 years and the trends of max and min temperatures are not significant.

### 3.3.3 Vulnerable System/Sectors

Theoretically, climate change has impacts on natural system whereas human systems do play a critical role in inviting abrupt climate changes. As a result the livelihood assets basically natural, human and social capitals are primarily vulnerable to climate change. In this regards, on the basis of local historical recorded climatic data, particularly rainfall and temperature shows that the study area are likely to be vulnerable to water resources, food and agriculture, forest and ecosystem and climate change disasters. The vulnerable sectors in the context of climate change impacts needs to be identified in detail.

### 3.3.4 Risks Specific

**Risk Due to Excessive Human Practices/Interventions on Marginalized Landscape**

Excessive human interventions like terrace buildings, framings on slope lands, clearance of forest, encroachment of river course, free and overgrazing, un-planned excavation for construction materials etc causes watershed deterioration. The watershed is at high risk to climate induced disasters due to such interventions. Climate induced disasters particularly landslides in uplands and floods in lowland are dominant. These disasters have intensified and are frequent due to excessive human intervention particularly on the landscape and forest resources in the watershed. Moreover, the communities that live in steep slopes in upland are socially, economically and physically vulnerable to landslides and erosions. Dependency for their livelihoods on the hill landscape and forest regions in upland is excessive. As already mentioned, about 58% of upland communities primarily depend upon agriculture and livestock practices on fragile lands. Of them, 91% work on slope lands where irrigation facility does not exist. As a result, the agriculture production is very poor (Annex 3). Likewise, communities practice paddy cultivation even in slope lands (about 1.5 ha land are used for paddy cultivation). From the field, it was observed that community had been adopting cultivation practices without adopting conservation measures in the slope lands.

When we talk in the context of forest uses, the forest products have unlimitedly been used from the watershed. Furthermore, based on the household survey within the watershed it was observed that the forest products like fuel wood are being consumed more excessively than required for daily use. For example, communities in upstream, midstream and downstream use more fuel wood annually than their requirements. Midstream community in Binsupaduka VDC has consumed more than the national average requirement per household (ref chapter 2).

The forest region in downstream-Charkose Jhadni (coniferous forest) has almost been cleared for the purpose of timber. Likewise, we observed un-planned excavation of riverbed for the extraction of boulders in Sardu River.

The up and down-land communities blame each other for increasing susceptibility to landslide. The communities in upland describe more pressure on the national forest zone (being undertaken the transform to community) is from down-land communities, particularly from Dharan as people come to the forest zone to collect firewood and fodder. In contrast,
communities in down-land describe heavy encroachment in national forest zone even around water sources by local communities in upland who go to forest for fodder and forage, cattle grazing and also do regular shifting of cultivation lands. The study team also observed rice farming on the slope fields near the old and current landslide zones. The farming practices were of conventional approach without adopting any soil conservation measures. Soil erosion due to extreme rainfall for a short period is likely to happen from the lands where farming practices are being undertaken in uplands.

Risk Due to Fragile Geo-Morphological Characteristic

The watershed is at risk due to fragile geomorphology of the watershed. The features of the watershed are landslides, fans-regions (where the granular debris is deposited and that extend from the base of mountain to a low land below), river valley, bhabar, sheets, rills, terraces, gulley and streams. The elongation of the watershed from North to South is sketched and shown in the figure 2.1. Siwalik, inner valley, alluvial fans are topographical features of the watershed. The region that lies in the northern part of Siwalik is called Chure. From the confluence of river Sardu with Khardu (originates from foot of Mahabharat region) the Sardu River emerges into inner valley and Bhabar zone and then the river follows the alluvial fan in the South. The Chure and slope regions in inner valley are unconsolidated from where large boulders, pebbles, concrete, sands are lost and they are deposited in the Bhabar region and the alluvial fan zone. Both sides of the river in the inner valley and Bhabar zones are erodible. Landslides in Chure and inner valley are the major threats. Likewise, flash floods and bank cuttings are the other threats in Bhabar and Fan zones.

In connection with risk to landslides in the watershed, a study was carried out by the PhD students of Lausanne University, Switzerland in 2008/09. This study\textsuperscript{10} analyzed the risk to landslides in upper Sardu. According to that study, slopes of the Sardu and bank erosion on the left bank of the river have a high destruction potential to risk. The figure 3.8 shows the principal landslides and secondary landslide with major cracks and vegetation coverage. Flow of debris is frequent and a number of tensions cracks are observed at the top of the major slides and around the vegetative coverage. The red and yellow colors in the figure indicate high risk to erosion in the left bank of the river (Figure 3.9). The buildup areas along the river sites are at high risk to flooding (Figure 3.9). Further, this study also highlighted medium and large landslides along the upper Sardu River in the right bank are expected to breakout and it forms temporary dam that causes flooding in Dharan city.

Peak flood estimation at the outlets of the watershed is expected to be 318 cumecs in 10 years and 397 cumecs in 25 years in Sardu River. The areas within the watershed, around the slum regions of Dharan city and left bank of Sardu River are at high risk to floods during the monsoon seasons\textsuperscript{11}. The detail study should be done in future.

\textsuperscript{10} Synthesis Report Landslide Risk and Vulnerability Eastern Nepal Study, 2009
\textsuperscript{11} Duvadi, et al., 2001
Figure 3.8: Map of Upper Sardu with Principles and Secondary Landslides with Major Cracks
(source: Sudmeir - Rieux et.al, 2010)
Figure 3.9: Risk Maps of Upper Sardu Khola
(source: Sudmeir - Rieux et.al, 2010)
Risk due to Rainfall Variability and Extreme Rainfall

Rainfall deviation from normal, spatial and temporal variation of rainfall and extreme rainfall are indicating factors of climate change. Temporal variation of rainfall at the selected station shows irregular occurrence of landslides in the study area. The rainfall deviation in pre-monsoon season has been above normal in the last five years whereas it is below normal in the monsoon season (Annex 6). As a result of irregularities in rainfall, the floods and landslides are uncertain. The range of rainfall changes were: -30.6% to +13.6 in the monsoon; -87% to 182% mm in the post-monsoon; -100% to +152% in the winter; and -73.9% to +146.9% in the pre-monsoon during 1975 to 2008.

Extreme rainfall recorded in 24 hours at the station during 1975-2008 is shown below. The average extreme rainfall in the station is 352 mm in 24 hours which play a significant role in inducing natural disasters around the watershed. Severe disaster impacts had happened in 1984 and 1985 in the study area.

The studies carried out by several experts reveal the relationship between extreme rainfall and landslides in Nepal. For example, a scientist group from China, India, and Nepal (Li and Li, 1985, Dhital et al, 1993, Joshi, 1997), identified the relationship of incidence of landslides and extreme rainfalls. The number of days of rainfall which were more than 50 mm in 24 hour was irregular in their findings. (Figure 3.11).

The relationships are stated as: if cumulative rainfall amounts to 50 mm to 100 mm in a day and daily rainfall is more than 50 mm, small-scale and shallow debris-landslide will occur; if cumulative rainfall within two days amounts to 150 to 200 mm and daily rainfall is more than 50mm, the number of landslides has a tendency to increase with rainfall; and when cumulative rainfall exceeds 250mm in two days and has an average intensity of more than 8mm per hour in one day the number of large and vast landslides increases abruptly12. Further, a study (D. Paudel, 2006) emphasizes that an intense rainfall within a short period of 24 hours, usually during the summer monsoon plays the most important role in inviting the floods and landslides in the country. However, it is not necessary that occurrences of any hydro-climatic disasters especially floods and landslides need rainfall equal to or more than 300mm in 24 hours. A Rainfall event that is below 300 mm per day can also invite risk of floods and landslides in the country (Paudel, 2001).

12 DSCWM, 2005;
The hydrologic condition of Sardu River implies that it is likely to get impacted due to climate change. Further, the river channel in Bhabar zone is unstable and there are sudden floods due to extreme rainfall. In this context, professionals on climate change impacts on hydrological dynamics suggests that hydrologic dynamics become more erratic due to the impacts of global climate change where rivers move latterly and transfer large sediment loads.

### 3.3.5 Integration of DRR and CCA

Poor and marginalized communities live in slum regions in the lowlands and steep slopes in uplands and they are most vulnerable to climate change impacts in the study area. These communities are vulnerable to disasters like floods, landslides and droughts. Further, they are at risk because of the impacts of climate change on livelihoods assets. Livelihood assets are the security of population and poor people in slum squatters and hilly regions of the watershed have very low assets to survive. In this regards, GoN emphasized in 2008 that poverty both in rural and urban regions are primarily vulnerable to climate change impacts in the country. Developing countries like Nepal are susceptible and also they may face larger water shortage, food insecurity and greater risks to health and life as a result of climate change.

Regarding rainfall extremities, ISET 2009, Agrawala et al 2003, DAN 2008 informs that trends of extremes of high rainfall within 24 hours will lead to abrupt climate risk and shocks. Further, the alternation of rainfall pattern may be due to global or regional climate change. Climate change will be expected to alter both rainfall and snowfall patterns.

The prediction of changing temperature and rainfall extremes for future is a great challenge not only at local level but also at national level. However, some predictions on impacts of climate change have been made at national level. A synthesis report (draft) produced by Climate Induced Disaster Thematic Working Group, GoN, 2009 reported that Global Circulation Models (GCM) projections projects an increase in temperature over Nepal of ranging 0.5-2.0 °C, with a multi-model mean of 1.4 °C by the 2030s, rising to 3.0-6.3 °C, with a multi-model mean of 4.7 °C by the 2090s. The reports also highlights those extremely hot days (the hottest 5% of days in the period 1970-1999) are projected to increase by up to 55% by the 2060s and 70% by the 2090s. GCM outputs suggest that extremely hot nights (the hottest 5% of nights in the period 1970-1999) are projected to increase up to 77% by the 2060s and 93% by the 2090s. GCMs project a wide range of precipitation changes, especially in the monsoon: -14 to +40% by the 2030s increasing -52 to 135% by the 2090s.

Likewise, incidence of extreme weather events such as droughts, storms, floods/inundation, landslides/debris flow, soil erosion and avalanches are also expected to increase in the country (GoN 2008). Bhabar regions will be more prone to flash floods from the rivers that originate in the Churia range. These rivers frequently change course and deposit sediments on the river bed.

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13 ISET, 2008
14 IPCC, 2007;
15 Holling, 2001:
In context of climate resiliency and coping to climate induced disaster within the watershed, the existing coping approaches to disaster risk reduction (DRR) will hardly withstand to climate change impacts in the study area. Government led approach for the protection from floods in downstream are structural measures like spurs, embankments, and gabion boxes. These measures are not likely to be sufficient to protect against large floods (Synthesis Report, 2008). Community-led approach preparedness measures have also been initiated to respond to floods by the community in downstream. These measures are community shelter houses, development of community organizations and awareness etc. Are these provisions initiated by the community enough to withstand the uncertainty associated with climate change impacts? In the context of withstanding climate change impacts, integration of DRR into Climate Change Adaptation (CCA) is a prerequisite. Indeed DRR is a basis of good practices in the reductions of historical major events in the past and CCA is expected for future practices. Climate Change Adaptive Cycle (CCAC) plays a crucial role in the integration of DRR in CCA. CCAC includes three major elements: inheriting potential wealth, developing internal control, and increasing adaptive capacity. Theoretically, the inheriting wealth includes the options for future which are influenced by variable/s and dependable/s. Internal control mechanism that applies to enhancing coping capacity is expected to control those variables. In the context of study area, identification of future options and mechanism to enhance coping capacity are expected to be studied in the future.

3.4 Water Status

Water status in the watershed is determined by the following aspects: Water sources and availability, water demand and supply system and water quality. Water availability is specific to surface water yield from major sources in the watershed and in this case Sardu and Khardu. Other water sources have also been assessed in general in the study. Water demand by Dharan people has been quoted in the report from the previous study in the area.

3.4.1 Specific to Water Availability

**Monthly Flow Estimation from Sardu and Khardu Catchments**

Since the catchments are not gauged, the monthly flow analysis of Sardu and Khardu Catchments are estimated using two methods: Non-dimensional hydrograph approach and WECS approach. The estimated values are presented in the table 3.8.

Based on the measurement of October

Based on the measurement of February

![Graphs showing monthly flow estimation](image-url)
Using Non-dimensional Hydrograph Approach

The non-dimensional hydrograph approach is a useful approach to compute monthly flow of un-gauged basin in the country. In the estimation of monthly flows throughout a year, measurement was carried out in October, 2009 in Sardu and Khardu kholas (rivers) during this study.

Runoff water was measured using Current Meter in October, 2009. The measurement was taken on 10th October, 2009 at three locations:

a) Confluence of Sardu with Khardu and Nisane in Sardu River;
b) Confluence of Sardu and Khardu in Sardu; and
c) Near Khardu inlet in Khardu Khola.

In addition, the water yield from Sardu and Khardu was also estimated on the base of measured water amount. The measurement was also taken in February 2010 at the same locations. October is the last month of the monsoon period whereas the February is the dry period. These two measured values are used to develop the hydrographs (Figure 3.12). But as per the practices and guidelines of this method, the estimated monthly flow based on the measurement taken in February is comparatively more reliable than based on the measurements taken in other months. Hence, the estimated values are given separately just for realization about the water availability in those catchments. For the details for any designed estimation, a hydrological gauging must be installed in Sardu at the confluence of Sardu, Khardu and Nisane.

The measured discharge was used in computation of the monthly flow in a year by using regional non-dimensional hydrographic approach. The monthly flows were estimated of Sardu and Khardu catchments separately (Table 3.8). Based on the measurement taken in February 2010, the estimated water amount in dry and wet seasons are 14 MLD and 68 MLD respectively at the confluence of Sardu and Khardu. The water amount estimated using WECS method at the confluence in dry and wet season are 24 MLD and 74 MLD respectively. Through all these estimated figures we have made a conclusion that the water availability for Sardu and Khardu catchments are of great variation in quantity. However, water availability for the users in Dharan civilians would be enough if the proposed land use, given in the annex (Annex No 12) need to be implemented.

Table 3.8: Monthly Flow Estimation for Sardu and Khardu Catchments in Cumecs

<table>
<thead>
<tr>
<th>Months</th>
<th>Using Non-Dimensional Hydrograph</th>
<th>Using WECS Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Based On the Measurement in Oct</td>
<td>Based On the Measurement in Feb</td>
</tr>
<tr>
<td></td>
<td>Sardu</td>
<td>Khardu</td>
</tr>
<tr>
<td>May</td>
<td>0.13</td>
<td>0.24</td>
</tr>
<tr>
<td>Jun</td>
<td>0.22</td>
<td>0.41</td>
</tr>
<tr>
<td>Jul</td>
<td>0.51</td>
<td>0.95</td>
</tr>
<tr>
<td>Aug</td>
<td>1.27</td>
<td>2.36</td>
</tr>
<tr>
<td>Sep</td>
<td>0.87</td>
<td>1.62</td>
</tr>
<tr>
<td>Oct</td>
<td>0.43</td>
<td>0.61</td>
</tr>
<tr>
<td>Nov</td>
<td>0.25</td>
<td>0.47</td>
</tr>
<tr>
<td>Dec</td>
<td>0.18</td>
<td>0.34</td>
</tr>
<tr>
<td>Jan</td>
<td>0.11</td>
<td>0.2</td>
</tr>
<tr>
<td>Feb</td>
<td>0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>Mar</td>
<td>0.04</td>
<td>0.07</td>
</tr>
<tr>
<td>Apr</td>
<td>0.04</td>
<td>0.07</td>
</tr>
</tbody>
</table>
3.4.2 Specific to Existing Water Supply System from the Watershed

From Sources in Upstream to Nepal Water Supply Corporation (NWSC), Dharan Sardu River and Khardu Khola (springs) are the main sources of water in the watershed. Nepal water Supply Corporation (NWSC), Dharan, collects water from these. The corporation does not have long records of water yield data. The monthly data of the fiscal year 2064/065 (Given in Annex ) was provided by the Corporation are analyzed season-wise and presented below. NWSC, Dharan collects 12 to 13 MLD in wet season and 4 to 4.5 MLD in dry season from both Sardu and Khardu Kholas (NWSC, 2009) respectively. From the above analysis (Figure 3.13), Sardu and Khardu Kholas supply water 10.25 MLD, 10.5 MLD, 7.83 MLD and 4.83 MLD in monsoon, post-monsoon, winter and pre-monsoon respectively.

The analysis, considering water yield from both the Kholas (Sardu and Khardu) give a sense that water available in post monsoon (31.43%) is comparatively greater than in monsoon (30.68%). It means water yield in post-monsoon is contributed through sub-surface in hydrological process. Runoff water in rain-fed river in post-monsoon depends on the vegetation coverage (bushes, non-deep root plants, canopy) in the catchments whereas water yield in winter depends on forest practices (DSWCM, 2005).

The other existing sources for the municipality are water from wells of 300 m deep situated in Charkose Jhadi which is about 8 km south of Bhanu Chock, Dharan. NWSC also collects ground water of about 6 to 6.5 MLD from wells no. 2, 3, 4, and 7 situated in Tarhara which too fulfills the demands of water in the municipality.

From Sources in Midstream to User Communities in Downstream

Communities in midstream and downstream (Dharan Nagarpalika-slum and permanent residents) get their water from the major tributary Khahare of Sardu River. The tributaries that originate in the midstream are: Pakuwa Khola (locally named as Upper Pakuwa and Lower Pakuwa), Kalikhola(Kalimati), Tamakham Khola, Simle Khola, Machhamara Khola, Khahare Khola, Chunpole Khola and Kholepane Khola. Specifically, Pakuwa and Kalikhola are the main tributaries that supply water to up-land people in Bishnupaduka and to the municipality, institutions and individuals down stream.

Tamakham Khola: About 90% people (60 households) in upstream of Bishnupaduka-7 have access to water from Tamakham Khola and this was done with support from UNICEF in 1986.
**Pakuwa Khola (Upper Pakuwa):** Water in Pakuwa Khola have a significant value in terms of water uses. For examples, three pipelines of diameter 40 mm each are used in water tapping. Of these, two pipelines have been used by Karkichhap Community in accessing water for about 90% households. According to communities, there is no scarcity of drinking water and irrigation facilities. Lack of irrigation facility is not due to unavailability of water in Pakuwa but due to lack of infrastructures. Likewise, they do not have water tanks and treatment tanks. Another pipe line is supplying water to Jorsokuwa community downstream (about 650 households) in Dharan-16. The agreement between Karkichhap Community and Joresokuwa is for 13 years and in the agreement conditions like NRs. 1500/- for the watchman of community forest and volunteers are included.

Jorsokuwa community also gets water from Khahare Khola through two pipelines of diameter 40mm each without any agreements between them (Jorsokuwa community).

**Pakuwa (Lower Pakuwa):** Two pipelines of 63mm diameter each supply water from Lower Pakuwa to Dhara municipality of wards 11 and 17 in downstream. About 60,000 LD (liters per day) water in wet season and 30000LD in dry season is drawn from Lower Pakuwa. About 850 households, 3 Balbikash Kendra and 1 Primary school gets the benefit with this supply. Likewise the other beneficiaries of the sources in midstream are Devimarga in DNP-13 and Sumnima marga in DNP-16, etc

**From Sources in Upstream to Communities in Upstream and Institutions/Individuals in Downstream**

Nisane Khola, a medium tributary of Sardu, supplies water to: a) Phusreline community in downstream, b) Shree Kali Box Army Gan (Engineers unit) and army schools in downstream that lies in DNP-13 and c) Community in Shikharbas in upstream (Table 3.9).

About 25 houses in Phusreline are being benefited from Nisane Khola water. They get only 8000 liters in a day in dry season (Dec to May) and enough water in wet season (rest of the year). Further, Army Gan has water tank of capacity 20,000 liters to collect water from Nisane Khola. According to administrative source of the Gan, it requires 12 hours to fill the tanks in dry season and 8 hours in wet season. It shows that about 2083 liters water is received by the Gan in dry season and about 25000 liters in wet season daily. During wet season there is overflow of water in Gan, however, water demands around the catchments and upstream has been rapidly increasing in Nisane catchment. Conservation practices in the catchment have been inadequate as per the field observation. As a result, the water availability in Nisane catchment has been threatened.

<table>
<thead>
<tr>
<th>Major Tributaries</th>
<th>Water Yield (in lit/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td>Kalimati Khola</td>
<td>0.61</td>
</tr>
<tr>
<td>Nisane Khola</td>
<td>195</td>
</tr>
<tr>
<td>Pakuwa Khola</td>
<td>7.2</td>
</tr>
<tr>
<td>Khari, Kavre, Chunpole &amp; Kholepani</td>
<td>Not recorded</td>
</tr>
</tbody>
</table>
3.4.3 Water Demand and Supply from Sardu Watershed

Sardu and Khardu Kholas are the main stream sources for drinking water supply for Dharan Municipality. Dharan municipality is one of major regions where water from these rivers has been primarily consumed for domestic use and various other industrial processes. About 85% of the population in the municipality is connected to the water networks of which 12,328 numbers of taps are private and 302 are public taps. About 15% of the population and some institutions are still not connected to the NWSC networks. About 20 MLD water is required for 150,000 populations in the municipality as estimated in 2002 (Sah, 2002). Today the population in the municipality has reached 178,618 and water demand too has increased. Likewise, according to a comprehensive report of the JICA, the total demand is 22 MLD based on the design year 2020 for only 95% of total expected population in the year (NWSC, 2005). About 196,840 are expected to have increased in the municipal by the year.

As described in the above sections, the population is expected to be about 277,365 with a growth rate of 4.43% and the water demand in dry season is expected to be 31 MLD by the year 2030.

From the above discussions and table 3.10, the water availability in the watershed is expected to meet water demand of the users in Dharan city and users within the watershed for the next 20 years and the water supply is also expected to increase from these sources if watershed is kept healthy.

<table>
<thead>
<tr>
<th>Major Tributaries that Supply Water Currently</th>
<th>Dry Season lit/sec</th>
<th>Wet Season lit/sec</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalimati Khola</td>
<td>0.61</td>
<td>0.0527</td>
<td>1.02</td>
</tr>
<tr>
<td>Nisane Khola</td>
<td>195</td>
<td>16.8480</td>
<td>278</td>
</tr>
<tr>
<td>Pakuwa Khola</td>
<td>0.63</td>
<td>0.054432</td>
<td>7.2</td>
</tr>
<tr>
<td>Khare, Kavre, Chunpole and Kholepani</td>
<td>NR</td>
<td>0.0000</td>
<td>0</td>
</tr>
<tr>
<td>Sardu and Khardu</td>
<td>280</td>
<td>24.0000</td>
<td>860</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41.5228</strong></td>
<td><strong>98.16176</strong></td>
<td></td>
</tr>
</tbody>
</table>

3.4.4 Specific to Water Quality

Water quality is of great concern in the study area. The field assessment in primary basis in terms of quality is not analyzed in this study. The secondary information specific to water quality has been considered in the assessment. Besides the literatures reviews regarding the water quality of Sardu and Khardu regions, communities, users and stakeholders perceptions about the water quality has been taken into account. Field observations on land use system in the watershed have also been considered in the assessment of the water quality.

A report says that Khardu Khola has a good quality of water16. Analytical study of the water quality of Sardu and Khardu rivers was carried out in 2002. In the analysis, the samples

---

selected from Sardu and Khardu washout pipeline point at Phusre were tested in April-May 2002. Physical, chemical and bacteriological characteristics of the water from these streams were analyzed and the results were presented. According to the results, raw waters of Sardu and Khardu Khola were potable only with respect to the physical and chemical characteristics but not with respect to bacteriological aspect. Further, standard plate count of CFU (Colony Forming Unit)/ml in Sardu and Khardu were of 2200 and 2600 respectively and were found to be unsatisfactory in terms of bacterial purity. Similarly, the total coliform count of Sardu and Khardu were of 1100 and 150 MPN (Most Probable Number)/100ml respectively that showed the Khola’s water was highly polluted and the quantities were higher than WHO standards (the total Coli-form per 100ml is close to zero). Bio-filters measures (growing aquatic plants) in the sources were recommended in that report. Likewise, land degradation had played a major role in the degradation of water quality. The processes of land uses and trends of land cover in the watershed have determined the water quality in the stream.

Risk of contamination of water is high due to lack of proper infrastructures like toilets, solid waste management system and also due to excessive use of fertilizers. About 45% families have been directly throwing solid waste in the open spaces and rivers and as a result the water in the river has been contaminated (Figure 3.14).

In the catchment area there is a great chance of contamination of water due to excessive use of fertilizers and pesticides in agriculture practices. From the household survey, it is found that about 25% of the communities in midstream have used pesticides and about 70% people didn’t want to respond on this issue (Table 3.11).

**Figure 3.14: Community’s Practices the Solid Waste Management**

**Table 3.11: Community’s Respondents About the Use of Fertilizers and Pesticides in the Watershed**

<table>
<thead>
<tr>
<th>Use of Fertilizer and Pesticides</th>
<th>Upstream</th>
<th>Midstream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5.40%</td>
<td>25.50%</td>
<td>16.80%</td>
</tr>
<tr>
<td>No</td>
<td>24.30%</td>
<td>64.70%</td>
<td>5.00%</td>
</tr>
<tr>
<td>Don’t know</td>
<td>70.30%</td>
<td>9.80%</td>
<td>78.20%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

During the field survey, the assessment was carried out on the perception of local people about water quality in Sardu River. Their responses have been classified into three categories and those are: Good, Moderate and Poor (Figure 3.15). Only 27% of total people in the watershed said that the water quality was good till date. About 33% of the people don’t know about the water quality they use. They have little or no knowledge about water quality.

The above discussion shows that the fecal bacteria contamination in the sources is highly probable. The results do not harmonize with the existing situation of the water quality in these sources as it has been accepted that physical, chemical and bacteriological constituents content in natural water vary from time to time. In particular, water quality depends on flood, acid rain and land use practices and human” interventions and behaviors and people’s understanding about the watershed. Likewise, water quality also depends on global climate change impacts on local weather patterns. Such factors have been observed in the watershed. Further, significant uses of fertilizers and pesticides (particularly on Sim Sag in Sardu and Khardu Kholas) and disposal of chemicals, discharge of domestic wastewaters and drain waters without treatment are the major causes of contamination of the rivers. In addition to these, contamination risks increases due to leakage through pipelines and inadequate maintenance of the distribution network. Here, NWSC has estimated that about 30% of supplied water is lost due to leakage.

3.5 Conclusions

Degradation of forest due to mass sliding and shifting cultivation is predominant in the midstream region. The forest coverage in terms of quantity seems to be well but the plants controlled soil erosion and hold of water quantity is not satisfactory at present in the watershed. This is applicable mostly in the upstream and midstream regions. The forest coverage in downstream of the watershed is significant but the loss of timber trees from the region is a major issue. Likewise, the area under agricultural use has decreased from 992 ha to 733 ha during the last 32 years. The decrease in cultivated land is due to varies reasons like lack of irrigation facility in upland, low productivity of soil, cultivation on steep slopes terrain, shifting cultivation practices, decreasing supply of agriculture laborer, lack of technology and knowledge about high values crops, etc.

Ecologically, the watershed varies from flat region to poorly erodible region in the mid hill. Similarly, the conventional tillage cultivation practices are extensively observed in both steep and high steep slopes. As a result, the watershed loses its fertile soils by 65.39 ton/ha yearly but it is expected to decrease by 32.74 ton/ha/yr if conservation programmes are adopted in the watershed. The watershed area can be developed for agro-forestry on the lands of slope less than 60% and the area of slope greater than 60% should be strictly prohibited against any human activities as these types of lands are considered to be fragile to extreme erosion hazards.
So far as the floods are concerned in Sardu Khaola, the number of flooding years in monsoon season has comparatively been decreasing but the chances of occurrence of the uncertain floods is high. The uncertain floods will increase the chances of disasters in the flood zones and landslide in slope regions of the watershed. Further, the number of years of having rainfall below than normal has increased in the last 33 years. As a result there is a decrease in the runoff yield in the Sardu River during the dry season.

The hydrologic condition of Sardu River implies that it is likely to face a lot of impacts of climate change. In the context of withstanding the climate change impacts, integration of DRR into Climate Change Adaptation (CCA) is a prerequisite. In regards to the relationship of vegetation coverage and the water yield in the watershed, runoff water in post-monsoon depends on the vegetation coverage (bushes, non-deep root plants, canopy) in the catchments whereas water yield in winter depends on forest practices. As per the field observation, conservation practices in the catchments have not been adequate and as a result the water availability in Nisane catchment has been threatened.

The water availability in all the major tributaries of Sardu River (estimated 42 MLD in dry and 98 MLD in wet season) in the watershed is expected to meet the water demand for drinking purpose (31 MLD in dry season) of the users in Dharan city and users within the watershed for the next 20 years if watershed is kept healthy. Water quality depends on flood, acid rain and land use practices and human interventions and behaviors and people’s understanding about the watershed. In addition water quality also depends on global climate change impacts and local weather patterns. Further, significant use of fertilizers and pesticides (particular used in Sim Sag in Sardu and Khardu Kholas) and disposal chemicals, discharged domestic wastewaters and sewage waters drained into the rivers without treatment, and contamination risks due to leakage of pipelines and inadequate maintenance of the distribution networks are factors that have deteriorated the water quality in the recent years.
Chapter 4

Bio-diversity Condition in the Watershed

4.1 Introduction

Eastern Nepal is very rich in biodiversity due to humid climate, altitudinal variation and drainage with many streams and tributaries of rivers. On the basis of vegetation, forest of Nepal is divided mainly into three zones viz. Tropical and Sub-tropical, Temperate and Alpine and Sub-alpine zones. Tropical and sub-tropical zone include Terai, Siwalik Hills, Dun Valley and the southern slope of Mahabharat range. They are below 2100 m. elevation and dominated by various deciduous trees and shrubs.

Shardu watershed area falls on the tropical and sub-tropical zone and is dominated by broadleaf Quercus forest and Karam forest at different elevations. Vegetation study of Shardu watershed area was carried out by the process of “Rapid Biological Assessments” (Primack, 1998 where it is not possible to collect and report all of kind plants and animal species), however, attempt has been made to include all the common species found in the watershed.

4.2 Floral Diversity

The upper region of the watershed area is dominated by Quercus lantana (Banjha) and Macaranga indica (Maledo) tree plant and Nephrolepis cordifolia (Pani amala) and Hedychium sp. (Saro) shrub and grass plants. The lower region is covered with Trewia nudiflora (Pithari) and Adina cordifolia (Karam) tree plants and Lantana camara (Banmara) and Woodfordia fruticosa (Dhaero) shrub plants.

From the Rapid Biological Assessment and information collected from the local people, members of community forest user groups and foresters the table below of the flora and fauna of Shardu watershed area was prepared.

Table 4.1 reveals that the watershed is rich in floral diversity. The Shardu watershed area has 147 species of vascular plants. There are 130 species belonging to dicotyledons, 12 species of monocotyledons and 8 species of pteridophytes. On the basis of their uses, there are 28 medicinal plants, 29 edible plants (vegetable/pickles/fruits) and 20 timber plants listed. The details are in the annexes (6, 7 and 8).

<table>
<thead>
<tr>
<th>Plant Types</th>
<th>No. of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular Plants</td>
<td>147</td>
</tr>
<tr>
<td>Dicotyledons</td>
<td>130</td>
</tr>
<tr>
<td>Monocotyledons</td>
<td>12</td>
</tr>
<tr>
<td>Pteridophyta</td>
<td>8</td>
</tr>
<tr>
<td>Medicinal Plants</td>
<td>28</td>
</tr>
<tr>
<td>Edible Plants (vegetable/pickles/fruits)</td>
<td>29</td>
</tr>
<tr>
<td>Timber Plants</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: Field Survey, 2009
The main functions of the vegetations of the watershed area are as follows:

- Vegetation makes the soil moist and covers it and prevents excessive evaporation of the soil water;
- It reduces the hit force of the rain water and prevents natural soil erosion and keeps the soil particles intact;
- Plant’s root binds the soil;
- Vegetation regenerates new layer of soil from its dead parts;
- It provides basic need of livelihood to the local people;
- Plants purifies water;
- It maintains ecosystem and food web by providing clean water, food, fiber and habitat for species and communities; and
- It increases water percolation capacity of soil by aerating soil particles.

Besides the wild vegetation there are numerous cultivated plants in the form of vegetables and crop which play an important role for the sustainability of ecosystem of the watershed area. The landscape is not apt for paddy production because of steep lands and gravel soil. Therefore, main agriculture productions are maize, millet and vegetables like radish, cabbage, Indian mustard (Rayo) and ginger. The common crop and cultivated plants (41 in numbers) are listed in the Annex 8. At the lowland region, Rorippa nastrurtium (Sim sag) is cultivated. It is the main source of income of denizens of that area.

4.3 Fauna Diversity

During the study period the different kinds of fauna were found and those are listed below (Table 4.2) on the basis of their class. Sardu watershed area does not have dense forest and is not a suitable habitat for big wild animals and birds. However, these animals are chief components of the ecosystem of the watershed area. The list of fauna available in the watershed is given in Annex 9.

4.4 Conclusions

Non-Timber Forest Products (NTFPs) which are available in the watershed should be promoted for ensuring not only the needs of the poorest but also wishes of Dharan civilians and others. For this, attention should be given to develop village level development plans in a collaborative approach to promote NTFPs. Community Forest User Groups should be institutionally, financially, economically and socially strengthened. A harmonized relationship ought to be developed between forest users groups and other stakeholders, along with symbolic relationship for socio-cultural life, especially of indigenous ethnic groups in the watershed. The relationship should be based on 3Es approaches (ecology, economic, and equity) at the community level project site. Likewise, native/indigenous plants should be used in conservation and protection of soil and water. The plants should also be used for landslide control using bio-engineering technology. Cereal food product’s promotion is not recommended in the watershed.

<table>
<thead>
<tr>
<th>Animal Types</th>
<th>No. of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammals</td>
<td>8</td>
</tr>
<tr>
<td>Birds</td>
<td>26</td>
</tr>
<tr>
<td>Reptiles</td>
<td>14</td>
</tr>
<tr>
<td>Amphibians</td>
<td>5</td>
</tr>
</tbody>
</table>
Chapter 5

Economic Valuation of the Services and Major Benefit-costs

5.1 Introduction

As mentioned earlier, this watershed is very important for providing drinking water to Dharan Municipality. It also provides facilities and benefits like maintaining biodiversity, foods and fodders, fuel wood and timber, herbs and other NTFPs, carbon sequestration, aesthetic/recreational, water for irrigation downstream etc.

However, with the changing landscape in the watershed, degrading quality due to increasing pressure over its resources and improper management in the upstream, the downstream water users especially the people in Dharan Municipality are facing the problem of water shortage and are insecure about the future of water supply. Further, the quality of water is deteriorating and is found to be unsafe. This may be due to pesticides and open sewerage used in and around the upper catchment area. Efforts were made in the past to relocate the watershed residents to Morang (see chapter one) but there are still people living in the watershed. The inhabitant of the watershed and people living in the central region of Dharan city are dependent on this watershed for fuel woods, fodder, woods for building purposes and other minor resources. As mentioned in the previous chapters, the observed problems are: growing population inside the watershed, increasing pressure on the watershed resources, lack of understanding of ecosystem services and lack of knowledge of the importance of the watershed and its conservation among stakeholders, lack of watershed management authority and poor or no coordination between watershed residents.

Thus, there is urgent need of a mechanism to conserve this watershed mainly for the drinking water supply of Dharan Municipality and also for promotion of livelihood of marginalized communities. This chapter intends to provide a tentative estimate of economic value of selected goods and services directly used by people in and around the watershed and also explores on the opportunities of implementing PES in the Watershed.

5.2 Economic Valuation: Lessons Learned

Economic valuation methods place consumer's preferences in the center and thus ecosystem goods and services are valued by people are based on the welfare they obtain from them. Economic valuation of a natural ecosystem helps policymaker quantify in economic terms their relative importance, and thus, in deciding the level of investment for their conservation. From the economics viewpoint, investment for conservation would go on increasing until per additional unit cost returns the benefits worth more than or equal to that and has no incentive to invest more beyond that point. However, this principle would not be applicable when there are no choices and alternatives sources for drinking water available for
the target people in the project. Thus for analyzing the aggregate costs and benefits from goods and services, through Total Economic Value (TEV) framework, an appropriate managerial policies can be devised for effective management that benefits both society and the health of the ecosystem.

Goods and services are traded in the market and their economic value is indicated by the market price. However, in case of environmental goods and services which are often not traded in the market or are traded in the imperfect markets, their true economic value is underestimated. Inadequate recognition of the true value of an ecosystem is because of the lack of attention by the policymakers and managers who take management decisions are tilted in favor of environmentally degrading practices. It usually results in inefficient resource allocation and thus, depletion, degradation and overexploitation of the environmental resources which eventually lead to loss of social welfare (Barbier, 1991). Over the past few decades, economic valuation of non-marketed ecosystem goods and services has received much attention, yet it remains as a challenge and work is in progress (Krchnak, K.M. 2007). For example, it is often difficult to measure reliably the services like natural hydrological functions, sustainable upstream agricultural practices and associated protection of downstream areas against flooding, sedimentation etc. Several tools and techniques have been devised and used widely for valuing the non-market benefits, and costs associated with the environmental and natural resources (Farber et al., 2002). It includes tools like avoided costs, replacement cost, factor income/effect on production, travel cost, hedonic pricing, etc.

Economic valuation of the ecosystem’s goods and services is relatively a new concept, especially in the developing world. Review of available literature on economic valuation shows that very few efforts on the topic have been made in Nepal. Some of the related studies in economic valuation in Nepal are those by Karn, 2007, Emerton and Iftikhar, 2006; Kanel and Sigdel, 2004; Karki, 2002; Kanel and Varughese, 2000; Houghton and Mendelsohn, 1997; Ujjwal, 2000; etc. These studies have used different methods of valuation for traded and non-traded goods and services, depending upon availability of resources and information. For this study, only the direct and indirect use values are given priority and estimated while other values were explored based on availability of time and resources. For the goods and services that are commercially traded in the market, their values are determined from market prices and for those goods and services which are not traded in the market, the opportunity cost of time they spend in extraction of resources is used.

5.2.1 Valuing Goods & Services

Forest goods especially the non-timber forest products which are collected and consumed for subsistence or informally traded are valued using a range of tools and techniques based on the particular context; some examples are Shone and Caviglia-Harris, 2006; Mahapatra and Tewari, 2005; Delang, 2006. As many of the NTFPs are not traded in the established markets, estimating their value is often harder than that of timber benefits. Most commonly extracted forest ecosystem products from Sardu watershed are firewood, fodder, herbs, timber, etc. These goods are usually collected for household use while some of these resources are traded in the local and distant markets. Valuation work in this study considers the total reported quantity of resources collected legally or illegally. For the traded goods, market prices are
available and thus, often stumpage price\textsuperscript{19} is used to value them. The cost of extraction and transportation is usually in the form of opportunity cost of labor employed in those activities and finally enters as income to the household. However, in this study the market values are directly used as the value for those traded goods which also includes the labor costs involved in their extraction and transportation, and gives gross values. For fodder which is generally not traded, opportunity cost of labor involved in its collection was used at an official wage rate of NRs. 300/- for men and Nrs. 250/- for women for eight hours a day.

\textbf{5.2.2 Valuing Water as Goods}

Water from Sardu watershed is being used for drinking, livestock and irrigation by the people living downstream. In this study, irrigation water is considered as intermediate goods that contribute to agricultural products, as well as finished goods for drinking purpose mainly to Dharan people.

The value of water to a user is the maximum amount the user would be willing to pay for the use of the resource. Currently, the drinking water is being sold by NWSC in the Dharan Municipality to people through piped water supply against a certain price per unit and the value is extracted using this information through simple accounting. This study acknowledges that value could be better captured through consumers’/users’ willingness to pay. For valuing water as intermediate goods some techniques available are producer’s demand function, residual imputation, value-added and alternative cost. The residual imputation method is one of the most prominent techniques employed among them. However, due to limited information, this study estimates its value addition in productivity of major crops.

\textbf{5.3 Economic Value of Water and Other Resources from Sardu}

\textit{Drinking Water:} As mentioned in chapter 3, major user of water from Sardu watershed in the downstream is people in Dharan Municipality. It supplies water through 12,328 private taps and 302 public taps and covers about 85 percent of the municipality population. Though most of the people living inside the watershed also use water from this watershed, there is no structured and organized system and no good estimate available for water amount used and costs involved in tapping. Thus, only the recorded amount of water value by NWSC is taken as the water value. In recent years (2065/066), NWSC made a gross income of NRs. 26,116,666/- from water and spent about NRs. 23,999,259/- making a net profit of NRs. 21,17,407/- Looking at this huge gross value of water, there seems to be a possibility of making larger net profit through reduction in expenditure for extraction and improving the system efficiency.

\textit{Irrigation water:} Sardu watershed currently contributes irrigation water to about 1111 ha of land in up, mid and downstream areas. Though it contributes water to cultivation of various crops, paddy is the major crop cultivated utilizing irrigation water and thus, its value is estimated for only this crop. Water used in paddy adds value of about NRs. 21,40,924/- per annum.

\textsuperscript{19} Market price net of extraction and transportation costs
**Fodder/Forage:** People living in and around the watershed collect fodder and forage worth NRs. 1,76,280/- per annum. This cost is based on the estimated value in the local market which is much less than the opportunity cost of time they spend in collection. Likewise, the value of fuel woods collected from the watershed is estimated at NRs. 2,50,686/- per annum.

**Pebbles/Boulders:** Pebbles and boulders from Sardu River are collected in huge amount per day. The costs and benefits of such collection from the river in the downstream is a topic for special investigation. Its ecological impacts are not clear and at the same time there are some pragmatic benefits in terms of lowering the river bed that contributes to restraining water from overflowing out of the river. As an immediate benefit in monetary terms to downstream people and local government, money is collected daily for at least eight months a year which amounts to about NRs. 36,480,000/- per annum. The major beneficiaries are contractors, people (the users) and local government DDC/VDC which contracts out the collection of these goods. Economic values of the direct use services are summarized in the table table 5.1.

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Upstream</th>
<th>Midstream</th>
<th>Downstream (NRs/yr)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water</td>
<td>602350</td>
<td>1290750</td>
<td>26116666</td>
<td>26116666</td>
</tr>
<tr>
<td>Irrigation water</td>
<td>89200</td>
<td>68080</td>
<td>247824</td>
<td>176280</td>
</tr>
<tr>
<td>Fodder/forage</td>
<td>60686</td>
<td>132400</td>
<td>57600</td>
<td>250686</td>
</tr>
<tr>
<td>Fuel Woods</td>
<td>36480000</td>
<td>36480000</td>
<td></td>
<td>36480000</td>
</tr>
<tr>
<td>Pebbles and Boulders</td>
<td>752236</td>
<td>1491230</td>
<td>62921090</td>
<td>65164556</td>
</tr>
</tbody>
</table>

**Timber:** Besides the above mentioned resources, local people also get benefit of timber which is required for household purposes, though its cutting and collection is illegal. Further, there are community forest groups who take care of trees’ and thus trees are not collected commercially these days and no effort is made to assign a value to whatever is being collected.

**Recreational Value and Regulating Services:** Recreation value also has been of great importance as it attracts large number of people to its upper catchment area (Bhedetar), wherein many hotel/restaurant businesses are flourishing. The flow of locals as well as international tourist has added additional value to the real estate in Bhedetar and this needs further exploration for better assessment of its value. Likewise, the watershed has high value in terms of protecting the downstream community from floods and the up and midstream communities from erosion and landslides.

**5.4 Major Benefits & Costs**

Though the watershed provides a large number of benefits to local people as well as to the state, efforts here are made to concentrate only on selected goods and services that are of direct relevance to local people. As the aim of this study was to develop a plan to improve drinking water supply to Dharan city, water provisioning service and some goods of daily life requirement such as fuel wood, fodder, herbs, sand and boulders, timber, etc. from the Sardu river and other minor products are considered in this study.
Nepal Water Supply Corporation (NWSC) collects water from the watershed through a reservoir constructed inside the watershed area and supplies to the people in the Municipality. It does not supply to some newly settled communities at the slum areas of municipality due to lack of their property rights over the land. However, they live close to and depend on watershed area for fuel wood and fodder and thus have stakes in the watershed conservation. Similarly, this watershed also offers a beautiful scenic view with its natural green landscape. It attracts a large number of visitors to a small market called ‘Bhedetar’ located in upstream area of the watershed.

Currently no attention has been given to conservation efforts of the watershed and no organization seems seriously involved in it. However, some local NGOs were interested in this issue and made efforts to seriously look into it with the support of IUCN Nepal under Global Trust Fund (GTF) program of DFID. Through their efforts, a committee named Dharan Integrated Watershed Conservation and Water Supply Management Committee (DIWCWMC) has been formed with representation from all the stakeholders, local government from different sections of the watershed area, private organizations and community forest user groups.

This assessment couldn’t identify any significant cost involved in this watershed management. However, there would be huge opportunity costs to watershed residents if they are to change their land use system from current practices to conservation practices that results in better hydrological services (assessment of agri. benefits currently). As described in chapter 3, upland’s communities are cultivating slope lands, using chemicals haphazardly in agriculture and exploiting the forest resources unsustainably. Under the desired scenario (which needs further exploration and study) that would result in expected hydrological benefits for downstream communities, the watershed residents would have to change their agricultural practices and adopt conservation activities and that would involve huge costs. In watershed management, it becomes an important issue to determine the type of land use that can generate desired hydrological benefits eligible to receive compensation.

5.5 Conclusions

The important services available in the watershed are: drinking water, irrigation water, fodder/forage, pebbles/boulders, timber, recreational value and regulating services. The economic valuation of these few goods and services being utilized currently indicates huge potentiality of capturing a part of these benefits for implementing some kind of innovative financing mechanism including PES. The system can become self financed and sustainable if appropriate mechanism can be set for capturing the benefits and utilizing them for the conservation of watershed. This can be done by providing incentive to those who have stake in management or who depend on watershed goods and resources for their livelihoods. In addition, the economic values from recreational services and regulating services, which need further exploration for better assessment of its value, could also be utilized for the conservation of watershed resources.
Chapter 6

Services Management: Gender and Social Inclusions

6.1 Introduction

Gender refers to the socially constructed roles and responsibilities of men and women in the society. These roles and responsibilities may be different and influenced according to diverse cultural, political, environmental, economic, social and religious background. Gender roles can be alerted if societal values can be modified. It also can vary among cultures at any given time and can vary within a culture over a time. Gender and Development (GAD) perspective emphasizes that while sex is biologically determined, gender is socially or culturally determined.

Globally, the concept of GAD emerged during 1980s. Government of Nepal has prioritized gender issues for sustainable development from the sixth plan (1980-85). Although seventh, eighth, ninth and tenth plans have committed gender equality and women’s empowerment in development programme, tangible achievement has not been seen in sustainable development field.

Gender analysis in the watershed management looks at how women and men are involved in managing land, water, forest, pasture and other natural resources conservation practices. Similarly, it focuses on their degree of access to control natural resources and decision making processes. It can help to explore the relationship between women and men in the watershed management and open avenues and opportunities for achieving equity between them in the watershed management and its development.

This chapter provides a brief overview of the gender status in Sardu watershed area. The analysis is based on field observations, focus group discussion and key informant interviews.

6.2 Gender Role in the Watershed in Different Aspects

6.2.1 Household Activities

Study reveals that women are more responsible and spend significant time to gather forest products including firewood and grass and also to fetch water as they have an important role in household chores. Women of the study area reported that men don’t spend much time for these activities because they have to leave the house early in the morning in search of work. In only rare cases they help in such activities. This situation applies to both upstream and downstream communities of the watershed area. Women of both upstream and downstream communities reported that they had to travel farther in search of fuel wood and fodder due to lack of accessibility of such recourses in nearby zones.
6.2.2 Land Management

Women’s involvement was found to be greater in land management and agricultural production as compared to their male counterparts in the upstream communities. In most cases, women contributed more hours and performed more tasks than men in agricultural production and they are the primary food producers for their families. Similarly, women have a great role in preserving and conserving croplands in the study area.

6.2.3 Conservation and Preservation of the Resources

Women of the watershed areas tend to have more interest as they have better knowledge in preserving and conserving croplands, planting and protecting forests and other natural resources for perpetual use because they have to get involved more in comparison to men in land management, firewood collection, livestock raring and fetching water.

6.2.4 Economic Activities

The upstream watershed area is the habitat of lower middle class families. People do not have sufficient land and the productivity of land is also not satisfactory because of steep topography and soil erosion. So, the major occupation of the male members of the village is either to go to Arabian countries or to work as a labour in Dharan city. Almost all men work as unskilled labour and some as labour contractors in construction companies in the city. The major occupation of females is to make local wine known as Rakhi in local language. However, the trade is not so beneficial; most of the women are engaged in it because there is no alternative. Lots of firewood is needed while making wine and women have to spend lots of time in collection of firewood.

Generally it costs NRs. 20/- per kg for “khudi” which is the raw material for the manufacture of local wine and they will get NRs. 20/- to NRs. 30/- per bottle (sher in local language) according to quality of the wine. Although the trade is not so beneficial but bi-product can be used as fodder for piggeries. Beside this trade, few of the women are involved in animal husbandry. According to the local people major cause of low involvement in animal husbandry is the lack of sufficient pasture land.

In the lower parts of watersheds, the inhabitants belong to lower class families where people do not have their own land. Therefore, the major occupation of the men is unskilled labour work as of upstream and few are found to be working as a driver in Dharan municipality while women are often heavily involved in stone breaking for construction.

| Table 6.1: Time Contribution for Different Activities in Hours Per Day by Male, Female and Children in the Watershed (US = Upstream; MS = Midstream; DS = Downstream) |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Contribution for                          | Adult Male US   | Adult Male MS   | Adult Male DS   | Adult Male Avg  | Adult Female US | Adult Female MS | Adult Female DS | Adult Female Avg |
| Agriculture Cropping                       | 9               | 7.4             | 8.6             | 7.4             | 8.7             | 5.8             | 6.8             | 6.9             |
| Construction                               | 1               | 8.5             | 8.5             | 8.5             | 0.3             | 10              | 8.4             | 8               |
| Livestock                                 | 5.9             | 3.9             | 3.9             | 3.9             | 5.6             | 3.8             | 2.2             | 3.5             |
| Fetching Water                            | 2               | 2.6             | 2.6             | 2.6             | 0.4             | 0.8             | 2.4             | 2.3             |
| Firewood Collection                        | 4               | 4.4             | 4.9             | 4.4             | 3.6             | 3.8             | 6               | 5.3             |
| Grass Collection                          | 3.7             | 2.8             | 3.2             | 2.8             | 3.1             | 2.5             | 5.4             | 3.2             |
|                                              |                 |                 |                 |                 | 3.4             | 1.5             | 0               | 2.3             |
|                                              |                 |                 |                 |                 | 0.3             | 0.4             | 1.3             | 1.1             |
Women are heavily dependent on Sardu River for raw materials for their survival. In few cases they are involved in animal husbandry, sewing cloths and other income generating activities. The communities contribute significant time for different works particularly for cropping, constructing, grazing livestock, fetching water and collecting fuel wood and fodder.

In both upstream and downstream of the watershed area, men and women are involved in economic activities but the earning of the men is higher than that of women even if they are working in the same field. It was found that men shared their earnings for household purposes. Some of the women reported that men were always dominating as they felt that they were the main breadwinners of the family and earned more than the women.

6.2.5 Decision Making Process

Decision making process is one of the key factors to know the gender status in the household and the community level as it plays a vital role in people’s participation in utilization, conservation and preservation of natural resources. Here, efforts have been made to analyze the gender status within the households and communities with special emphasis on women’s decision making process as compared to their male counterpart. This was done on the basis of responses obtained in the focus group discussions and key informant interviews about different activities.

Table 6.2 reveals that in most of the decision making process, both men and women play equal roles whereas in some cases like decision about firewood collection, water fetching, fodder collection, participation on community meeting, awareness campaign and involvement in CBOs, women have greater role than men.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Male</th>
<th>Female</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household Activities (firewood collection, water fetching, fodder collection etc)</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Economics Decisions</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Participation in Meetings</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Awareness Campaign (if any)</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Education and Training</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Production</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Marketing of the Products</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Involvement in CBO’s</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Investment</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

6.3 Reproduction and Health Situation

Women of the study areas do not have the culture of taking rest during menstruation and not even during pregnancy. In fact, they don’t inform the family members even if they are having menstruation. Key informants reported that women have to walk a lot in search of firewood, water and fodder and have to work heavily in agricultural and household activities even during such periods. Because of heavy burden on such activities some women and girls are suffering from uterus pain and in many cases they suffer from gastric problems. The health posts are located far from the villages. It is also found that young married women
cannot seek health care without the permission of their husbands or other family members. Generally they can’t pay for health care services independently.

Most of the delivery cases are carried out in the hospitals but in some cases they try it at home. Both in upstream and downstream, the level of awareness to visit a doctor during pregnancy is very high and they go for regular check up.

One of the key informants told that teenagers were especially vulnerable when it came to health related issues. There is an increased risk of unplanned pregnancy, sexually transmitted disease and unassisted childbirth as they have the practice of having sex at the age of fourteen or fifteen and marrying in teenage.

Level of awareness related to family planning is very high in Rai community, whereas in the case of Tamang community, the situation is not so satisfactory. Many of the couples in Rai community have either one or two children but in Tamang community, the number of children ranges from three to eight. Also there is no preference of son or daughter in Rai community. It is seen that many women practice permanent family planning methods in Rai community. Women of the communities said that men hesitated to adopt permanent family planning methods because of the misconception that “the body gets weak due to permanent family planning methods”

People of the study area also use different herbal plants and products in many health related issues. An herbal plant called “chanmaruwa” is especially used in jaundice and diabetes. Women group of upstream areas were involved in planting and managing different herbal plants by establishing an organization known as “Sumnima Jadibuti Utpadan Mahila Samuha (Sumnima Herbal Production by Female Group)”.

6.4 Land Ownership Situation

Most of the people in upstream are occupied in agriculture and pig husbandry whereas downstream community is landless. According to the study, most of the people working in the land are tenants and very small fraction of land is owned by them. The study reveals that female ownership of land is very little but the interesting fact is that ownership over the land increases as the age of women increases. According to key informants, almost sixty percent of household head are male and it is obvious that most of the properties are in men’s name.

6.5 Ownership of Livestock

Livestock is an integral part of farming in Nepal. Even the landless farmers raise some animals for income generation and other purposes. The study reveals that the people of the study area do not have sufficient livestock due to the lack of fodder. Some females do have goats as “Pewa”, which is their own property. People use the bi-product of local wine production as fodder for pigs.
6.6 Involvement in Social Organizations

Most of the male members of the families of both upstream and downstream areas go out of their villages in search of work. Generally, they go to Dharan and in some cases foreign countries like Malaysia, Saudi Arabia and Kuwait. Therefore, women are more involved in social organizations, community meetings, and meetings at schools and so on. Women’s incredible initiation and their involvement have been found in community works and organizations like “Sumnima Herbal Production by Female Group”. It is the best example of community organization managed by women in that area. Women of the downstream area are also found to be very active in organizing women’s group and raising voices for their rights. In fact, women are taking leadership roles in decision-making process.

6.7 Conclusions

The issues from the perspective of gender and social inclusion have been focused on health and income, awareness about the degradation and conservation of the services provided by the watershed, skills and knowledge related to watershed management and its importance and on labor contribution and wages and their involvement in the development related works.

The major issues in this regards are:

- Depletion rate of the forest in Sardu watershed area found to be higher and that is negatively affecting the health, income and work burden of women;
- Community people (both men and women) from both upstream and downstream of the watershed area are not aware about the consequences of natural resource depletion and environmental degradation. If fact knowledge about conservation awareness is virtually nil in the communities.
- Education and training related to watershed management for both men and women is absent.
- There is a huge gap in wages between men and women while getting involved in the same type of work and there is unequal participation on development related works in the watershed area.
Chapter 7

Problem Identification and Analysis of Issues in View of Conservation

7.1 Introduction

This chapter deals with an overview of the major problems and issues related to watershed services in view of conservation aspect. The concerned issues are of bio-physical, socio-economic and institutional in nature (Annex 10). The problems identified in the watershed are land degradation, water inadequacy, food deficiency, flood risks and not enough coordination between upland and down-land stakeholders. About 2300 people in upland and more than 11000 people in down land region within the watershed face the above mentioned problems. Likewise, urban community of Dharan faces the problems of water inadequacy and consequences of environmental degradation in a direct or indirect way. The consequences of these problems are reflected in the entire ecosystem services within and outside the watershed.

In general, both human and natural forces cause these problems. The human induced causes are: high livestock density in upland, free grazing feedings, over exploitation of forest products (specially for fodder and fuel wood) conventional farming practices (frequent tillage, up-down plough on slope lands), dilatation of soil fertility, shifting framings, encroachments of lands, forest depletion and weak relationships among the people living in upstream and down-stream. Meanwhile, natural forces have accelerated the problems and made it even worse. Some of the natural forces that create watershed degradation are: sensitive land system, insignificant land capability for the cultivation, erratic rainfall, floods, landslides etc.

7.2 The Problems

The four major problems concerning socio-economic, bio-physical, and institutional issues identified by the locals were:

1. Inadequate food production and poor income levels;
2. Prone to flash flood, landslides and erosion;
3. Threat to environmental services (water, forest, landscape beauty and bio-diversity); and
4. Weak linkage between communities in upland and lowland and also with watershed management stakeholders in Dharan municipality.

7.3 The Issue

In relation to the above mentioned problems, the sector wise issues were assessed and analyzed from conservation view point as well as from the aspect of watershed management and monitoring. These sectors are: lands and land use, water, forest, bio-diversity, agriculture and economy.
7.3.1 Land Use and Planning

The problems identified in the land use and its planning in view of conservation was susceptible land system, inadequate land capability for crops farming, high population density and livestock density.

**Geological Sensitive and Poor Land Capability**

The upland area around Khradu and Sardu catchments are degraded with respect to soil erosion and it varies from medium to high degradation. The upland area around midstream region is highly sensitive to mass wasting and poor consolidated geology. The lowland is highly alluvial and has depositional surface. As a result, the river channel is much dynamic. It causes bank cutting both in left and right banks in low land areas. There is a high potentiality of temporary dam formation due to falling waste in the right bank. If a temporary dam is formed there is a high risk of flash-floods in the lower regions of the watershed. In addition, the drainage density is higher in upstream region than in midstream region. As a result of high drainage density, the Sardu catchment is sensitive to erosion.

General textures of the watershed are moderately clayey, loamy and sandy. Texture of the upstream of the watershed around Khardu and Sardu regions is sandy loam whereas loam, clay loam and sandy clay loam are found around the midstream of the watershed. The permeability of the upstream of the watershed rapidly allows water to enter into the soil whereas the permeability of the midstream soil is moderate. The midstream of the watershed is at risk to landslide.

The upstream of the watershed contains acidic soils, whereas midstream comprises of acidic, saline-alkali and alkali soils. Precisely, it shows that the water and nutrient absorption by roots is comparatively lower in Khardu catchment than in Sardu catchment in the upstream of the watershed. Saline alkali is observed around Salbote region in the midstream and has low infiltration which is not suitable for growth of plants. The tillage is also difficult in the midstream region.

The infiltration category of the watershed falls on the moderate (20-60 mm/hr) in the upstream and moderately slow (5-20mm/hr) in the mid stream region. Such ranges on infiltration category are not suitable for rice cultivation from conservation perspective (DSCWM, 2005).

The soil structure of the watershed is Fine Granular and Organic Matter (OM) content is about 2.5% on an average. Permeability of the soil is medium and its class is equal to 3. Based on the soil structures, textures and infiltration category; hydrological the soil group falls on Group B, which has moderately low runoff potential. It means, these soils have a moderate rate of water transmission (Singh, et, al.1990)

The land is not suitable for agriculture farming particularly for cereal crops. All land classes, especially Class II and Class III are at risk to erosion and mass wasting if human intervention takes place without any preventive measures. Likewise, Class IV and Class V are not acceptable for any human activities. It only needs forest coverage and protection from human interference.
Land Encroachment

Human interventions in upland and flood zones within the watershed have made the watershed susceptible to environmental degradation. Likewise, livestock density in upstream is higher than the midstream and the downstream. As a result, all the regions in the watershed are physically vulnerable. The population density is comparatively higher in the midstream region than in the upstream region. But the potential of human encroachment around Bhedetar which lies in the upstream is predicted to be high if proper land use plan is not adopted.

Lack of Land Use Plan

Existing land use in the watershed region is unstable. Cutting trees, grazing and buildings made haphazardly in the flood zones have caused degradation of the land. Besides human encroachment, there is no system that has been adopted for effective and efficient land use. However, Government of Nepal (then His Majesty Government of Nepal) in 1976 tried to control human encroachment by discouraging settlements in the upland regions for the protection of the water sources but it was announced under the ad-hoc basis without completion of the legal process. As a result, human encroachment is expected to increase if there is no linkage between the upstream and downstream communities along the people in the municipality. In view of linking the upland and the lowland, watershed management act of 1982 stresses only on control of encroachment for the continuation of services. But the act has not been effectively implemented nor has it addressed the watershed management for long term sustainability. Likewise, Local Government Self Act 1998 also focuses on conservation of degraded lands. But due to lack of people's representatives in local government authority, the effectiveness of the act and its implementation is weak. In regards to land use policies in view of watershed management, the following strengths have been addressed by GoN in watershed management policy and strategy (MoPE, 2004):

- Ensure multiple use of land and water to fulfill diverse needs through rational land use planning;
- Implement integrated package programmes (vegetative, agronomic and water management measures) to tackle erosion problems taking place in the sub-watershed area as an unit of planning and management and on the basis of watershed conditions;
- Establish linkage and networking with all other related sectors like forestry, agriculture, livestock, water and land resources;
- Ensure people's participation by developing appropriate technologies and by expanding conservation extension education and demonstration;
- Adopt ways and means to minimize environmental damage during the development of infrastructures;
- Protect watersheds near hydroelectric dams, irrigation systems and riverbanks through plantation and other conservation techniques;
- Expand and institutionalize Soil Conservation and Watershed Management (SCWM) services in all districts; and
- Focus on conservation activities in the Siwaliks and other marginal lands.
However, there is still no focus on linking the upland and lowland stakeholders and in sharing the benefits from the watershed services.

7.3.2 Water Source Conservation and Water Supply Management

Water beneficiaries particularly in the municipality are facing scarcity of drinking water. Even though there are still significant water sources existing in the region, water users in the upstream are also facing the same problem along with shortages of water supply for irrigation. But the availability of water in terms of quality and quantity depends on the people’s land use practices and their involvements in forest zone in the upland region. A good understanding between upland community and beneficiaries can play a vital role in maintaining quality and quantity of water but such a relationship has not been developed in the watershed. There is no agreement between the NWSC (a major beneficiary of water use) and local communities of the upstream region of the watershed. Some facts related to water problems identified from the analysis of the study and in the ground level are listed below.

a. Challenging Water Production Due to Global Environmental Changes and Land Use Practices: Average annual rainfall over the watershed is about 1824mm which is greater than the national average annual rainfall of 1760mm. About 80% (1456mm) of the total rainfall occurs from June to September and the rest (368mm) over the year. But it varies between -29% to +45% from the annual average. So far as the water yield is concerned, water production in Khardu catchment is better in terms of quantity than the Sardu catchment even during the dry season. Infiltration through Sardu catchment is poorer than Khardu because the surface coverage by forest and bush is better in Khardu. The total volume of water yield in dry season varies from 29 MLD to 40 MLD (surface water in Sardu Khardu and Nisane catchments in upstream). As discussed above (Section 3.4.3-Water Demand and Supply), it is estimated that water requirements for the estimated population of 196840 by year 2020 in the municipality is about 10 to 20 MLD and for a population of 277365, it will be about 31 MLD during the dry season by 2030.

The water quality in the watershed depends on the flood, acid rain and land use practices and human interventions and behaviors and people’s understanding about watershed. Significant uses of fertilizers and pesticides (particular in Sim Sag in Sardu and Khardu Kholas) and disposal of chemicals, discharge of domestic wastewaters and draining water without treatment and contamination risks during leakage through pipelines, inadequate maintenance of the distribution network are likely to deteriorate water quality in the coming years. Here, NWSC has estimated that about 30% of supplied water is lost by leakage. Similarly, total coli-form count of Sardu and Khardu were of 1100 and 150 MPN (Most Probable Number)/100ml respectively. This shows that the river water is highly polluted and the quantity of coli-form were higher than that recommended by WHO (the Total Coli-form per 100ml is close to zero). Bio-filters measures (growing aquatic plants) in the sources were recommended in that report. The above discussions shows that the water required is available in the catchments but the catchment should be treated and protected from possible impacts and consequences of global environmental change.
**b. Lack of Conservation Measures of Water Sources:** Poor efforts have been made for conservation of water resources in the watershed region. 12% farmers’ use terrace farming in upland but it is not technically sustainable. Very few organizations have been involved in water source conservation and protection. Just the efforts of organizations like NWSC are not substantial enough for the conservation of water sources. As a result, about 65 ton/ha soil is lost from the watershed annually. The consequences of soil loss are reflected in the land quality for agriculture farming and water holding and infiltration. Involvements of CFUGs and water users groups in the conservation efforts are not satisfactory as they lack knowledge and have resource constraints.

**c. Non-integration of Water Sources:** Water sources in the watershed are good in number but the sources are being fragmented by different users without any scientific study. The water sources are haphazardly used by local communities including NWSC. About 5 catchments have good water sources within the watershed. But these sources need to be conserved and integrated for proper management and utilizations. Two reservoirs, one in upstream and the other in the midstream can be made for the collection and integration of water from the existing sources in the watershed. For this a detail engineering study with focus on hydrological analysis is immediately needed. Likewise, small water ponds for rainwater harvesting in the community level can be made in the upland region for irrigation purpose. Efficient water using technology should be used for optimum utilization of water from the proposed community ponds.

**7.3.3 Forestry and Bio-diversity**

As mentioned above, about 580 ha land was under forest coverage in 2009. The forest cover has decreased by about 30% in upstream since 1992. Likewise, depletion of forest in midstream region has also been observed and it has decreased by 18% in the region in the last 30 years. It shows that as dependency on forest resources is significantly high in both the regions. The dependency has increased in the recent years and it will continue to be exploited unless alternative methods are introduced to reduce dependency on the resources (follow chapter 2). Increasing human population and human encroachment on forest areas and around water sources need to be discouraged and managed with minimal impacts on biodiversity values. The fuel wood demand has been projected along with the estimated growth of population for the next 25 years and is given in the Figure 2.14.

According to the locals, forest products particularly timber were significantly lost during 1978/79 and 1989/90. It seems that forest loss has basically happened at the time of political transition. In recent years, forest products basically non-timber products like herbs, grasses, bushes, fuel-wood and litter are massively lost in the watershed. On an average 25 metric ton (MT) fuel-wood is extracted from the forest zone of the watershed daily. Similarly, grasses and litter are also unsystematically exploited from the watershed.

Vegetative cover determines the condition of the watershed in regards to erosion. Soil conservation professionals say a dense cover of vegetation is the most powerful weapon for reducing erosion (Singh, 1990). Based on the field visit and local consultations, the vegetative cover in the watershed is not satisfactory. The timber forest zone has been changed into mixed forest and then into bare lands in the region. Poor condition in view of vegetative
covers is the main problem in the watershed. Field observations and assessment of land use changes shows that controlling mechanism is not satisfactory to reduce timber cuttings, overgrazing and faulty cultivation practices in the watershed. As a result, there are poor vegetative covers that can protect against soil erosion. Some of the major reasons for loss of bio-diversity and forest cover are as follows:

- Increase in temporary settlement in the flood zone in downstream and bare-lands both in upstream and downstream of the watershed;
- Increase use of fuel-wood instead of renewable energy sources by the people;
- Dependence of people's livelihoods on selling fuel wood and river materials like stone, pebble and sand;
- Lack of forest management system by local communities; and
- Lack of government's presence to control forest loss from the watershed

7.3.4 Agriculture

Only about 18% of the total existing agricultural lands are suitable for farming but the people do practice on more than 52% lands within the watershed. The practices are intensively focused on lands of slope greater than 30% and are done without any conservation measures. The major agricultural problems identified are loss of soil fertility due to heavy erosion, degradation of agriculture lands due to high livestock density and free grazing, inadequate local institutions to address farmers' problems and low animal productivity in the upstream region of the watershed. The main causes of these problems are:

- Farmers do not believe in getting good produces from agriculture and as a result they have moved into different sectors for earnings and better life. However, they hardly get adequate food throughout the year;
- Farmers are mostly interested on goat and pig farming but they do not have enough income from the sources and it needs to be developed in a professional way;
- The cultivation practices are done without adopting any conservation measures;
- There are limitations to arable agriculture or forestry and the limitations are due to: lack of flood protections measures in the flood zones, lack of controlling measures for sheet erosions and shortfall of measures to protect and preserve the existing forest coverage;
- Lack of terracing or contouring to control erosion when used for arable agriculture and non-maintenance of ground cover for sustained forestry related usages;
- High soil erosion due to cultivation without any conservation measures and use of only traditional crops;
- High risk of flooding in low lands and risk of mass sliding is at the existing landslides zones;
- Lack of careful management for soil conservation on slopes of 15-30% when used for agriculture practices; and
- Physical handicaps like stoniness, internal drainage, soil structure and nutrient deficiency.
7.3.5 Disaster Risks Reduction

The main problem and limitations in disaster risk reduction are poor measures enforcement of the existing practices, climatic and non-climatic threats to potential assets and weak mechanism of community to enhance capacity.

**a. Poor Adoption Measures and Inadequate Community Development Mechanism:** In the upland, the measure to make soil slopes stable has not been adopted in almost all the regions. Only about 12% farmers have used terracing farming in the upland region of the watershed. But it is very poor because stability analysis including failure model and share strength has not been estimated. Likewise, it has been observed that no measures were adopted to control even sheet and rill erosions. As a result, gully erosions are increasing and it could lead to mass land slides in the upland regions. This shows that the vegetation stabilization is still inadequate to control sheet erosion. Therefore, vegetation stabilization should be made adequate to stabilize sheet erosion. Likewise, hill slope protection measures like vegetation and check dams are required to stabilize the gully floor. For this a detail bio-engineering study from the hydrological aspect is required for long run stabilization of soils in the upland regions of the watershed.

In the lowland, government-led approach for the protection from floods in downstream consists of structural measures like spurs, embankments, and gabion boxes. These measures are not sufficient to protect against large scale flooding. Likewise, community-led approaches consists of preparedness measures like community shelter houses, development of community organizations and awareness programmes but are still inadequate to cope with severe flooding.

For long term management to control flood risk in lowland, several measures can be adopted. For examples, in-migration to flood zone should be discouraged and community and science based early warning systems to flood should be established, bio-engineering measure should be adopted on the overland flow zone, systemic channeling of the main-flow should be developed and capacity buildings programmes should be conducted on a regular basis. For this a master plan for Disaster Risk Reductions (DRR) for Dharan municipality including its surrounding areas is immediately required.

**b. Climatic and Non-climatic Threats:** Climatic threats particularly due to consequences of global warming are considered a great challenge to the watershed and its surroundings, particularly to Dharan city. Furthermore, past climatic trends (see details in previous chapters) shows that the frequency of rainfall below normal is greater than above normal but the occurrence of such situation is not certain for any particular year. As a result, the assets particularly natural, physical and human assets are threatened in the watershed and its surroundings including Dharan city. Natural assets like land productivity, rehabilitation of lands and forest coverage are threatened in the watershed. Likewise, physical asset like availability of water has great variation due to temporal rainfall patterns in the watershed. Meanwhile, other human assets like psychological strength and knowledge have also been threatened by climatic variability in the watershed.
Additionally, consequences of global warming on normal climate system would be of great challenge to the watershed services. In this context, Government of Nepal has been exploring the impacts of such consequences. For example incidence of extreme weather events such as droughts, storms, floods/inundation, landslides/debris flow and soil erosion is expected to increase in the country (GoN 2008). Particularly, Bhabar regions will be more prone to flash floods from the rivers that originate in the Churia range. These rivers frequently change course and deposit sediments on the river bed. In this connection, future risk to climate change impacts on climate sensitive areas in the watershed needs to be studied. Meanwhile, non-climatic threats like weak institutional mechanism, fragile geo-morphology, overexploitations of natural resources particularly lands and forest in the watershed have made the watershed susceptible to sudden extreme weather events. A detail study is required to obtain specific climate change impacts on watershed services in the watershed.

7.4 Conclusions

Whatever problems mentioned above in each sector are workable and the issues are manageable locally because the resources needed for addressing the problems are expected to be obtained from watershed’s services itself. For example, watershed is itself generating huge income only from water services. About NRs. 2 million is the annual income recorded by NWSC in existing condition by providing water service only from the upstream region of the watershed. But these income figures will increase if the accessible water that is available is exploited effectively. Likewise, other services like timber, fuel wood, agriculture, recreational services, herbal service and river resources are the key that could provide huge financial gains if their services are capitalized in a professional way (chapter 4 & 5).

The problems are also addressable in terms of improved agriculture practices, reduced dependency on forest resources, improved infrastructures facilities especially for soil stabilization through bio-engineering and efficient irrigation system, increased economic opportunities through herbal plants and vegetable produces and proper land use in the upstream and downstream regions. In fact these problems and issues provide a basis for developing the appropriate policies, strategies and programs which are discussed in the next chapter.
Chapter 8

Proposed Programmes: Locations, Policies, Strategies and Activities

8.1 Thoughts

The watershed conservation plan is conceptualized based on the vision proposed in chapter one. The vision ‘Sardu Watershed is proposed as a Heart of Dharan City” is perceived on the functions of a heart which includes the ideas mentioned below. The basic concept is that the watershed resembles a heart to address the problems and issues described in Chapter 7 (Table 8.1).

- It is a heart that pumps water for Dharan city;
- It is life giving as it supplies food/energy for upland people and fresh air for all;
- Primary health of the communities are taken care by the watershed;
- It is a home that protects us from outer changing condition (e.g. global environmental change).

In addition, the land has been proposed for conservation and development purposes. For this, the watershed area has been classified into five classes based on its land capability (chapter three). These lands classes emphasizes on agriculture and forest promotion, development and uses. The programmes proposed below complement the vision of developing a heart for Dharan city by integrating conservation and development activities. The proposed programs are visualized in the Figures 8.1 and 8.2.

8.2 Purpose of the Program

The proposed programs are expected to promote ecosystem services that enhance community’s resilience for sustainable development and DRR and harmonize the linkage between the upland and lowland stakeholders and people in Dharan city.

<table>
<thead>
<tr>
<th>Heart</th>
<th>The Sardu Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veins</td>
<td>Tributaries (Simle, Chhotimorang, Nisane, Kalikhola, Pakuwa and Khardu)</td>
</tr>
<tr>
<td>Aorta</td>
<td>Sardu and Khardu</td>
</tr>
<tr>
<td>Auricle</td>
<td>Forest Block: Upland (Bhedetar, Panchkannya and Bishnupaduka)-Water flows down</td>
</tr>
<tr>
<td>Ventricle</td>
<td>Forest Block: Lowland (Charkose Jhadi)-Fresh air goes up</td>
</tr>
<tr>
<td>Blood</td>
<td>Water</td>
</tr>
</tbody>
</table>

Table 8.1: Resemblance of Sardu Watershed as Heart

Figure 8.1: Existing Land Use of the Watershed

Figure 8.2: Proposed Land Use of the Watershed (See Annex 12 for details)
8.3 Proposed Land Use

Land use study is of fundamental significance, since land resources play a strategic role in the determination of people’s economic, social and cultural progress (Bhandari, n.d)\textsuperscript{20}. In this context, the suitability of land use policies have been proposed after examining the existing land use conditions and exploitation of services and the land capability based on its slope criteria and other land features (Figure 8.1 & 8.2). The land within the watershed cannot support the settlement with its population growth for the next 15 years and upland and flood affected zones in lowland is not suitable for human settlement. However, attention must be given for new settlements with the ever increasing households within the region. It is proposed that existing built up areas having high flood risk and fragile erosion areas should be immediately taken care of by using bio-engineering practices. A master plan on land use for the next 15 years is required to sustain the population density and to protect areas where there is permanent vegetation cover (Pink and Green in the map) and high flood risk zone in the lowland against human encroachment.

\textbf{Figure 8.3: Proposed Programmes for Sustainable Sardu Watershed Management}
8.4 Proposed Programmes

Figure 8.3 presents eight key programmes that are proposed for a sustainable watershed management in Sardu. The proposed programmes are based on the people-driven programmes listed in the box below and are described in the sections below in terms of programs area, policy objectives, strategies and permissible activities.

The following programs are recommended by the communities to avoid dependency on the watershed so that it could be conserved in a sustainable way.

**Box: People-Driven Programmes**

1. Capacity Buildings Programs for income generation (about 60% community of upland and 54% of lowland have the same idea);
2. Options for fuel wood for energy (the options should be community affordable);
3. Capacity buildings programs for sustainable agriculture farming and cropping practices;
4. Community based controls and user system mechanism to conserve and manage watershed services (may be routing system to bring resources from the watershed on a weekly basis);
5. Settlement replacement from around the water sources (14% people of upland and 33% of low land believe that this will help);
6. Win-win approach in linking upland and lowland community issues and problems

**8.4.1 Improved Environment for Forest Conservation and Rich Biodiversity and for Sediment and Solid Waste Management**

**Areas**

- Divide forest zones into two blocks including all community forest areas: Upstream and Downstream;
- Sediment depositional zones; and
- Settlement zones.

**Policy Objectives**

- To develop and utilize forest both in municipal and VDCs areas in order to maintain ecosystem services for supporting, provisioning, regulating and fulfilling human needs (water and energy) and to maintain biological diversity and natural weather system;
- To reduce flood impacts and manage floods by developing canals for natural flow during floods and sustain flood zones management of flood zones; and
- To minimize pollution and make waste management effective in order to maintain water quality.
**Strategies**

In order to achieve the above stated policies the following implementing strategies are suggested:

- Mobilizing local people at community level for the development, management and protection of forest resources;
- Maintaining win-win policy/scheme that encourage people living in lowlands and uplands to participate in the development, management and conservation of forest;
- Decreasing community’s dependency on forest products especially fuel wood and fodder by initiating programmes like plantation of suitable species, silvi-cultural operation, alternative energy source, improved cooking stoves and livestock improvements to meet local people’s need;
- Avoiding intensive agriculture activities (cereal crops and chemical fertilizers uses) on slopes greater than 30% by providing alternatives for income generation;
- Avoiding haphazard exploitation of sediment loads and pebbles, sands, gravel by strictly making the EIA (Environmental Impact Assessment) and (IEE) Initial Environmental Examination mandatory;
- Discouraging human shelters inside the high flood risk zones and water source areas by massive plantation in flood zones and open lands and by conducting awareness programs on sensitive ecosystem and importance of watershed;
- Declaring protected zone in the upstream and downstream forest blocks (may be national park around Charkose Jhadi). The declaration should be done by mutual understanding between CFUGs, Dharan civilians and concerned authorities and also by proposing the zones around the existing water sources as reservoir location;
- Encouraging non-consumptive use of forest resources like litters for alternative energy (e.g. making briquettes);
- Encouraging ecotourism (trek track), NTFPs and agro-forestry in the slope lands;
- Strengthening capacity of CFUGs and other committees by providing institutional, financial, technical resources and advocacy mechanism;
- Minimizing pollution and making waste management effective by promoting water recycle plants before discharging it into rivers;
- Ensuring community forest’s ability to increase the natural system to sequester carbon; and
- Maintaining habitat of birds by making nests in upstream and midstream forest zones.

**Activities**

- Afforestation and dissemination of information about the benefits of medicinal plants (listed in Annex 6);
- Promotion of nitrogen fixing plant;
- Silvi-cultural operations for tree improvement;
- Tree plantation for carbon sequestration (listed in Annex 6);
• Indoor wastes treatment plant program;
• Outdoor waste treatment-recycling of non-degradable wastes;
• Transition from food crop system to agro-forestry activities; both in private and community forest lands (fruit trees, timber trees, rubber tree, jatrophyte, tea etc - listed in Annex 6); and
• Nests for bird’s habitat establishment.

8.4.2 Soil Conservation, Landslide Control, Flood Management and Land Utilizations

Areas

• Existing fragile and erodible hazard zones shown in Red and Green colors in Land Capability map (Figure 8.1) and major landslide zones shown in Existing Land use maps (Figure 8.1 and Figure 3.3);
• Left and right erodible banks zones both in Bishnupaduka and Dharan municipality; and
• High flood risk zones (shown in Annex 12)

Policy Objectives

• To stabilize degraded lands in uplands by adopting measures of conservation (structures and non-structures);
• To provide natural flow to Sardu flood during flood season by channelizing the river course in a proper way (for this a detail and well planned investigation is recommended to make modification of the river bed);
• To optimize land use values and continuation of ecosystem services by adopting land capability of the watershed;
• To sustain ecosystem services from the watershed by mobilizing upland and lowland communities, other stakeholders and Dharan civilians through a common forum;
• To reduce risks from climatic change factors especially droughts and floods by integrating ecosystem service values into DRR and Flood Risk Management (FRM); and
• To encourage women participation in conservation processes and giving them a leading role in the conservation processes.

Strategies

• Adopting land suitability system and using them appropriately (suitability of land use is divided into five classes in the study. For details see chapter 3);
• Utilizing Class I type of lands for crop cultivation by adopting flood protection measures in lowland except on existing forest zones;
• Developing Class II type of lands for cultivation by terracing or contouring the slope

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lands to control soil erosion and by using conservation measures for maintenance of ground for sustained forestry related practices;

- Exploiting Class III type of lands for agro-forestry and for fodder production by terracing and controlling gulley;

- Utilizing Class IV type of lands for fuel wood, fodder and timber production and by maintaining a permanent vegetative cover to minimize erosion;

- Avoiding any human activities in Class V type of lands as these lands are considered fragile in terms of erosions and also have very poor regeneration potential.

- Developing disaster preparedness plans by incorporating watershed conservation and drainage management programs and income generating activities, early warning system and awareness creation; and

- Developing capacity of women by involving them in conservation practices particularly livestock management in a sustainable manner and other income generating activities at local level;

Activities

- Promote soil and water conservation techniques among smallholders. Some conservation techniques are: bench terrace, planting of fruit trees, fodders, bamboos, minimum tillage and mulching, grass strip cropping, Sloping Agriculture Land Technology (SALT), Natural Vegetative Strips (NVS) etc. Hydrological regime and quality promotion for co-beneficiaries of water and forest products needs to be developed;

- Land re-claming in lowland flood zones;

- Massive plantation of native plants for protection against erosion (The Best Practices of Plantation to stabilize eroded lands: A Case Study of controlling Soil Erosion and Landslide in Phusre in Sardu Watershed shown in the Box below Photo 5);

- Training on soil conservation practices and awareness activities for water conservation;

Photo 5: A Good Practice in Soil Conservation Adopted in the Watershed
(Massive soil erosion and landslides in Phusre shown in the left photo taken in 1997. Control of soil erosion and landslide at the same place shown in the middle photo (taken in 2009), gentleman (Mr. Ananda Shrestha-local inhabitant) who led such a successful operation-right).
- Preparing climate induced disaster management plans. A study on the impact assessment of watershed services within and around the Dharan city is required for a long term development strategic planning;
- Severity analysis of major landslides for controlling mass movement and promoting stability of the land surface which should be immediately carried out so that bio-engineering works can be adopted in the region;
- Propagation of vegetation;
- Promotion of Bio-engineering; and
- Developing early warning system against floods.

8.4.3 Stream & Rainwater Harvesting

Areas

Sardu, Khardu, Nisane and Simle catchments in the upstream and Kali khola and Pakuwa khola in midstream and Khare, Kavre, Chunpole and Kholepani in the lower reach.

Policy Objectives

- To conserve water sources in optimum quantity by integrating the major tributaries;
- To bring stability between water supply and water demand for long term by adopting integrated watershed management approach and also by integrating water sources and reservoir approach;
- To increase cash crops production by promoting irrigation facility through rainwater harvesting and adopting efficient and effective modern technologies; and
- To harmonize between beneficiaries in lowland including Dharan city and the upland communities by making them understanding the importance of watershed and its service in a co-benefit approach.

Strategies

- Adopting and protecting water sources by supporting conservation and community development programmes in the upland communities;
- Collecting surface and rain water from Sardu and Khardu catchments by constructing lined reservoir and expanding the capacity of existing water reservoir in Phusre (confluence of Sardu and Khardu) by maintaining gravity flow;
- Collecting surface water from Nisane catchment and mainstreaming it through gravity flow;
- Accumulating surface water from Pakuwa and Kalimati Khola by constructing reservoir in downstream. For this the Dharan municipality should lead in getting together the communities in downstream and upstream. NWSC can support in mobilizing the local water users and NGOs and may also provide technical support where required; and

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22 In the existing condition, on average 92 MLD water in wet season and 31 MLD in dry season are available in major tributaries of Sardu River
• Adopting rainwater harvesting through small irrigation ponds at community level in the upland regions (Annex 12).

**Activities**

• Massive plantation around water sources by mobilizing CFUGs;
• Construction of small ponds at community level for irrigation uses;
• Carrying out a feasibility study for lined and open reservoir constructions in collecting surface and rainwater; and
• Including all the concerned stakeholders (upstream, midstream, and downstream) in the existing platform (Dharan Integrated watershed Conservation and Water Supply Management Committee) and strengthening them through trainings, workshops, etc so that they would be able to take responsibility for sustainable watershed management in a collaborative approach.

**8.4.4 Capacity Development Programme (Livelihood Enhancement Program - Poverty Reduction - A Multi-pronged Approach)**

**Areas**

Upland communities particularly in Bishnupaduka region and lowland communities living in the slum regions of Sardu River.

**Policy Objectives**

• To empower economically marginalized communities so that they could perceive the importance of the watershed;
• To minimize discrimination between men and women in decision making process especially in lowland community by strengthening them about the importance of watershed management and their roles in conservation;
• To reduce community’s dependency on the forest products particularly fuel wood collection and stones crashing; and
• To make climate change resilient communities by ensuring services of watershed so that they could cope with risks of floods and droughts

**Strategies**

• Ensuring productivity in the watershed from horticulture, agro-forestry products and not cereal products;
• Promoting the products that gives high value and yield by using compost fertilizers and off season crops priority;
• Marketing the products through co-operative finance system at women group and farmers groups; and
• Reducing poverty by using ecological services in a sustainable and integrated way.
Activities

- Horticulture promotion by integration of diversification, value addition, harmonization and strengthening community organization and CBOs;
- Awareness creation on the issues of watershed on priority basis;
- Capacity buildings through trainings and micro-credit financing program including technical back-support;
- Professional skill development trainings for human resource development;
- Introduction of new technologies like micro-irrigation system, solar energy system, briquettes making, improving soils fertility, pest management and diseases controls techniques etc;
- Promotion of vegetable and herbal developments (provide subsidy for inputs, provide trainings on Green House Making-GHM etc);
- Integration of indigenous knowledge, gender equity and farmers decision making to promote small and marginal communities;
- Promotion of compost fertilizer (making compost pits in farmer’s fields);
- Promotion of livestock through genetically improved goats, veterinary camps and stall feedings;
- Development of plant nurseries with collaboration with Soil Conservation Wing;
- Promoting dry land farming in the upland and flood prone zones in the lowland;
- Promotion of mushroom farming for both communities;
- Production of honey by providing trainings to farmers focusing mainly on women;
- Construction of public toilets;
- Promotion of bio-mass energy and other alternative energy sources;
- Plantation of bamboos and promotion of the products produced from them; and
- Promotion of off season vegetables.

8.4.5 Open Space and Bare-land Management Programme

Areas

Areas around the left and right banks of Sardu, existing open lands that is both private and government, Dharan municipality wards 13, 16, 11, 17, and 18 and BP 7, 1, 2, 5, and 6. Area around Bhedetar, Panchkannya and Bishnupaduka zones in uplands

Policy Objectives

- To develop recreational facilities with the objective of maintaining an open space in the fragile and ecologically sensitive areas; and
- To enhance economic and social well-being of local residents and tourist in the prescribed areas.
**Strategies**

- Promoting environmentally friendly activities and maintaining wildlife inhabitants; and
- Developing a good understanding between the local residents, authorities and Dharan residents by sharing the objectives and benefits (equity basis) of the programme.

**Activities**

- Level terracing and bio-engineering works in bank cutting regions on both sides of the river;
- Development of nurseries, floriculture, and children parks;
- Awareness to discourage new settlements;
- Bio-fuel plantation and fodder promotion in the upland region; and
- Picnic spots, religious festivals and fairs and recreational activities

**8.4.6 Tourism Development**

**Areas**

Dhnan city, Bhedetar, Nisan Devi, Panchkannya, Budasubba, Bishnapaduka, Sangurigadi and other places where famous temples exist.

**Policy Objectives**

- To develop and implement village tourism processes to boost the local economy by preserving the existing natural landscape and enhancing tourist attraction sites in rural areas;
- To harmonize Dharan civilians and uphll residents by sharing and respecting their culture, religions and natural beauties;
- To develop Dharan city as an entry point and Barahchhetra (South-West of the watershed) as an exit point by promoting religious tourism and natural beauty. (For this a special study is required to assess the potentially of tourism development by networking all potential sources);
- To preserve natural landscape of Bhedetar and its surrounding hills by promoting eco-tourism and discoursing further expansion of residents towards Sardu facing landscape. (For this a special feasibility study on tourism is recommended for long term developments and sustainability);
- To develop greenery in open and barren lands in uplands of the water reservoir and promoting picnic spots in the lower reservoir (proposed in the study) by keeping a good relationship and understanding between rural communities in Bishnapaduka VDC, Dharan city civilians and authorities; and
- To develop Bishnapaduka VDC as rural tourism site by promoting foot-trails improvements and eco-friendly developments infrastructures but strictly avoiding heavy equipments uses in the developments.
Strategies

- Harmonizing relationship among rural community and Dharan community on the issue of sustainable economic activities in the regions through tourism development;
- Buildings capacity of local entrepreneurs and communities by providing education and skills training for the development of rural tourism; and
- Emphasizing foot-trails and not heavy motor-able roads throughout the uphill sites of the watershed.

Activities

- Picnic spot development;
- Greenery development;
- Recreation promotion through natural beauty;
- Foot trails improvement;
- Increase and improve infrastructures facilities particularly water supply in Dharan and Bhedetar, sewage management and toilet facilities with eco-friendly approach in Bhedetar;
- Keep records of tourists visiting the popular sites;
- Preparation of a map by including tourist sites, picnic spots, cultural sites, tracking roots etc;
- Manage Charls Tower in Bhedetar by the local community;
- Build a transportation network (foot trails) joining all the peak hills and build view tower like Charls Tower in scenic viewing sites;
- Invest in training for tourism related skills;
- Develop training programmes for small-scale entrepreneurs and income generating activities in rural sites within the watershed;
- Prepare a Tourism Management Plan;
- A special study to assess the potentiality of tourism development by networking all potential sources throughout the region in the watershed (long term activity); and
- A special feasibility study is recommended to find out whether tourism development is suitable in the Bhedetar zone.

8.4.7 Promotion of Bio-Industrial Watershed

Areas

Upland zones both in Bishnupaduka and Panchkannya area.

Policies

- To promote Non-Timber Forest Products (NTFPs) by ensuring not only the needs of the poorest but also wishes of Dharan civilians and others;
- To develop village level development plan in collaborative approach to promote NTFPs;
• To strengthen CFUGs institutionally, economically, socially and to harmonize the groups with other stakeholders;
• To give symbolic relationship of socio-culture life specially of indigenous ethnic groups;
• To promote industrial enterprises by sustainable utilizations of NTFPs that are available in the Sardu watershed; and
• To link the 3Es approaches (ecology, economics and equity) at the project site

**Strategies**

• Developing agribusiness centers, food and herbal technology parks and related market driven enterprises by collaborative approaches in active participation of CFUGs and technical institutes;
• Building capacity of CFUGs and women groups on the importance of NTFPs available in the watershed through trainings, informal education, skill development programmes and small technology promotions;
• Planning pilot programmes to exploit biological sources like horticultural crops, floricultural plants, medicinal and aromatic plants, medicinal and edible leaves, roots, flowers, fruit, seed, nuts, glue and bamboo shoots (tama) in a sustainable way by developing bio-industrial products from the biological sources; and
• Adding value addition to the products by supporting the three approaches: structural

*Figure 8.4: Triangular Relationship of Promotion of Bio Industrial Watershed in the Watershed Region*
mechanism (farm ponds, terracing lands, drainage treatment, collection centers, small cottages and industries), non-structural mechanisms (centralize CBOs, equity, decentralization and trainings) and institutional approach.

**Activities**

- Bamboo farming for two purposes: industrial purpose that can be used by paper mills and other commercial uses and daily uses;
- Trainings to FUGs and women groups;
- Promote pickle making, jatropha curcas and other potential medicinal plants listed in the annex; and
- Promote livestock production, cash crops production, fodder production, regeneration of seeds, etc;

**8.4.8 Institutional Development, Monitoring and Research**

**Policy Objectives**

- To monitor the overall objectives of integration of ecosystem management and disaster risk reductions particularly for water availability and management and ecosystem restorations;
- To restore ecosystems and natural defenses/guards;
- To monitor ecosystem services and its sustainable uses;
- To develop a resilient ecosystem by supporting livelihoods and providing human security to all stakeholders; and
- To sustain the objectives of Payment for Environmental Services (PES-Scheme) recommended in the study for sustainable watershed services.

**Strategies**

- Designing monitoring mechanism based on the project objectives;
- Giving priority to PES scheme recommended in the study; and
- Identifying indictors for watershed monitoring system. (For this, a study is required to develop the possible indicators which are suitable for the Sardu watershed to monitor the watershed in integrated relationships including institutional development indicators, social and economical indicators, natural resource use indicators, environmental importance indicators, water improvement indicators etc).

**Institutional Development Activities**

- Strengthen the multi-stakeholders platforms through technical supports, trainings, exposures visits, interaction workshop in the context of linking upstream and downstream issues regarding environmental services. (Here, Dharan Integrated Watershed Conservation and Water Supply Committee is a multi stakeholder platform that was established by this project. It includes upstream, downstream services users committee, private partners, local governments and political bodies);
• Capacity buildings through training programs to implement the PES mechanism;
• Institutional strengthening programs for community forest users groups; and
• Capacity development programs for local NGOs and CBOs

**Monitoring and Research Activities**

• Bio-engineering survey for the stabilization of slope lands to increase land capability and minimize the landslides impacts and soil erosion from a hydrological perspective;
• Installation of hydrological gauging in Sardu River for the estimation of water yield for long term water use programs for the up and downstream communities;
• Installation of meteorology station at Bhedetar which lies in the upstream of the watershed and would be used for climatic representations;
• Total economic valuation of direct and indirect use of the resources;
• Climate change impacts on bio-diversity and hydrological regimes in the watershed;
• Development of manuals for conservation of Siwalik region and its linkages to flat regions as a Case Study of Sardu Watershed;
• Development of strategic manual for the implementation of Payment for Environmental Services (PES) at the local level: A case study of Sardu watershed;
• Several workshop and trainings on PES at national and community level;
• Development of Climate Change Adaptation (CCA) strategy through Catchment management of Sardu watershed;
• A study on the assessment of watershed services around the Dharan city is required for a long term strategic planning to adopt collaborative watershed management approach; and
• Severity analysis of all major landslides for controlling mass movement and promoting stability of the land surface should be immediately carried out so that bio-engineering work can be adopted in the regions.

**8.5 Conclusions**

The programmes and implementing strategies mentioned above can be changed as per need of the stakeholders during the implementing period. The proposed activities are recommended in short term (3-year), medium-term (5-year) and long term basis. The activities ought to be carried out in an integrated approach for conservation and capacity development of the communities (given in chapter 10 and annex 13).
Chapter 9

Collaborative Approach for Sustainability of the Sardu Watershed Management through Innovative Scheme

9.1 Introduction: Major Innovative Financial Mechanisms for Conservation

This chapter deals with a brief overview of the global experiences with innovative financial mechanism including PES to give an idea of what is being done where. It also gives a view the financing scheme and implementing mechanism for the proposed programmes.

9.1.1 Public Payment Schemes (PPS)

Watershed services are often considered a public good, meaning that nobody can refuse to use them even if they do not pay for its conservation and people are often reluctant to pay if it is not mandatory. In such case, public payment schemes are relevant for common financial mechanism to protect watershed services. The government provides the institutional foundation for the conservation programs and directly invests in it and also through the fund generated by some type of fee or tax. Examples include payments for fund management activities such as purchase of permanent conservation easements; contracting farmland to set aside for conservation or change land management practices (in Europe, 14 countries spent an estimated $11 billion between 1993 and 1997 to divert over 20 million ha into long-term forestry contracts - OECD, 1997); programs to co-finance investments in afforestation or sustainable forest management (e.g. watershed management in Colombia wherein part of the fund is availed through a 6% tax on the revenue of large hydro-electric plants); and payments for the confirmed presence of endangered wildlife species.

9.1.2 Voluntary Contractual Arrangements (VCAs) Named as PES

These are self-organized private deals directly between buyers (service users) and sellers (services producers). For example, the negotiations may be between individuals or between associations of buyers and sellers, i.e. water users and upstream landowners to implement agreement upon management practices. Government intervention is very limited but sometimes very crucial especially in enforcement of property rights and contractual agreements. This kind of arrangement is very commonly known as Payment for Environmental Services (PES). This is very widely used model with contextual modifications to fit in the local situation.

With respect to PES, Costa Rica has demonstrated great success in experimenting different schemes. Costa Rica established tax-based economic incentives for the reforestation sector through its first Forestry Law in 1979, and thereafter a number of appealing and incentive based schemes have been developed incorporating learning from previous policies and
schemes and implemented over time (Watson et al. 1998; Chomitz et al. 1998, Pagiola, 2002, Rojas and Aylward, 2003). Many countries around the globe are implementing different schemes for collecting payments to finance watershed protection. For examples:

- Cauca Valley Columbia, where downstream farmers pay additional water fees for the watershed protection to ensure minimum dry season water flow (Echevarria, 2002). Japan has been charging water users to compensate upstream land owners successfully for over 100 years (Richards, 2000). The Kanagawa Prefectural Assembly adopted an ordinance in October 2005 that would impose an additional residence tax to be used exclusively for protecting water sources, with the funds going to projects aimed at conserving and restoring forests and rivers.

- In Costa Rica, where a PES scheme developed for the protection of watershed is funded by partly a fuel tax and rest amount is generated through payments from services users. A hydropower company pays US$ 10 per ha/year to a local conservation NGO for hydrological service in the Peñas Blancas watershed. In the city of Heredia, the drinking water company earmarks a portion of water sales revenue for reforestation and forest conservation.

- In Brazil, where a water utility in Sao Paulo pays 1% of total revenues for the restoration and conservation of the Corumbatai watershed. The funds collected are used to establish tree nurseries and to support reforestation along riverbanks.

- In Ecuador, where municipal water companies in Quito, Cuenca and Pimampiro impose levies on water sales, which are invested in the conservation of upstream areas and payments to forest owners (Landell-Mills and Porras, 2002).

- In Lao PDR, where The Phou Khao Khouay Protected Area currently receives 1 percent of the gross revenues from a downstream hydropower dam, and the proposed Nam Theun 2 hydropower project is expected to pay over US$1 million per year for the management of the Nakai-Nam Theun Protected Area.

This kind of arrangement also includes a NGO partnering with local people to restore degraded land. A pharmaceutical company paying for access to a certain area or for the collecting work by local people of potentially valuable organisms.

9.2 Local Experience - Nepal’s Initiatives

The most common type of conservation financing in watershed management sector is implementation of PES schemes in many countries which have been successful in most cases. However, this concept is still an emerging science in and at rudimentary stage among developing countries in general. In Nepal, few efforts towards setting up PES mechanism have been made recently. It still remains fairly a new concept amongst most stakeholders. Some of the important efforts made in Nepal includes: Kulekhani watershed conservation wherein the major water beneficiary is a hydropower and certain percentage of its royalty is ensured for the development activities in the upland communities (with Winrock Nepal’s support); Feasibility studies conducted jointly by IUCN Nepal, CARE Nepal and WWF Nepal in Churia hills region; feasibility study by IUCN Nepal in the Shivapuri National Park, Nepal;
Sardu Watershed Conservation Plan

PES related studies conducted by ANSAB; etc. Community forestry and buffer zone programs of Nepal are also PES-like initiatives as they try to provide incentive to local community to seek their efforts for conservation.

9.3 PES in Sardu Watershed: Results and Discussions

9.3.1 General Criteria for PES

There are four important dimensions for effective, efficient, sustainable as well as equitable compensation and reward mechanism for environmental services, viz. realistic, voluntary, conditional and pro-poor (Van Noordwijk et al., 2007). They are briefly described below:

**Realistic:** The basis for payment mechanism should be a real cause-effect relationship between land use changes upstream and the environmental services under trade. Many of the current PES schemes are based on correlations (e.g. between existing forest and provision of water) or assumed relations rather than on true cause-effect relationships or unproven relationships between ecosystem conservation efforts and the actual provision of valuable environmental services.

**Voluntary:** One of the important requirements of PES is that it should be a voluntary agreement between buyers and sellers. However, some local organizations often play intermediary role to facilitate the process. Buyers and sellers negotiate and agree on the nature and level of deliverables in reward agreements.

**Conditional:** The delivery of services and payment for these services should be logically related in the transaction, i.e., payments are made conditional on realization of agreed level of targeted services. In practice, many schemes rely on perceptions of services and good faith between the contracting parties. There needs to be a strong monitoring mechanism with clearly defined indicators to measure the actual supply of environmental services and determine has met if it the set conditions. For examples payments can be made per m3 of clean water derived from a watershed.

**Pro-poor:** Though the main aim of PES is watershed conservation, it has to play another role of supporting the poor in the developing world where upland people are usually poor. Though, benefit to poor doesn’t come automatically through PES it has to be planned meticulously. Ethical principles suggest that respect, tangible benefits to poor stakeholders engaged in such schemes, social justice, gender, welfare and intergenerational equity need to be considered in any rural development activity. Attention should be given to ensure additional portion of the value going to the seller where there are poor smallholders. An example of pro-poor mechanism could be to offer employment.
9.3.2 Feasibility of PES in Sardu Watershed

Following few points highlight the feasibility of innovative financing mechanism in the Sardu watershed area:

**Hydrological Linkages:** Potential beneficiaries in the downstream could be asked to invest only if some assurance could be provided that proposed management actions will result in the delivery of expected hydrological services. A quick hydrological assessment indicates that Sardu watershed produces sufficient water to meet the annual demand of Dharan people. However, the concern is over its tapping and use efficiency and sustainability. Even though a quick hydrological assessment can’t assure the increased benefits to downstream people immediately, better conservation upstream is bound to result positively and the scheme can be implemented optimistically as is done in many other countries. To the benefit of this study, people in and around the watershed is already convinced on the existing linkages between watershed conservation status and downstream hydrological benefits through their long period of observation. It is often easier to convince the users to pay for the existing services by demonstrating the existence of a threat than to pay for restoration to increase the level of services and that is how many PES schemes around the world have worked out. Some examples of such schemes in relation to watershed protection, bio-prospecting and ecotourism are provided by Calder (2001), Tognetti et al (2003), Rojas and Aylward (2003).

**Service Demand:** Downstream people in Dharan Municipality and dwellers of lower catchment area in the watershed are already facing water shortage. This is partly due to increasing population pressure and partly due to declining water supply. Though part of the water shortage problem is due to leakage from the system which accounts for about one-third of total water tapped, the major concern is about the declining capability of watershed to supply sufficient water through out the year. Thus, there is an increasing concern of Dharan residents over watershed conservation and they are willing to pay reasonably for the conservation and improved hydrological services. Though no effort was made to elicit the level of payment the different socio-economic category would be willing to pay but a quick assessment indicated their willingness reflecting their needs and concerns.

**Potential to Capture the Benefits:** As mentioned earlier in the report, this watershed generates huge amount of benefits through its different goods and services, especially through its water used for drinking purposes and other goods it produces. Other non-economic reasons for beneficiaries to participate in the PES could be additional benefits if the users acquired from a “green” brand image and philanthropic work. Similarly, for the service providers, when their actual economic benefits of providing the environmental service may be lower than the other opportunity costs, some other motivation factors to participate like: agreeing voluntarily today rather than being forced through regulation later; latent threats of losing out their productive land (to protected areas) or seeing PES as an informal recognition of their land titles, etc could be utilized (Halsema, 2005). Further, the beneficiaries have showed their willingness to support conservation. Thus, there seems a good opportunity to capture a part of these benefits for the conservation.
**Institutional/Legal Aspects**: Basic existing related policies and acts already support the implementation of PES or like mechanisms. The National Park and Wildlife Conservation Act-1973, The Local Self Governance Act-1999, The Electricity Act-1992, The Forest Act-1993 and a few others contain the concept of benefit sharing. Likewise, different strategies including Nepal Biodiversity Strategy 2002, Terai Arc Landscape Strategy Plan 2004-2014, National Water Plan 2007-2027 and Nepal Water Resources Conservation Strategy 2002 positively support the watershed conservation for water and other benefits. With dual objectives to develop incentive systems for resource conservation and to improve the livelihood, Ministry of Local Development has developed guidelines to use environmental funds collected from the natural resource use, emphasizing rewards to local people, especially the poor, who can contribute to environmental services. Some initiative has been taken at case basis advocating allocation of certain benefits for the upstream service providers. This has to be brought at the national policy level to facilitate the process elsewhere in the country.

**Local Initiatives**: A very challenging task in implementation of such innovative mechanism among developing countries is to convince people upstream and downstream about the hydrological relations, importance of conservation, payment mechanism and especially to downstream people to pay for the expected desired services. However, the local NGOs CETD and APEC involved in this initiative have already accomplished this task by convincing concerned people and the stakeholders. An enthusiastic committee Dharan Integrated Watershed Conservation and Water Supply Management Committee (DIWCWSMC) was formed with the chairmanship of a member of Constitutional Assembly and includes almost all the important stakeholders. This would enable the implementation of such scheme more smoothly.

Thus the overall context positively indicates the feasibility of implementing innovative financing mechanism in the Sardu watershed area. However, the existing situation does not build a strong case for implementation of PES scheme as such. It would require some modifications based on the given context which is described in next section below.

### 9.3.3 Discussions

The watershed communities who are currently heavily dependent on watershed resources especially those from up, mid and lower catchment areas will incur heavy initial cost in adopting conservation activities. A package of conservation activities should be explored and designed in detail based on local situation. Some examples could be land terracing, reducing cropping intensity, change in cropping patterns, organic agriculture, reduced use of forest resources, improved cooking stoves, systematic waste disposal and toilets (substantial number of families use open defecation thus contaminating the water sources), etc. Such activities should be discussed with the service provider communities and implemented through them at the cost of conservation fund. Depending upon many factors of watershed, it takes few years to very long periods to show and get the desired results. However, if payment to service provider communities is continued for initial few years with the assumption of change in their land and resource use behavior, payment in further years can be made conditional based upon their performance. Payments need to be made with respect to adopted indicators. As one of the important indicators for watershed conservation is forest quality, the payment is linked to per hectare of forest improved – quality and density.
For the purpose of monitoring their progress against set indicators, the involved institution needs to collect and maintain baseline information in the beginning which contains mainly the information on land use, land cover, resource use levels etc. Monitoring may be done periodically through joint visits by the institution/committee and community people and/or satellite images which are often costly and contains technical processes requiring external technical support.

Attention needs to be paid to the distribution of payments or conservation benefits among the service provider households. A quick livelihoods assessment of watershed area indicates that all people living in the watershed area depend substantially on watershed/forest resources but poorer households depend more. Thus, they would incur opportunity costs of not being able to use these resources under conservation scenario. It, therefore, makes sense to at least offset this cost for all inhabitants, which would be done through the payment mechanism. The payment system should also facilitate access to alternative energy such as kerosene or gas cylinders, to further counterbalance those costs. All the conservation project activities should encourage labor-intensive practices and should be done through local residents so as to support and compensate their livelihoods. The payment could be in different forms and that should be decided together with the communities, e.g., promoting health and education facilities, cash to households/groups, community development project support, assured and safe drinking water supply, income generating enterprises, etc. However, such payments should not be linked with any enterprises that require watershed resources but should promote conservation of those resources, e.g., fruit plantation, solar dryer for processing of agri-products. Currently, watershed communities burn a huge amount of fuel wood for alcohol making which needs to be diverted to other enterprises immediately. Biogas plant reduces the pressure over forest for fuel wood. However, its promotion in the watershed area may contradict with conservation efforts if it depends only on livestock excreta – as it requires larger number of livestock and leads to more extractions of fodder and forage.

Sometimes, the property rights issue adds complexities to design and implementation of such schemes. Majority (83%) of people living inside the watershed area is aboriginal residents and rest came from other nearby districts. However, some squatters living in the fringes of Dharan city are denied water supply and electricity due to lack of their land ownership of the lands they are living on. These are some more political issues but it will be worth covering them all in the conservation program as they too have stakes in conservation.

Under any conservation scenario there is often many restrictions and limited infrastructure development that denies access to many opportunities. It would thus be more effective if the payment for this hydrological service is combined with other forms of income generation and would also address the poverty concerns. Ways of effectively linking PES to poverty alleviation and ecosystem conservation are presented by Wenger et al. (2004), Landell-Mills and Porras (2002) which has reviewed the markets for forest ecosystem services and their impact on the poor and Scherr et al. (2004) has reviewed markets for low-income forest producers.
9.4 A Framework for PES like Scheme for Sardu Watershed Management

An effective conservation financing mechanism should address the needs of service providers as well as the service users. In Sardu watershed context, service providers are not very clear and defined. It’s not only the population in the upper and mid catchment areas who could manage and conserve the watershed but also the people from lower catchment area and squatters living in Dharan Municipality. This lower catchment population is downstream water beneficiaries and upstream resource users; still they negotiate the long term sustainable benefits for fulfilling their immediate needs and collect the resources unsustainably from the up/mid-stream areas. Thus, as required for PES implementation there is no distinct upstream managers and downstream users. It is observed that Sardu watershed’s conservation requires motivation for up, mid and lower catchment population including those living in Dharan city.

This given context does not build a strong case for PES implementation but a PES-like mechanism like creating a conservation fund would be a more appropriate approach. However, the operation and management of this conservation fund should capture the important and relevant features of PES mechanism. Based on the available information, a simple guideline for such conservation fund is described in the sections below (9.5.1 and 9.5.2), however, detail needs to be explored and worked out.

9.4.1 Conservation Fund (PES like Scheme)

The first step should be explored and decide on creation of conservation fund. Who pays and how much is to be paid is a big question and needs exploration. Contributors to the fund are evidently the beneficiaries especially the water users in Dharan Municipality (civilian, organizations, hoteliers, and others). It can also be argued that water from this watershed is also used by people in upper, mid and lower catchment areas and they should also pay for it. However, the intention of this mechanism is to keep them motivated to manage the watershed in a sustainable manner and thus it should be left as an optional system for them but they should be motivated to contribute.

Other important source of income can be water supply authorities that enjoy water resources available for free from the watershed. Certain amount per unit (eg. cu.m.) of water tapped can be contributed from its benefits to conservation fund. The payment associated with per unit of water will help motivate upland people and others to generate more water through conservation. Likewise, hotels and businesses being operated near the upper catchment area are also other important sources for the contribution to the fund.

Though how much the beneficiaries should be willing to pay for a service and how much should the service providers be willing to accept for generating the services through desired activities are derived from economic value of the service for beneficiaries and the opportunity cost of service providers. Downstream users will be willing to pay an amount less than the value of expected benefits. However, a survey in Latin America has indicated that PES negotiations are rarely based on economic value of services but on expected aversion of expenditure that an otherwise diminished or degraded water resource base would bring to their water dependent businesses. There are different groups and types of beneficiaries from
the watershed and who supports how much should be discussed and agreed with concerned parties keeping in mind the voluntary criteria of this mechanism, rather than imposing a certain value estimated economically based on limited information. In this context, people’s perception on willingness to pay for conservation of the watershed has been assessed at sampled households.

All the communities in up, mid and downstream catchments are willing to contribute in the conservation fund by two ways: cash and kind (follow chapter 2 for community perceptions on willingness). But the execution mechanism should be made effective, efficient and free from political interference. Likewise, major stakeholders of service user were also brought in the discussion to know about their perception on the conservation fund and mechanism of Sardu watershed management. The discussion results have been tabulated in Annex 11.

Usually in the beginning, huge amount of money is required to meet the upfront costs in changing the land uses upstream, terrace formation and diverting the forest dependent communities to other sources of income, management cots etc. Thus, until the scheme becomes fully operational and self sustainable, external support will be needed. DDC, VDC, Municipality and other local and external organizations need to support the initiative.

9.4.2 Execution Mechanism for PES like Scheme

An institution is required to mediate the whole process of scheme implementation and to manage the fund. This institution has to play a great role as the whole success depends on how the system is managed and how well the service producers and service users are kept motivated with its transparent processes and other operations. There are local NGOs like APEC and CETD and local government authorities already working for the watershed conservation and there is a special committee called DIWCWMSC dealing with these issues. This existing committee can take up this role. However, it needs to be broadened to cover all the stakeholders and representation from all the service provider and service user communities.

As the size of this committee will become larger it can serve as General Assembly (GA) while an Executive Board could be formed which meets more frequently and involves in regular decision making process. This Board may form different committees as deemed important. For example implementation of this scheme would require special teams like Watershed Conservation and Management Committee to design and work on conservation activities upstream and linkages with downstream; Resource Mobilization and Monitoring Committee to monitor the progress & to look after the administrative and financial aspects of the scheme; and Dharan Municipality Water supply Management Committee to take care of water management aspects in the municipality, etc. A very tentative structure is depicted in the picture below just to spark off the idea, which needs to be adjusted as per the feasibility in local institutional context.

The figure below indicates the possible sources of fund for developing the proposed Conservation Fund. And the lower figure indicates the institutional mechanism for managing the Conservation Fund and the conservation needs. Each of these committees, mentioned above, may be led by different stakeholders involved in the process, such as, Dharan
Municipality, FNCCI and the local NGOs involved in the process. As those NGOs have gained substantial experience working in the watershed, they may have comparative advantage in leading the watershed conservation activities. Likewise, others could take the lead in areas where they have better experiences and knowledge. All these institutions should work together to detail out the financing mechanism from beneficiaries and payment mechanism for land and resources users.

Since this scheme works better with motivation among people and not by enforced rules, this institution needs to take special care in maintaining transparency in its operation and accountability. Formation of executive body and other committees should follow the transparent and democratic process. Their activities and process should follow the participatory approach. As shown in the figure below, the board and different committees are overlapping; it indicates to their overlapping roles and thus their work should be in coordination with each other.

![Figure 9.1: Proposed Execution Mechanism for PES](image)

9.5 Conclusions

Its implementation can prove as a great tool in the context of addressing the conservation as well as poverty issues. In essence, it suggests that there is potential to match the interests of those who can influence the provision of a specific environmental service and those who benefit from its provision. Application of its modified version seems feasible in Sardu watershed, which can encourage the sustainable supply of hydrological services addressing the water shortage problem of Dharan Municipality. As this concluding section suggests a simple guideline on payment scheme that has been designed (described in the sections 9.5.1 & 9.5.2) on the basis of limited hydrological information. A detailed hydrological assessment with gauging system should be conducted to provide scientific information on upstream and downstream linkages. It assures people to pay for the conservation for sustainable water supply viewpoint.
Chapter 10

Conclusions and Recommendations

The Sardu watershed, expanding from foot hills of Middle Mountain in North to Terai region in Charkose jhadi (coniferous forest) in South supports livelihoods of upland and lowland communities and people living in the slum areas of Dharan municipality. It also supplies significant quantity of water to people in Dharan. It means upland communities and Dharan municipal people are the main users of the environmental services available in the watershed. In this regards, what the upland communities and Dharan people do in the watershed to achieve benefits can have positive and negative impacts on its services, particularly on provisional and recreational services. After looking at the depletion of watershed due to over-exploitation of forest and lands by these users, this study can conclude that alteration in hydrology and recreational services has decreased water supply, weakened the municipal environment and increased soil erosion and threatened community resilience both in upland and lowland of the watershed. To reduce effectively these changes, collaborative approach and upland-lowland linkage mechanism through integrating of conservation and development programmes in the watershed are required. For this, the conservation and development programmes (with reference in chapter 8) has been proposed in immediate, short-term (3-year), medium-term (5-year) and long-term basis in Annex 13.

The issue of Payment for Ecosystem Services is still in its infancy and further experiment with a pilot project is required. Its implementation could prove a great tool in our context for addressing the conservation as well as poverty issues. In essence, it suggests that there is potential to match the interests of those who can influence the provision of a specific environmental service and those who benefit from its provision. Application of its modified version seems feasible in Sardu watershed, which could encourage the sustainable supply of hydrological services addressing the water shortage problem of Dharan Municipality in the long term. Required legal support and stakeholders support seem very favorable for its implementation. Local initiatives towards the conservation of Saradu watershed is already been practiced which would further support the implementation of PES. The study suggests a rough guideline on payment scheme that is designed based on limited hydrological information, it would be worth conducting detailed hydrological assessment to provide scientific information on upstream and downstream linkages.
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Annexes

Annex 1: Structured and Semi-structured Questionnaires Followed in the Study

At VDC level (Group Discussion/Cluster Interaction/official records and discussions)
CHECKLIST FOR DATA COLLECTION FOR STUDY PROGRAM OF WATERSHED CONSERVATION PLAN
Name of VDC /Cluster/Tole........................................... Survey Date...........................................

1. Population Within the Watershed

<table>
<thead>
<tr>
<th>Name of VDC and Other Toles</th>
<th>Population in Number/%</th>
<th>Literacy in %</th>
<th>PD</th>
<th>HH Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
</tbody>
</table>

2. Population and Ethnic Size (Household and Population in % or in Numbers)

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Total</th>
<th>Literacy in %</th>
<th>Toles and VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
<td>Pop</td>
<td>HS</td>
</tr>
<tr>
<td>Dalit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brahamin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rai</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chhetri</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tamang</td>
<td></td>
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<td></td>
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<tr>
<td>Magar</td>
<td></td>
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<td></td>
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<tr>
<td>Tharu</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yadav</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limbu</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

3. Occupation: Sources of Family Income (Number of Households/Percentage)

<table>
<thead>
<tr>
<th>Name of Toles /VDC</th>
<th>Occupation in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agriculture</td>
</tr>
<tr>
<td></td>
<td>Business</td>
</tr>
<tr>
<td></td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>Wages</td>
</tr>
<tr>
<td></td>
<td>Masonry</td>
</tr>
<tr>
<td></td>
<td>Others specify</td>
</tr>
</tbody>
</table>

Please take other sheet of paper if required

4. Migration Status

<table>
<thead>
<tr>
<th>Toles/VDC</th>
<th>HHs and Population in Number</th>
<th>Remarks (In-migration or Out migration)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permanent</td>
<td>Seasonal</td>
</tr>
<tr>
<td></td>
<td>HHs</td>
<td>Pop</td>
</tr>
</tbody>
</table>

108
5. Farm Size (In No. or In %)

<table>
<thead>
<tr>
<th>Toles/VDC</th>
<th>Ll</th>
<th>M (&lt;0.5ha)</th>
<th>S (0.5-2ha)</th>
<th>Me (2-4ha)</th>
<th>L (&gt;4ha)</th>
<th>Remarks</th>
</tr>
</thead>
</table>

Ll=Landless; M=Marginal; S=Small; Me=Medium; L=Large

6. Food Sufficiency Within the Watershed

<table>
<thead>
<tr>
<th>Toles/VDC</th>
<th>Food Secured, Monthly Basis, in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Months</td>
</tr>
</tbody>
</table>

7. Types and Areas of Cultivated Lands and Forest Coverage in the Watershed

<table>
<thead>
<tr>
<th>Agriculture Lands</th>
<th>Forest Products/ Coverage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types</td>
<td>Areas in ha</td>
<td>Types</td>
</tr>
<tr>
<td>Khet</td>
<td>Hard wood</td>
<td></td>
</tr>
<tr>
<td>Bari</td>
<td>Mixed wood</td>
<td></td>
</tr>
<tr>
<td>Fan cultivation</td>
<td>Conifers</td>
<td></td>
</tr>
<tr>
<td>Valley cultivation</td>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Report in separate page about the details of Watershed plus (Bio-industries, horticulture crops-citrus fruits, floriculture plants, species and medicinal plants)

8. Areas and Consumption of Forest Resources and its Availability

<table>
<thead>
<tr>
<th>Types of Resources</th>
<th>Private Forest</th>
<th>Government Forest</th>
<th>Community Forest</th>
<th>Religious Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel wood Mt</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fodder/Forage(Ghomespat) Mt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timber(cubicft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bamboo Mt</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Medicinal herbs Mt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others specify</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

9. Livestock Types and Situation and Foddered Capacity

<table>
<thead>
<tr>
<th>Types</th>
<th>HH number</th>
<th>Livestock Head No.</th>
<th>Av. Livestock/HH</th>
<th>Fodder required per livestock in Mt OR total TDN in Mt</th>
<th>Total TDN available in Mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>He-Buffalo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>She-Buffalo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.1 Computation of Total TDN Available in Mt Can be Obtained Using the Following Table

<table>
<thead>
<tr>
<th>Fodder From Agri by-products</th>
<th>Total Production</th>
<th>Coverage Area</th>
<th>TDN in Mt</th>
<th>TDN Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fo by-Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rangelands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrub/Fodder tree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total TDN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: TDN factor may be obtained from DADO/Literatures; may be: Paddy 0.66; Wheat/Maize 0.28; Millet 0.61; Rangelands 0.77; Forest 0.43; and Shrub/Fodder tree 0.05

10. Coverage of Drinking Water, Sanitation and Other Facilities Available Within the Watershed

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Facilities in Number</th>
<th>Name of VDC/Wards/Toles</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposal pits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved stoves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar panel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health post</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag. Service Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Police station</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School/College</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Specify the number of HHs with drinking water facilities: taps, wells and other sources.

11. Agriculture Production in Mt and Food Status

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area in ha</th>
<th>Cropped Area in ha</th>
<th>Types of Lands (Bari, Khet)</th>
<th>Yield (Mt/ha)</th>
<th>Total Production (CA X Y)</th>
<th>Total Food Available (Production-Losses)</th>
<th>Total Food Requirement in Mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Yield can be obtained from DADO or from local discussion averaging the last five years yield.
11.1. Losses Can be Obtained from DADO or From Local Discussions Using the Following Table

<table>
<thead>
<tr>
<th>Crops</th>
<th>Types of Losses</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Harvest Loss in % per ha</td>
<td>Seed Storage Kg/ha</td>
</tr>
<tr>
<td>Paddy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Food requirement in kg per person is to be obtained from DADO or Group Discussions

12. Vegetables, Livestock and its Production, Oil seeds, Cash Crops and Spices

<table>
<thead>
<tr>
<th>Types</th>
<th>Area in ha</th>
<th>Farmed Area</th>
<th>Production in Mt</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash Crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The crops: Paddy; wheat; Maize; Millet; Barley; Buckwheat; Other cereal, Soybeans, Red grams, Black grams, Lentil, Gram, Pea, Green gram, Peak, Other leguminous, Potato, Sweet potato, Mustard, Groundnut, Linseed, Sesame, Other oils seeds, Jute, Other cash crops, Chilly, Onion, Garlic, Ginger, and Winter Vegetables

13. Fuel Wood Timber Requirement and Situation Assessment

<table>
<thead>
<tr>
<th>Demand Pop</th>
<th>Fuel Wood Required in Mt</th>
<th>Timber Required in Cu. m.</th>
<th>Supply Fuel Wood/Timber</th>
<th>Total Prod Fuel wood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Area in ha</td>
<td>Prod in Mt</td>
<td>Prod in Mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Area in ha</td>
<td>Prod in Mt</td>
<td>Prod in Mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Area in ha</td>
<td>Prod in Mt</td>
<td>Prod in Mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Area in ha</td>
<td>Prod in Mt</td>
<td>Prod in Mt</td>
</tr>
</tbody>
</table>

Note: A. Identify Per capita annual fuel consumption In ………..kg/person/year, it may through HH survey/ Discussion/Secondary data;

Note: B. Fuel wood yield……. from the sources can be obtained from DFO or from Literatures. It may be: Forest 3.0; Shrub 0.5; Fodder 0.5; Ag residue 0.4 Mt/ha;

Note: C. Obtain Per capita timber consumption……….Cum through DFO or from literatures. May be: 0.086 cum;

Note: D. Compute Timber yield using forest area and annual timber yield from the area. Annual timber yield ………….. Cu m will be obtained from the DFO or local discussion; and

Note: E. Compute Fuel wood requirement and Fuel wood available and obtain surplus or deficit of fuel wood and timber in Mt.

14. Water Requirements: Drinking Water and Irrigation
IUCN Nepal
P.O. Box 3923
Kathmandu, Nepal
Email: info-np@iucn.org
URL: www.iucnnepal.org