# Nibuwa-Tankhuwa Watershed Management Plan

# Nibuwa-Tankhuwa Watershed management plan

Submitted by

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"धनकुटा नगर : स्वच्छ सुन्दर समुन्नत शहर"

# धनकुटा नगरपालिका
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प्रस्तुत विषयमा धनकुटा नगरको मुख्य शहरी क्षेत्रमा खानेपानी व्यवस्थापनका लागि संचालित बृहत खानेपानी योजनाको मुहान रहेको धनकुटा नगरपालिका वडा नं. २ भिरगाउँ क्षेत्रमा खानेपानीको मुहान संरक्षणको लागि मुहान क्षेत्रका समुदाय तथा अन्य सरोकारवालासंग विभिन्न समयमा छलफल तथा अन्तरकृया गरी जलाधार संरक्षण सम्बन्धी विगत ३ बर्ष देखिनै तहाँ केन्द्रबाट विभिन्न प्रकारका अध्ययन अनुसन्धान गरी यस नगरपालिकालाई जलाधार संरक्षण सम्बन्धी कार्यमा पुऱ्याउनु भएको महत्वपूर्ण सहयोग प्रति आभार प्रकट गर्दछौं । तहाँबाट भएको अध्ययन अनुसन्धान प्रतिवेदनको आधारमा उक्त क्षेत्रमा जलाधार संरक्षण, समुदायस्तरमा आय आर्जन सम्बन्धी कार्यक्रम लगायतका एकीकृत विकास कार्य गरी दिगो रुपमा जलाधार संरक्षण गर्न आवश्यक भएकाले तहाँ केन्द्रबाट चालु आर्थिक वर्षमा धनकुटा नगरपालिका जलाधार संरक्षण र व्यवस्थापन योजना निर्माण एवम् योजना कार्यान्वयनको लागि आवश्यक आर्थिक तथा प्राविधिक सहयोग उपलब्ध गराई दिन अनुरोध छ ।

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# Preface

The Dhankuta Municipality in eastern Nepal faces water scarcity and has concerns regarding the long term supply and maintenance of water to the increasing population in the municipality. The Dhankuta Municipality and the International Centre for Integrated Mountain Development (ICIMOD) partnered in a joint action research on the application of the incentives for ecosystem services (IES) approach from 2015 to 2017 to identify the willingness to pay of the downstream communities for drinking water for the purpose of upstream watershed conservation. The upstream communities can benefit from technical and financial support for implementing various watershed conservation activities upstream that would sustain the source of water and ensure water quality downstream.

Dhankuta Municipality recognized that there needs to be a planned investment in watershed management to sustain the ecosystem services and improve the well-being of the people living in the basin. Thus, the Dhankuta Municipality and ICIMOD embarked on developing a watershed management plan in partnership with the Department of Forests and Soil Conservation and the Soil Conservation and Watershed Management Office in Dhankuta in December 2018. As the Nibuwa-Tankhuwa Watershed (NTW) encompasses both the Dhankuta Municipality (wards 1 to 8) and the Chattar Jorpati Rural Municipality (Wards 2 and 3), it requires a common understanding as well as collaborative actions for watershed management.

Hence, a joint watershed management committee was also formed on BS 2075/11/12 (24 February 2019) to oversee the development, implementation and monitoring of the watershed management plan.

The watershed management plan was prepared based on research and participatory consultation between the communities and key stakeholders of the NTW during the period 2018 and 2020 . During the process, cross learning opportunities such as exposure visits to observe watershed management practices in some parts of Bagmati Province were also organized. Furthermore, the capacity of the local stakeholders to monitor discharge of the spring sources and rivers were also enhanced. The NTW builds on the sub-watershed management guidelines of the Department of Forest and Soil Conservation and adds to critical topics such as springshed management and institutional mechanisms.

The watershed management plan is expected to bring together diverse and stakeholders as well as different line agencies to have a common understanding of watershed issues. The actions proposed in the plan are suggestions that could be integrated into the sectoral plans and activities of the different institutions, including the municipalities. It is expected to be a living document that would be periodically updated and reviewed by the watershed management committee.

# Acknowledgements

This watershed management plan has been prepared by Dhankuta Municipality and Chhathar Jorpati Rural Municipality in partnership with the Department of Forests and Soil Conservation and Soil Conservation and Watershed Management Office, Dhankuta, and in close collaboration with the ICIMOD team. The aim of the plan is to ensure watershed-friendly development activities in the Nibuwa-Tankhuwa Watershed to sustain the sources of water and the quality of water downstream. This plan also contributes to the Framework of Cooperation between DoFSC and ICIMOD on Strengthening Integrated River Basin Management.

This plan has been prepared with the support of many stakeholders and line agencies.

The coordination and facilitation support provided by Dhankuta Municipality and Chhathar Jorpati Rural Municipality is especially acknowledged and appreciated. Similarly, the team would like to acknowledge the offices of wards 1, 2, 3, 4, 5, 6, 7 and 8 of Dhankuta Municipality and offices of wards 2 and 3 of Chhathar Jorpati Rural Municipality for supporting the field study and sharing information.

We extend our sincere thanks to the Ministry of Forests and Environment (MoFE) and Department of Forests and Soil Conservation. We also thank the Government of Nepal, Ministry of Industry, Tourism, Forests and Environment – Province 1; Soil Conservation and Watershed Management Office, Dhankuta; Division Forest Office, Dhankuta; Agriculture Knowledge Centre, Dhankuta; Livestock Services Offices, Division Road office, Cottage and Small industries Office, Dhankuta; Water Supply and Sanitation Division Office, Dhankuta; and the Irrigation Development Division, Dhankuta.

Special thanks are owed to Federation of Community Forestry Users, Nepal (FECOFUN) and the Drinking Water Users Committee for providing the data and information needed to prepare this plan. Successful completion of this work would not have been possible without the support and cooperation of communities from the upstream and downstream areas. The team would like to express their sincere appreciation to all of them for providing information. Similarly, members of the watershed management committee are also acknowledged for their inputs and insights.

Thanks are also due to the Society for Local Volunteers Efforts (SOLVE)-Nepal; Human Rights, Social Awareness and Development Centre (HUSADEC)-Nepal; Red Cross; and, the Poverty Alleviation and Rural Development Program (PARDEP) for all their inputs.

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# Acronyms and abbreviations

| | |
|---|---|
| **ADSL** | Asymmetric Digital Subscriber Line |
| **AEPC** | Alternative Energy Promotion Centre |
| **AKC** | Agriculture Knowledge Centre |
| **CCDRM** | Climate change and disaster risk management |
| **CDMA** | Code Division Multiple Access |
| **CEO** | Collect Earth Online |
| **CF** | Community forest |
| **CFUGs** | Community forest user groups |
| **DAO** | District Agriculture Office |
| **DCC** | District coordination committee |
| **DEM** | Digital Elevation Model |
| **DFO** | District Forest Office |
| **DHM** | Department of Hydrology and Meteorology |
| **DHK-CHU** | Dhankuta-Chuliban System |
| **DHK-NIG** | Dhankuta-Nigale System |
| **DHK-PST** | Dhankuta-Pumping Station |
| **DHK-SAL** | Dhankuta-Salleri System |
| **DHK-SCH** | Dhankuta-School Dada System |
| **DHK-TNK** | Dhankuta-Tankhuwa |
| **DO** | Dissolved oxygen |
| **DoFSC** | Department of Forests and Soil Conservation |
| **DoSCWM** | Department of Soil Conservation and Watershed Management |
| **DoUDBC** | Department of Urban Development and Building Construction |
| **DRO** | Division Road Office |
| **EC** | Electrical conductivity |
| **EIA** | Environmental Impact Assessment |
| **FECOFUN** | Federation of Community Forestry Users Nepal |
| **FGDs** | Focus group discussions |
| **FNJ** | Federation of Nepali Journalists |
| **FYM** | Farm yard manure |
| **GEOBIA** | Geographic Object-Based Image Analysis |
| **GESI** | Gender equity and social inclusion |
| **GIS** | Geographic Information Systems |
| **GoN** | Government of Nepal |
| **GPS** | Global Positioning System |
| **Ha** | Hectare |
| **HH** | Household |
| **HYVs** | High yielding varieties |
| **ICIMOD** | International Centre for Integrated Mountain Development |
| **IEE** | Initial environmental examinations |
| **IES** | Incentive for ecosystem services |
| **INGOs** | International non-governmental organizations |
| **IPM** | Integrated pest management |
| **IWRM** | Integrated water resource management |
| **KII** | Key informant interviews |
| **LSI** | Landslide Susceptibility Index |
| **LULC** | Land use and land cover |
| **LPG** | Liquefied petroleum gas |
| **Lps** | litre per second |
| **Lpm** | litre per minute |
| **Masl** | Meter above sea level |
| **MCM** | Million cubic meters |
| **MCT** | Main Central Thrust |
| **MEA** | Millennium Ecosystem Assessment |
| **MIP** | Medium Irrigation Project |
| **MoFE** | Ministry of Forest and Environment |
| **NABRC** | National Agricultural Business Research Centree |
| **NDVI** | Normalized Difference Vegetation Index |
| **NDWQS** | National Drinking Water Quality Standards |
| **NGOs** | Non-governmental organizations |
| **NRM** | Natural Resource Management |
| **NT** | Nibuwa-Tankhuwa |
| **NTFPs** | Non-timber forest products |
| **NTU** | Nephelometric Turbidity Unit |
| **OBIA** | Object-based Image Analysis |
| **OWL** | Other wooded land |
| **PES** | Payment for ecosystem services |
| **PRA** | Participatory rural appraisal |
| **RDS** | Regional Database System |
| **RIL** | Reduced impact |
| **ROC** | Receiver Operating Characteristic |
| **RSLUP** | Risk sensitive land-use plan |
| **RUSLE** | Revised Universal Soil Loss Equation |
| **SCIO** | Small and Cottage Industry Office |
| **SCWMO** | Soil Conservation and Watershed Managment Office |
| **SOLVE** | Society of Local Volunteers' Effort |
| **SWMO** | Soil and Watershed Management Office |
| **TCU** | Total Colour Unit |
| **TDS** | Total Dissolved Solids |
| **ToR** | Terms of reference |
| **UDBCO** | Urban Development and Building Construction Division Office |
| **UNDP** | United Nations Development Programme |
| **USGS** | United States Geological Survey |
| **USLE** | Universal Soil Loss Equation |
| **VHLC** | Veterinary Hospital and Livestock Service Centre |
| **WASH** | Water, sanitation and hygiene |
| **WRIDD** | Water Resources and Irrigation Development Division |

# Executive summary

The Nibuwa-Tankhuwa (NT) Watershed is located between the 87.32˚ and 87.40˚ E longitude and 26.95˚ and 27.05˚ N latitude in the Dhankuta district of the Koshi river basin of the eastern development region of Nepal. The NT Watershed has a total population of 33,349 of which 53% is female and 47 % is male. There are 8,432 households in the watershed which includes the Dhankuta Municipality (Wards: 1, 2, 3, 4, 5, 6, 7 and 8) and Chhathar Jorpati Rural Municipality (Wards: 2 and 3) having total area of 73 sq km. The watershed is rich in natural resources and supports over 80 species of flora and fauna. It also provides essential ecosystem services which shape the wellbeing of the people living in the watershed and downstream, including water for drinking and irrigation, fuelwood and other ecosystem services and contribute to local development. However, the NT Watershed in the Koshi river basin faces multiple challenges relating to its various watershed services from both climatic and socio-economic drivers. Hence, while the watershed itself has immense opportunities, the watershed management plan needs to be more inclusive to harness these opportunities. In a changing context where climate and other anthropogenic changes are posing serious threats to the mountain environment and its people, a sustainable watershed management plan that takes into consideration a sound balance between conservation and development with a particular focus on gender and social inclusion is a must. The proposed watershed management plan is one step in that direction.

The purpose of this watershed plan is to help decision makers and practitioners at ward, municipality, basin and national levels to understand the NT Watershed's status, problems, issues, risks and opportunities as well as leverage investments for improving watershed management in both the short and long-terms. The methodology used for developing this plan would also be relevant to other watersheds in the mid-hills of Nepal. Successful implementation of such a plan at the watershed level can also support integrated river basin management of larger river basins.

Since 2017, the Dhankuta Municipality and ICIMOD have been collaborating in order to support watershed management practices of the Dhankuta Municipality. ICIMOD and DoFSC have generated data and information on climate, hydrology, ecosystems, gender, livelihoods and governance aspects through literature review, field studies, participatory methods, and modelling and geospatial techniques to obtain a comprehensive understanding of the biophysical and socioeconomic situation of the NT Watershed in the Koshi river basin, Nepal. The planning process was supported by the Koshi Basin Initiative of the River Basins and Cryosphere Programme of ICIMOD. The watershed assessments focused on natural resources (soil, land, forests, surface water, and groundwater) and infrastructure and services as well as gender, socioeconomic and governance aspects, with the aim of designing and implementing interventions for integrated NT Watershed management from an upstream-downstream linkage perspective.

## Existing management issues of NT watershed

The main biophysical and socio-economic issues of the NT Watershed are as follows:

*Soil erosion, landslides and sedimentation:* Most erosion seems to be originating from road construction and landslides and need improved management responses comprising prevention and mitigation measures. Fragile geological formations and unplanned construction of rural roads were found to be a major causative factor in the occurrence of landslides in the area (see section 3.5.5). Hence, rural road construction should be well planned to control landslides including bioengineering efforts. Soil erosion from the land use systems, by and large, is not a serious problem yet in the watershed. It is currently estimated at 9.70 tons/ha/yr (See 3.5.4).

*Water availability and demand:* Springs, streams and rivers are the three main sources of the water supply in the NT Watershed, which is also a major source of the water supply for the Dhankuta Municipality. Water availability during dry seasons is perceived to be decreasing due to declining discharge from springs and streams caused by human and natural factors such as erratic rainfall, infrastructure development, landslides, loss of traditional ponds, and overexploitation of aquifers through deep boring. At the same time,

demand for water has increased over the years owing to population growth, increased irrigated vegetable farming for marketing, and an increasing number of hotels and lodges. About 6% of the households of Dhankuta Municipality in the watershed area travel up to one hour, which is significant work load, especially for women and children (Table 19, Section 4.4).

*Water quality:* During the monsoon, a major problem faced by the local people is the high turbidity and sediments in the drinking water. However, the degree of turbidity in rivers is observed to be also due to the fact that eroded particles from hill slopes are washed into the stream network. To address this problem, areas with high soil erosion and sedimentation need to be identified and restored. Overall, the quality of water from the springs and streams in the NT Watershed is within the national water quality standards of Nepal.

*Forest cover change:* The land use and land cover change (LULC) shows that the forest cover in the area has recorded a slight increase of about 0.38% over the last two decades from 2010 to 2018. The forest area, which in 2000 was 16.65%, had increased to 16.64% in 2010 and 17.03% in 2018. However, there is high dependency on forest resources for cooking. Hence, felling of trees, especially around water resources, could lead to fragmentation and degradation of forests. This would impact biodiversity and ecosystem services, including essential water services, and contribute to trigger sedimentation and turbidity of the watershed.

*Climate change:* The average annual precipitation is 960 mm in the NT Watershed with 73% occurring in the monsoon season while the average annual minimum and maximum temperatures are 15 ˚C and 24 ˚C, respectively. The temperature and precipitation are projected to increase towards the end of the century along with climatic extremes which are likely to impact the watershed characteristics and functions with socio-economic implications (see section 3.4)

*Livelihood systems:* Agriculture is the main source of livelihood with nearly 54% of the households in NT Watershed. The small landholdings and low level of income are pushing people, especially men, to migrate to urban or semi-urban areas resulting in a shortage of labour for agriculture and natural resource management in the watershed. In addition, there has been a shift from the traditional choice of crops and subsistence farming to a commercial system of growing cash crops, fruits and vegetables. A few off-farm options such as small businesses, hotels and lodges to cater to tourists have also emerged. Farmers with access to irrigation water have started to grow vegetables for marketing.

*Gender and social inclusion:* In the watershed, there has been a significant change in gender roles and responsibilities (see chapter 4) where women are held responsible for household activities although their work has extended to the agriculture sector due to the increasing out-migration of male members. The switch from subsistence farming to commercial cultivation has increased women's entrepreneurship in the watershed. However, this has led to the mushrooming of financial institutions, increasing the household debt, 1064HHs out of 4481 HHs in the Dhankuta Municipality spent loan amount on meeting the household expenses. Commercialization of agriculture, increasing use of pesticides and fertilizers, high rates of interest and increasing domestic violence have also resulted in significant health problems for women and young girls such as micronutrient deficiency and physical and psychological problems. In a watershed, it is important to understand how micro-financial institutions are increasing women's vulnerability as they try to ensure food security and manage the debt burden.

*Institutions and governance:* Although institutions in the watershed are meant to be inclusive, they do not allow women and other socially marginalized groups in institutions to challenge the existing power structures and cultural values that have shaped gender differentials and norms. However, active participation and inclusiveness of all stakeholders are vital for the successful implementation of the watershed management plan. Moreover, implementing the watershed plan needs stakeholder convergence in the implementation phase with a good horizontal coordination mechanism. Similarly, mechanisms for robust upstream and downstream linkages and an understanding on the roles and responsibilities of the two municipalities need to be drawn up and their capacities enhanced. The NT Watershed management committee will play an important role in supervising, supporting and coordinating the watershed management activities and mobilizing local leaders for collaborative actions. Hence, developing terms of reference detailing roles is also needed. Lastly, the IES mechanism needs to be revisited and scaled up within the watershed as a model for upstream and downstream linkages.

The table below shows the major issues in the watershed and the proposed solutions including the implementing partners at the local, provincial and national levels.

| Proposed solutions | Implementing partners |
|---|---|
| **Sustainable conservation, management and use of water resources**<br>• Assessment of demand and supply of drinking water<br>• Construction and maintenance of pipelines and water tanks<br>• Construction of recharge structures to rejuvenate drying and dried springs.<br>• Roof rainwater harvesting and improved water use efficiency<br>• Conservation and preservation of water recharge areas, along with planting of appropriate tree and plant species which assist in increasing the abundance of water sources. | • Municipality, Rural Municipality, SCWMO, Water Resource and Irrigation Development Division, Water user group, Water Supply and Sanitation Division, watershed management committee, local communities, ICIMOD |
| **Sustainable land use management**<br>• Establishment of an Operational Municipal Land Use Council which would help in comprehensive land use planning using a participatory approach.<br>• Identification of barren areas for plantation and agriculture.<br>• Promote horticulture and agroforestry practices in the areas which encompass land with an incline of more than 30 degree | • Municipality, Rural Municipality, DCC, DFO, Agriculture Knowledge Centre (AKC), Cooperatives and local communities |
| **Diversification and improvement of livelihoods options**<br>• Farming of high value agricultural products such as timur, chiraito, and others, which do not draw the attention of wild animals.<br>• Providing comprehensive training on irrigation techniques, preparation of compost manure, water ponds for irrigation, Integrated Pest Management (IPM) and others technical skills to women, men and marginalized communities.<br>• Promotion of multi-year crops. | • Municipality, Rural Municipality, DCC, DFO, DAO, AKC, SWMO and local communities |
| **Climate change, disaster risk management and sustainable infrastructures**<br>• Preparing risk sensitive Land-use Plan (RSLUP) and implementation<br>• Revitalization of erosion affected area, including stream banks<br>• Green road: Bioengineering and greenery promotion in landslide and erosion prone areas<br>• Focus on both structural (bioengineering, retaining walls) and non-structural (hazard/ susceptibility, vulnerability, risk maps, early warning systems) measures for landslide mitigation and preparedness | • Municipality, Rural Municipality, DFO, SWMO, AEPC and local communities |
| **Developing infrastructure**<br>• Hazard and Risk assessment should be done prior to the development to minimize the risk.<br>• Gully stabilization for erosion prone areas in the upstream micro-catchment<br>• Conducting EIA/IEE of major development projects to minimize impact on ecosystem.<br>• Effective and timely review and monitoring of infrastructure development projects. | • Municipality, Rural Municipality, DoUBC, DCC, SWMO, DFO, DRO, Urban Development and Building Construction Office, and local communities |
| **Integrating social development**<br>• Promoting women and marginalized communities to leadership positions through participatory approaches.<br>• Establishing counseling centers for handling domestic violence, grievances, psychosocial services for supporting the well-being of women, men and the marginalized communities. | • DCC, Municipality, Rural Municipality, DFO, SWMO, District and Local disaster management committees, Red Cross, local communities |
| **Strengthening institutional mechanisms**<br>• Strengthening the watershed management committee to implement the watershed management plan.<br>• Implementing production based incentives and monitoring mechanisms on agricultural land management.<br>• Following and implementing the SMART CITY plan.<br>• Developing mechanisms to ensure effective implementation and management of springshed and recharge areas, particularly on public and private land. | • Municipality, Rural Municipality, DoUDBC, DAO, DFO, SWMO, water user groups, CFUGs |
| **Mainstreaming gender and social inclusion mechanism**<br>• Ensuring equitable distribution of roles and responsibilities to women, men and marginalized communities during the planning, implementation and evaluation of any projects/plans/activities<br>• Providing training and exposure visits to both women and men in order to enhance their understanding on water conservation technologies and economic development.<br>• Identifying vulnerable areas and communities (with gender and social disaggregated data) to disaster and climate risks | • Municipality, Rural Municipality, DCC, cooperatives, local communities, local NGOs |

| | |
|---|---|
| **Interdisciplinary action research and extension**<br>• Action research on pertinent issues such as indigenous knowledge and practices, nature based solutions, effectiveness of soil conservation measures, watershed services for IWM, sediment yield, climate change on vegetation, pests, micro-finance and others for an evidence-based watershed management plan and strategies. | • Universities, Researchers, SWMO, DFO, Municipality and local government |
| **Capacity building**<br>• Watershed profiling<br>• Climate resilient nature based solutions<br>• Sustainable land and water management<br>• Hazard and Risk Assessment Methodologies<br>• Periodic monitoring of watershed services<br>• Inclusion of gender and social aspects<br>• Monitoring and evaluation of the plan | • Municipality and local government<br>• SWMO and DFO<br>• Department of Forests and Soil Conservation,<br>• User groups (community forestry, irrigation, drinking water) |

On 22 March 2021, a workshop on budgeting and handover of the plan was organized, jointly with the Dhankuta Municipality and Chhathar Jorpati Rural Municipality, Watershed Management Committee and other stakeholders. The total budget of NPR 109,090,000 for six intervention packages was validated by the participants (see table below). The potential demonstration sites for the implementation for the watershed management plan was also discussed during workshop. The two selected sites are: Site 1: Suke Pokhari area in Dhankuta-1 and Dhoje Danda area in Chhhathar Jorpati -2. During the workshop it was also decided to develop terms of reference for Watershed Management Committee and guideline for the implementation of the plan. In addition to this, it was decided to form Stakeholder Groups with all the stakeholders working in the watershed who can contribute towards the implementation of the plan.

## ESTIMATED BUDGET FOR 5 YEARS OPERATIONAL PLAN

| Component | Total amount (NRs) |
|---|---|
| **Component 1:** Sustainable conservation, management and use of water resources | 62,450,000 |
| **Component 2:** Sustainable Land use management | 15,250,000 |
| **Component 3:** Diversification and improvement of livelihood options | 13,450,000 |
| **Component 4:** Climate Change, disaster risk management and sustainable infrastructures | 9,690,000 |
| **Component 5:** Integrated Social Development | 4,150,000 |
| **Component 6:** Interdisciplinary action research and extension | 4,100,000 |
| **Grand Total** | **109,090,000** |

# Chapter 1: Introduction

## 1.1 Background

### 1.1.1 Watershed management issues in Nepal

The watersheds in Nepal have a complex physiography due to young and fragile geological formations and steep topography. Communities living in and beyond the watershed depend upon its resources for their livelihood-related activities. However, a watershed can be a source of hazard and risk (such as landslides and floods) with upstream-downstream socio-ecological implications. In the context of climate change, watershed dynamics are changing and watershed management approaches need to adapt to the changing context, including related socio-economic changes.

Natural and anthropogenic processes have led to the degradation of watersheds across Nepal co-shaping inequities in accessing and controlling water and land resources. The major challenges of watershed management in Nepal include soil erosion, land degradation, sedimentation, landslides, floods, droughts, biodiversity loss, and dwindling water supply including depletion of spring resources and gender and social inequities. All these issues emerge from a combination of natural processes and integrated effects of land and water use governance systems influenced by human interventions and sociocultural norms.

Watershed management approaches in Nepal have been continuously evolving since 1970 starting with addressing widespread land degradation and soil erosion problems to taking a more integrated and participatory approach by combining conservation and development (Achet and Flemming 2006; Pandit et al. 2007; DoSCWM 2016). Unfortunately, the socio-economic changes in watershed management are not gender progressive as they do not recognize and accommodate the equal relationships between women and men and their differential needs and capabilities when it comes to managing, accessing and controlling water and other natural resources (Seeley et al. 2000; Pangare and D'Souza 1998).

Watershed management also needs to include adaptive management considering climate change impacts. According to the climate change scenarios for Nepal (MOFE 2019), the temperature and precipitation of Nepal are projected to increase towards the end of the century. However, pre-monsoon precipitation is likely to decrease affecting many sectors including agriculture and water. This may intensify the prevailing situation of both too much and too little water. One of the emerging challenges in most of the watersheds in Nepal and other parts of the Hindu Kush Himalaya is the decreasing duration of dry season flows which are important for drinking water, irrigation, hydropower, riparian health and other ecological functions. It is therefore important that a climate lens be trained on watershed management interventions to make them more resilient to climate change driven impacts. It is equally important that proper gender responsive measures be introduced at watershed and springshed, including aquifer, levels to increase and efficiently manage dry season water yields.

To achieve integrated river basin management, the development and governance of watersheds of various scales are particularly important. The heterogeneity of watersheds, the major issues and responses are cumulatively reflected in large-scale river basins. As there are strong upstream-downstream linkages of land and water management at various scales, a multi-scale integrated river basin management can offer solutions across various watershed scales (Nepal et al. 2019; Nepal et al. 2018). Figure 1 shows the upstream-downstream linkages at the river basin level among source (upstream), transition (midstream) and floodplain (downstream) zones. The watershed level issues such as erosion, sedimentation, floods, water sources and landscape processes are also connected to a larger river basin.

### 1.1.2 Watershed management issues in Nibuwa-Tankhuwa Watershed

The NT Watershed is located in the Dhankuta district in the middle hills of eastern Nepal (see Figure 2). It spreads across the Dhankuta Municipality and Chhathar Jorpati Rural Municipality consisting of 10 wards (1-8 of Dhankuta Municipality & 2-3 of Chatthar

**FIGURE 1: THE UPSTREAM-DOWNSTREAM LINKAGES AT THE RIVER BASIN LEVEL AMONG SOURCE (UPSTREAM), TRANSITION (MIDSTREAM) AND FLOODPLAIN (DOWNSTREAM) ZONES**

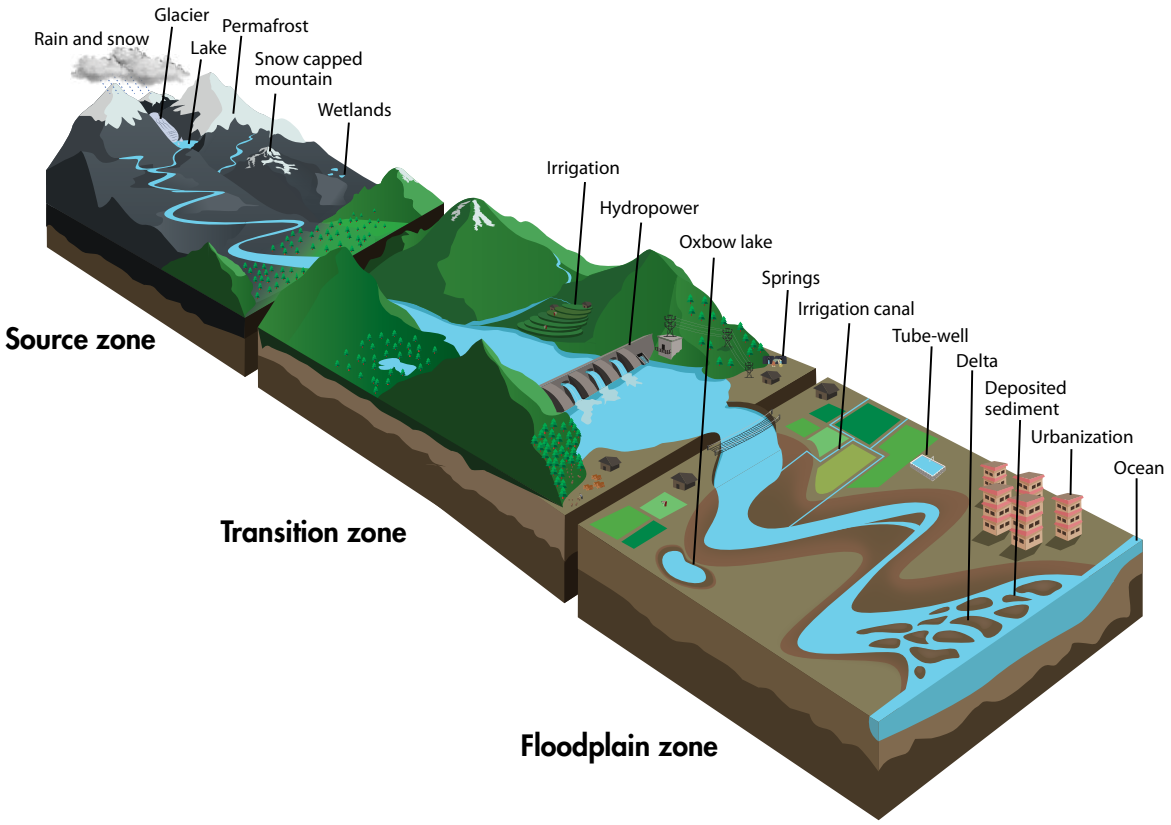
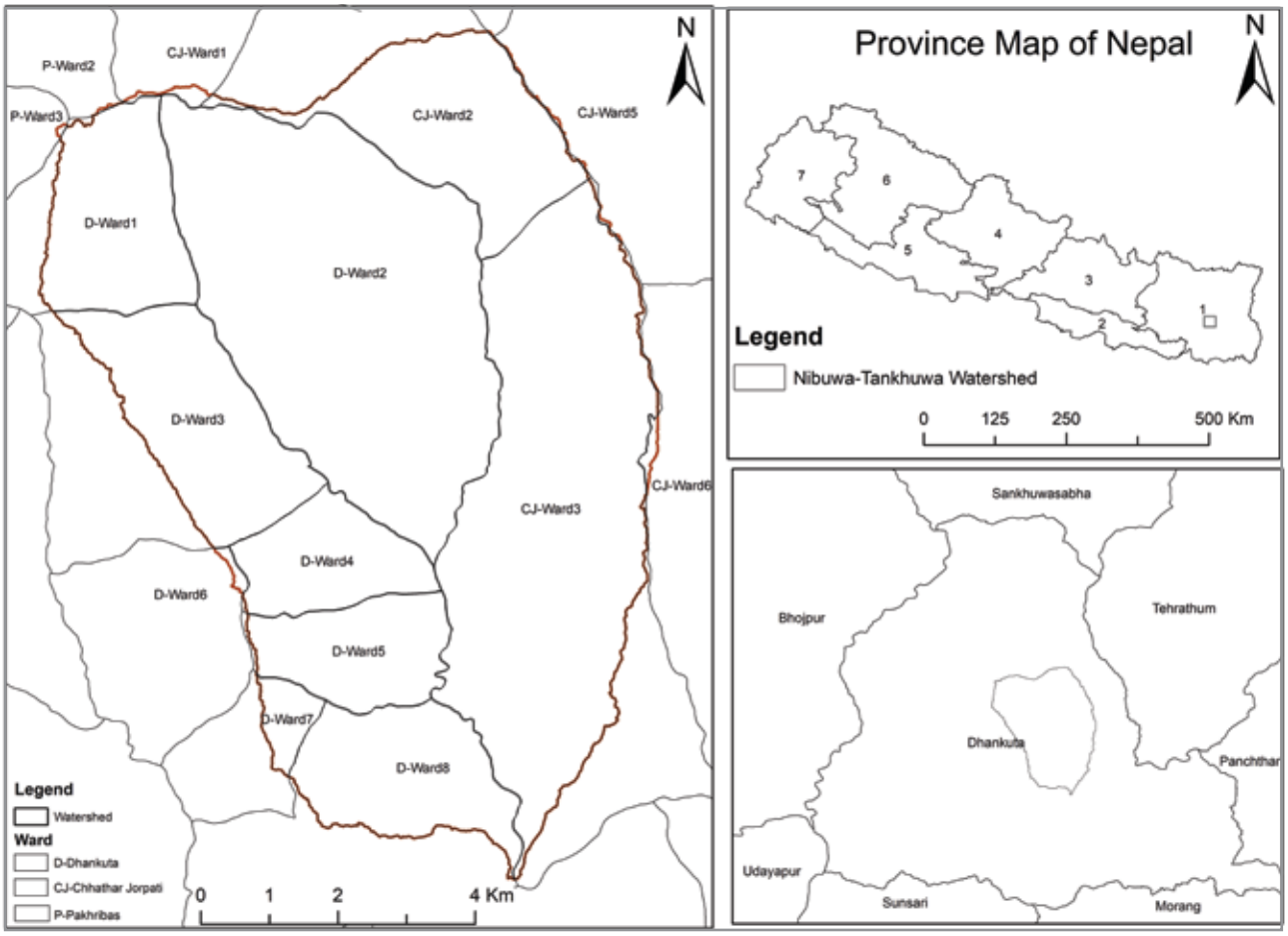



**FIGURE 2: LOCATION MAP OF THE NIBUWA-TANKHUWA WATERSHED**



Jorparti Rural Municipality) and having an area of 73 sq km. The watershed faces multiple issues and challenges. The significant watershed issues and challenges which are common to the Dhankuta district include soil erosion, landslides, sedimentation, land cover change, water availability and quality; and climate change, human-wildlife conflicts, livelihood systems and gender and social inclusion. In addition, water use conflicts and associated equity issues, lack of institutional mechanisms for planning, implementation and monitoring, and equal access to services are some of the prominent issues in the watershed. These issues were identified by a multi-disciplinary team during the field visit, expert discussions, key informant group meetings, and laboratory analysis. The detailed description of issues is presented in Chapter 6.

## 1.2 The need for an inclusive watershed management plan

To maximize the benefit of a watershed, minimize the risks, and share benefits equitably, a management plan is of utmost importance. A well-managed watershed not only supports the biophysical conditions of the watershed but also ensures improved ecosystem services for nature and people through conservation, restoration and management of diverse ecosystems and their biodiversity. It also enhances the wellbeing and resilience of the local communities whereby women and men utilize the resources equitably. The integrated watershed management plan not only leads to better ecosystem services and water resources for different uses including drinking and irrigation but also informs sectoral plans, policies and programmes related to forest, agriculture, pasture, and other land and water resources. It also helps to reduce inequity and disaster risks occurring from erosion, landslides, floods and drought. As such, the NT Watershed Plan takes into consideration owners' rights and access to assets such as land, water, livestock and household property (assets and income) from a gender perspective, and division of roles and responsibilities among women and men which are influenced by socio-cultural norms and practices.

Through a collaborative effort, the Dhankuta Municipality, Chhathar Jorpati Rural Municipality, Soil Conservation and Watershed Management Office, Dhankuta (formerly District Soil Conservation Office), Department of Forests and Soil Conservation (formerly Department of Watershed Management and Soil Conservation) and ICIMOD have worked together to develop a watershed management plan for the NT Watershed. The plan was prepared using a participatory, gender inclusive and adaptive watershed management approach to deal with changes driven by socio-economic and environmental drivers in the watershed, including climate change. The approach comprised linking both traditional and scientific knowledge involving a variety of stakeholders including local communities and institutions.

## 1.3 Objectives of the watershed management plan

The proposed watershed management plan has three-fold objectives:

#### SHORT-TERM OBJECTIVES

- To identify the major environmental, socio-economic and gender issues faced by population in the Nibuwa-Tankhuwa Watershed
- To propose mitigation and adaption measures from an environmental and socio-economic perspective to reduce the impact on the watershed and to maximize benefits of the watershed resources for all women, men and children keeping in mind strong upstream-downstream linkages
- To develop a mechanism for implementation of integrated watershed management plan to improve the existing status of the watershed and its services to the larger community on an equitable basis and propose a governance and institutional mechanism for sustainable watershed management
- To leverage resources for sustainable watershed management

#### LONG–TERM OBJECTIVES

- To ensure a regular supply and proper use of water and other resources for domestic, agricultural and development purposes on an equitable basis;
- To adopt a collaborative and participatory approach for the promotion and development of watershed services and maintain linkages between upstream and downstream communities for sustainable watershed management;

- To adopt a good governance institutional mechanism for sustainable watershed management and flow of its services.

#### EXPECTED OUTCOMES

It is expected that by achieving these objectives, the watershed plan will help to improve and enhance the water quantity and quality of the watershed which would contribute to better conservation and management of natural resources and improvement of the local livelihoods of women and men.

#### FUTURE OUTLOOK

By applying this plan, the local municipalities and communities can minimize the existing risks of the watershed in the Dhankuta district and maximize benefits arising from the watershed inclusively without compromising the sustainability of the watershed. The key issues of the watersheds are soil erosion, sedimentation, degraded forest conditions, drying springs, landslides, and lack of/inadequate institutional mechanisms and their implications for people's lives and livelihood. Overall, the plan aims to enhance water security, reduce disaster risk, and improve local livelihoods in the watershed area and immediately downstream.

This watershed plan would be useful in a similar ecological region after it is piloted and confirmed to be relevant in eastern Nepal. Also, the approach could be instrumental for Integrated River Basin Management implementation at the river basin level where watershed level issues such as soil erosion, sedimentation and equitable distribution of water between upstream and downstream communities and environmental flows are dealt with. At the river basin level, there are various watersheds and the cumulative effect of an individual watershed can be reflected in the larger watershed. However, an institutional and governance mechanism for multiscale river basin management is crucial.

## 1.4 Scope of the plan

The plan for the NT Watershed has a wider scope for the conservation and management of resources sustainably drawing upon the inter-dependencies of water and land resources, food security, equity, poverty reduction, ecosystem services, economic growth and disaster risk reduction. The interventions of the plan are identified in a participatory way based on a rigorous analysis of the major issues and challenges of the NT Watershed. The plan not only looks at environmental and socioeconomic issues from both watershed and ward levels but also focuses on technical, social and institutional good practices for better management of the NT Watershed. As such, the plan suggests convergence and partnership between soil conservation and watershed management plans and other sectors related to local adaptation plans, livelihoods, poverty alleviation, forestry, agriculture, gender and social inclusion and infrastructure development for addressing watershed management issues effectively. The data and information are gathered from primary and secondary sources including field visits and through use of GIS, Remote Sensing and climate and hydrology techniques which are described in the methodology section below (see Chapter 2).

## 1.5 Principles of watershed management

The principles of this watershed management plan are guided by the national sub-watershed plan developed by the Department of Forest and Soil Conservation (formerly, Department of Soil Conservation and Watershed (DoSCWM 2016).

- The NT Watershed management plan is a living document where new emerging issues and updated information will be incorporated and revised as needed;
- The Watershed Management Committee, Water User Committee, Dhankuta Municipality and Chhathar Jorpati Rural Municipality, Soil and Watershed Management Office and Ward Offices are committed to introducing and implementing programmes with technical, financial and facilitating support from other relevant government agencies and other non-governmental organizations, private sector, research and academic institutions in the district, if required. ICIMOD can provide technical input where applicable;
- Implementing nature-based solutions (NbS) to address the issues and creating co-benefits to the environment and people by adopting international and national good practices according to the local context and integrating local knowledge;

- Conflicts arising during the implementation of the plan should be addressed by the watershed management committee for a viable solution;
- The watershed management plan has set up mechanisms for meaningful and equal participation of women and men from different social groups, to encourage women's contribution as change agents, to recognize the differential needs and opportunities, and to ensure equitable benefits from water services and management for environmental sustainability;
- Additionally, principles of good governance will be emphasized and applied in the implementation of the plan. This includes the participation of beneficiaries and other stakeholders in decision making and implementation while also ensuring transparency and accountability in decision making, resource utilization, and distribution of benefits. Similarly, information and decisions made will be disseminated through proper channels so that everyone receives the communication. Integrating gender and social inclusion (GESI) strategies and mechanisms which provide opportunity to all sections of the population to participate in decision making, planning, implementation, and benefit sharing will be emphasized. Lastly, the role and responsibilities of the institutions involved, stakeholders and beneficiaries will be developed. Applying these principles will create a sense of ownership amongst all leading in turn to better outcomes;
- The vision of this watershed plan is inspired by the national plan, guidelines and strategies for watershed management of Nepal. It highlights a healthy watershed that supplies clean and safe water to all adequately; maintains harmonious relationships among women and men; addresses the differential needs between upstream and downstream communities, and provides watershed services and socio-economic benefits equitably.

# Chapter 2: Methodological approach

The methodology chapter gives an overview of the methods adopted and materials used as well as the process involved in the preparation of the watershed management plan. Both primary and secondary data were collected to understand the status, issues and challenges of the watershed. Primary data were collected using participatory rural appraisal (PRA) tools such as focus group discussions (FGDs), resource mapping and key informant interviews. Additionally, a geological and hydrological survey, water quality assessment and land mapping were conducted. The secondary data, especially reports, journal articles and pamphlets were collected using search engines like Scopus, Google Scholar, and Google, while the policy documents were collected from related government and non-governmental organizations. The flowchart (Figure 3) provides the methodology adopted during the preparation of the NT Watershed management plan.

## 2.1 Literature review

A literature review was done to understand the concept of watershed management and to identify the issues associated with the watershed, management actions and associated governance issues. The literature included peer-reviewed articles, policy documents, research reports, policy briefs, and official websites. Secondary data such as research papers, policy documents related to demographic characteristics, education, housing patterns, expenditure patterns, energy needs, health facilities, institutions, environment, natural resources and climate were collected from the concerned municipalities (Dhankuta Municipality and Chhathar Jorpati Rural Municipality), Division Forest Office, Soil and Watershed management Office (SWMO) and Department of Hydrology and Meteorology (DHM).

## 2.2 Focus group discussions and key informant interviews

Focus group discussions (FGDs) were carried out to understand people's perceptions on the issues, problems, and challenges related to water management, natural resources management and livelihood opportunities (see Photo 1). FGDs were conducted in all the wards that were within the watershed area, especially with local communities from upstream and downstream areas, community forest user groups, farmers' groups and mothers' groups. A total of 45 participants attended the FGDs in five different FGDs in which there were 29 male and 16 female participants.

The key informant interviews (KII) were carried out separately and included interviews with personnel from the line offices of government of Dhankuta, ward chairperson, FECOFUN, members from the water user committees, hoteliers, and members of women's groups. Altogether 25 key informants were interviewed, among whom all of them were male. These interviews focused on eliciting the level of understanding of water management issues, practices, natural resources and

**FIGURE 3: METHODOLOGY ADOPTED FOR DATA COLLECTION**

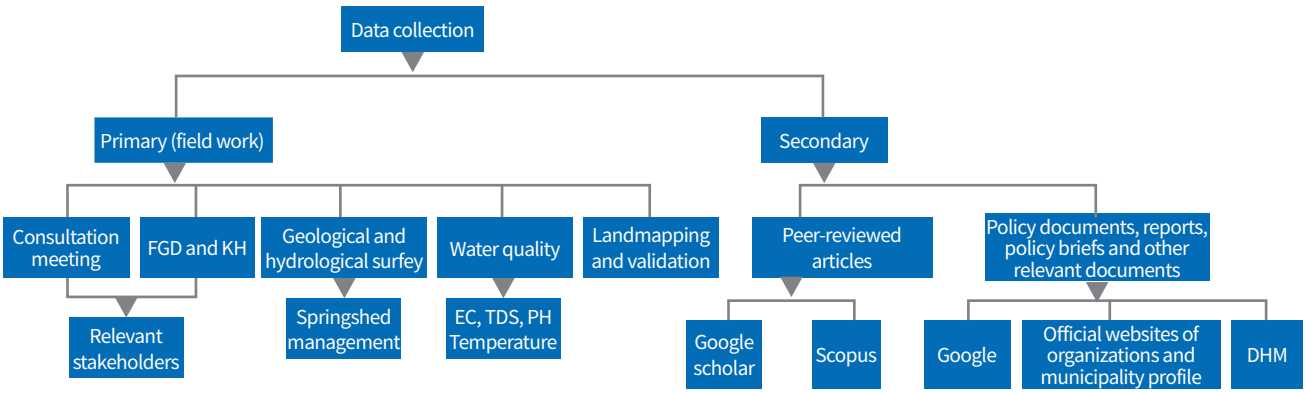


**PHOTO 1: FGD (RIGHT) AND KII (LEFT)**

government policies on water management among interviewees, and to understand the division of labour among women and men, their decision-making capabilities, access to and control over resources, changing socio-cultural norms, cropping patterns and agriculture practices. In addition, in-depth interviews were conducted with six males and seven females from the watershed.

Participatory Rural Appraisal tools (Transect Walk, Crop Calendar, Daily Activity Schedule and Then and Now Analysis) were used to understand the social dynamics of the population, and changing socio-cultural and gender norms at household and community level related to the management of water for drinking and agriculture purposes. A combination of quantitative and qualitative data was applied to analyse the socio-economic and gender-disaggregated data for the watershed management plan. The participatory tool – Then and Now Analysis, Daily Activity Schedule – applied through a gender lens helped to understand and relate to changing gender roles and water management at the local level. The Crop Calendar technique was applied so that women from the village could relate to changing agricultural practices with the availability of water and changing infrastructure facilities at the community level.

## 2.3 Consultation meeting with stakeholders

A half-day stakeholder consultation meeting was organized under the leadership of the vice mayor of Dhankuta Municipality (Photo 2). The main objective of this meeting was to delineate the watershed, identify the upstream and downstream areas and to inform the residents about the process of watershed management plan preparation in addition to identifying the role of stakeholders in implementing the plan. Wards 1, 2, 3 and 4 of Dhankuta Municipality, and wards 2 and 3 of Chhathar Jorpati Rural Municipality were identified as upstream areas while wards 5, 6, 7 and 8 were considered as downstream areas. Wards 1, 4, 5, 6 of Chhathar Jorpati and wards 2 and 3 of Pakhribas have not been included in the watershed management plan since the area covered is very little (<0.16 $km^2$). Realizing that institutions are key to implementing any agreement, a 21-member committee was formed during a half-day meeting in February 2019 (see Annex 1). The committee was chaired by the Mayor of Dhankuta Municipality and co-chaired by the Mayor of Chhathar Jorpati Rural Municipality. To form an inclusive committee, chairpersons of all the wards located within the watershed, the senior Watershed Management Officer, and 7 female representatives from upstream and downstream were included as members of the Committee.

**PHOTO 2: CONSULTATION MEETING WITH STAKEHOLDERS**

## 2.4 Water resource mapping, identifying issues and demonstrating solutions

Drying up of springs and deterioration in water quality were identified as among the key issues during the focus group discussions. Water resource mapping was conducted based on "The protocol for reviving springs in the Hindu Kush Himalaya: A practitioner's manual" (Shrestha et al. 2018) and it was followed throughout the springs' related activities during preliminary studies as well as in the fieldwork. The six-step protocol combines hydrogeology with social sciences and community action and it can be used as both a research tool for generating basic knowledge and to prepare detailed local implementation plans for spring revival. The six steps of the protocol are listed below.

### Step 1: Comprehensive mapping of springs and springsheds

Comprehensive mapping of water bodies is the basic step to visualizing the spatial distribution of the water resource and its beneficiaries in order to develop an appropriate management plan. During the stakeholders' meeting held at the Dhankuta Municipality Office, locations of springs present in their locality were suggested. Furthermore, water bodies were easily located with the assistance of community members and ward representatives during the field visits. Zones which hold water bodies were traced with the help of GPS following the spring inventory form (see Annex 5).

### Step 2: Setting up a data monitoring system

The data monitoring system includes the regular monitoring of springs' discharge and streams' discharge along with the rainfall pattern. A total of 29 springs were considered for long term monitoring on the basis of different criteria to understand the behaviour of springs with respect to quality and quantity over time. Rainfall data were obtained from the DHM stations. There is a plan to establish rain gauges at the spring sites to obtain site-specific data. For the regular data collection process, each staff member from the Dhankuta Municipality and SCWMO were trained in the field to measure river discharge using the area-velocity method and the salt dilution method (Photo 3). They were also trained to measure spring discharge as well as water quality. A water quality testing kit was handed over to the Dhankuta Municipality to measure the in-situ water quality as well as the discharge of streams using the salt tracer method.

### Step 3: Understanding social and governance systems related to springs

Understanding the current use of springs and the underlying institutions and governance systems is crucial for devising effective mechanisms for spring revival. This step will yield information on the number of households that depend on a spring, time to fetch water from the spring and ease of water collection, the uses of the spring water, perceptions of water quantity and quality (then and now), and rules, regulations, and institutions involved in spring management, and conflict management approaches. FGD, KII and transect walk were the tools used during the field visit in the NT Watershed to understand the social and governance systems.

**PHOTO 3: STREAM DISCHARGE MEASUREMENT USING AREA-VELOCITY METHOD (LEFT) AND SALT DILUTION METHOD (RIGHT)**

## Step 4: Hydrogeological mapping, development of conceptual layout and identification of recharge area

Traverses, walk-over surveys, and studies on the exposures, outcrops and the landforms were carried out for the geological survey using maps and tools to identify the rocks and minerals, rock types occurrences and relations of rock types (see Photo 4).

**PHOTO 4: ROCK OUTCROP MAPPING USING BRUNTON COMPASS**

A detailed study of groundwater sources and water bodies was done and analysed during the hydrogeological survey using the spring discharge (see Photo 5) and stream discharge measurement, water quality measurement and the socio-economic study. Later, stream hydrographs were prepared using the Medium Irrigation Project (MIP) method which requires coordinates of the watershed and seasonal river discharge which gives the mean monthly flow. The MIP is a reliable method which has been developed by the Government of Nepal to prepare a stream hydrograph.

The measurements of in-situ physio-chemical parameters of spring water in the NT Watershed was done by a tool kit (Photo 6) used to measure Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature and pH. Accurate steady values were displayed after dipping probes in water samples from a few seconds to a few minutes. The discharge of the springs was calculated considering the time taken to fill the bucket with water whereas the river discharge was calculated using the area velocity and salt dilution method (see Annex 5). Additionally, 10 samples were collected from the different water sources and reservoirs for the laboratory test including the microbiological test, i.e., the coliform test (see Annex 9).

**PHOTO 5: SPRING DISCHARGE MEASUREMENT (ABOVE) AND NOTE KEEPING (BELOW)**

**PHOTO 6: FIELD TOOLKITS: WATER QUALITY TRACER, BRUNTON COMPASS AND GEOLOGICAL HAMMER**

## Step 5: Developing springshed management and governance protocols

This step needs to be conducted during the implementation of the watershed management plan. The springshed management protocols need to be developed by mutual consent among the different villages involved. The management plans were also site-specific, developed to meet local needs and taking into account local possibilities and constraints. Land use and ownership play a role in determining what measures are possible. For example, construction of physical structures like pits and ponds may not be

possible on private land. In such instances, alternative interventions like terrace improvement, hedgerows or tree plantation may be suggested. In some cases, the recharge area might be located in a place like a rocky area, cliffs and dense forest where activities are not possible whereas in others artificial enhancement of recharge may not be needed. In such cases, management measures such as protection of forest, other land uses and spring sources are sufficient.

The proposed potential sites and structures in Dhankuta Municipality are:

- The Suke Pokhari, which is an ancient pond that can be renovated and has the potential to collect rainwater and road runoff;
- A pond at Shivalaya, which can be reconstructed to collect seepage water;
- Dharabari Rupitar, where the conservation of wetland is possible since this area itself is a recharge area for springs downstream.

The proposed potential sites and structures in Chhathar Jorpati Rural Municipality are:

- Four small ponds, which can be made at an elevation of 2148 m in the Dhoje dada area;
- Two ponds, which can be constructed at an elevation of 2238 m at the top of the Dhoje dada that lie within the community forest;
- The Chuldhunga, which is an ancient pond in a community forest that is located at an elevation of 2032 m, where a large pond can be renovated.

### Step 6: Measuring the impact of spring revival activities

Continued monitoring of the springshed activities described in the various steps is necessary to correctly gauge and understand the impacts of a springshed management programme. Springshed management impacts can be broadly categorized into:

- Increasing the resource (aquifers) feeding the spring system
- Improving the supply of spring water to users
- Improving the demand for spring water

## 2.5 Soil loss prediction

To estimate the distribution of the spatial distribution of soil loss, factors including slope, rainfall, Normalized Difference Vegetation Index (NDVI) and land cover were used. The Revised Universal Soil Loss Equation (RUSLE) was applied as given below (details in Annex 3).

$$A = R \times K \times L \times S \times C \times P$$

where,

$A$ is soil loss in tons per hectare,

$R$ is the rainfall-erosivity index,

$K$ represents soil erodibility index,

$L$ represents slope length,

$S$ is the slope steepness factor,

$C$ represents land cover management factor, and

$P$ represents the supporting practices factor.

The description of input data, data pre-processing and calculation of each factor are discussed in greater detail below. These factors (RKLSCP) were combined using the RUSLE framework in the ArcGIS model builder environment for the estimation of average soil loss.

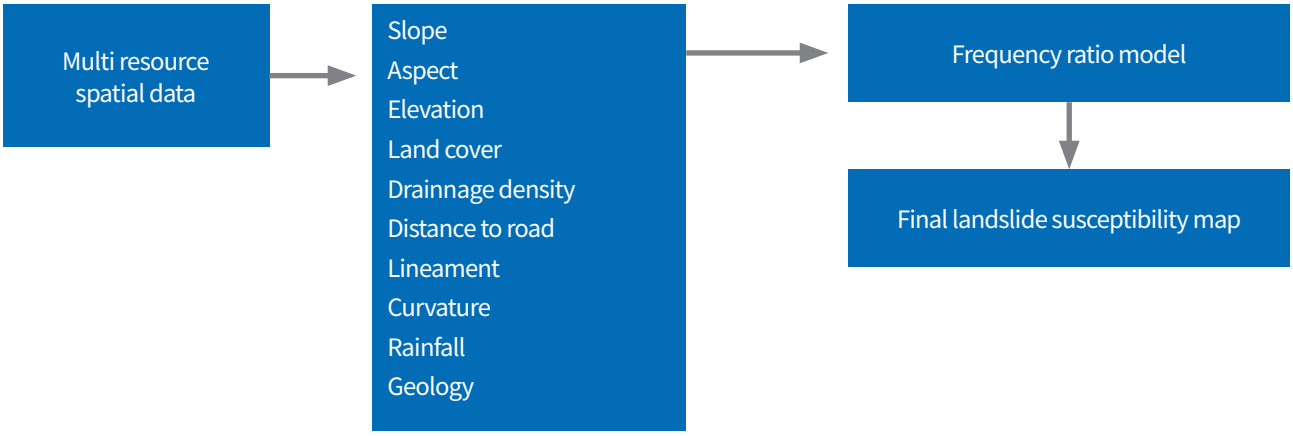
## 2.6 Landslide susceptibility

Landslide mapping was done on the basis of field visit and using Google Earth and Regional Database System of ICIMOD. The Frequency Ratio Model (Ehret et al. 2010) was used for the preparation of the landslide susceptibility map (see Figure 4 and annex 3).

## 2.7 Socio-economic and gender analysis

From a gender perspective, the watershed management plan focused on understanding the issues and problems related to the well-being of women and men. It also aimed at understanding the gender strategy adopted by the institutions for women's empowerment within the watershed. The field study focused on gathering primary and secondary gender-disaggregated data from both the Dhankuta Municipality and Chhathra Jorparti Rural Municipality. The gender analysis was limited only to a few parameters, such as education status, socio-economic

**FIGURE 4: FLOW CHART OF LANDSLIDE SUSCEPTIBILITY MAP PREPARATION**




status of households, and time taken for fetching drinking water in the Dhankuta Municipality. In the case of the Chhathar Jorpati Municipality, gender-disaggregated data for the watershed were unavailable to draw a gender analysis.

Quantitative secondary data were analysed to understand the self-help groups (savings groups) and their income generation activities, migration patterns at the local level, and the increasing burden of agricultural labour on women. This information was obtained to strengthen the arguments supporting the qualitative findings within the scope of the plan. The gender-disaggregated data available from Dhankuta Municipality and Chhathar Jorpati Municipality include information on the education status, economic status (including income and household loans), livestock, and other livelihood options.

## Limitations of the methodology

The Dhankuta Municipality had limited information on the socio-economic status of the population (such as income and loans), whereas there was no data whatsoever for the Chhathar Jorpati Rural Municipality. The data on the gender division of labour and microfinance were gathered from the field study in a few of the wards located in Dhankuta Municipality. Therefore, validation on the information related to the gender division of labour and financial burden were triangulated through t Participatory Rural Appraisal (PRA) tools and FGDs. In doing so, the gender analysis exclusively focused on the women engaged in agricultural production and those who were members of financial institutions. This gave a better understanding on the gender issues and problems related to water management and women's entrepreneurship.

# Chapter 3: Basic characteristics of the watershed

## 3.1 Introduction

This chapter presents the results of the primary and secondary data analysis conducted as described in Chapter 2. It presents the basic characteristics of the watershed with a particular focus on soil, geology, climate, hydrology, land use and water resources status. The major ecosystems and their services as well as the socio-economic characteristics of the demography are also presented. The basic characteristics of the watershed provide a foundation to analyse the issues and plan actions wisely for sustainable watershed management.

## 3.2 Physiography

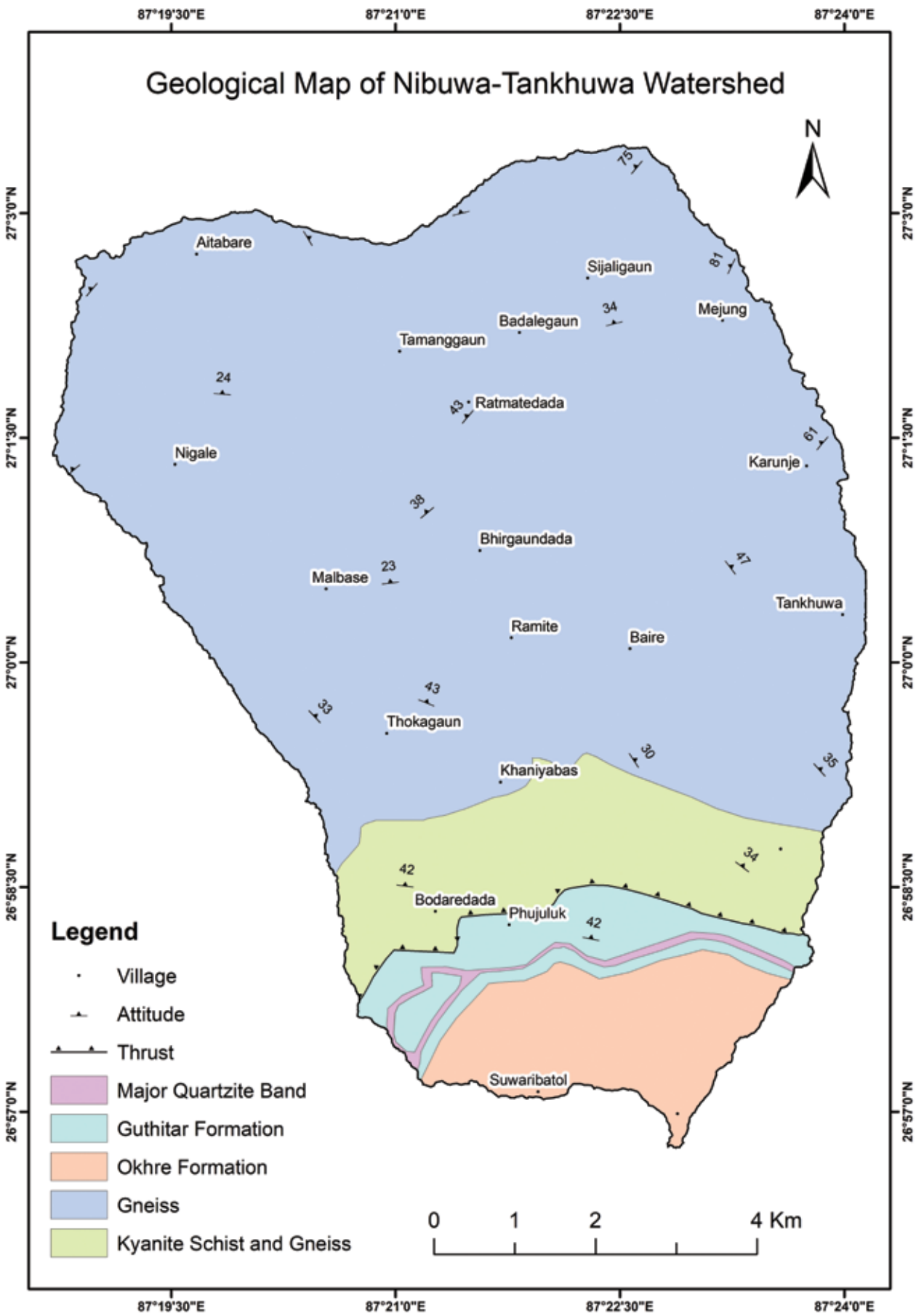
The NT Watershed lies partly in the Midlands and partly in the Mahabharat Range, consisting of gradually sloping hills, wide river valleys and tectonic basins (Upreti et al. 2001). This watershed is located between the 87.32˚ and 87.40˚ E longitude and 26.95˚ and 27.05˚ N latitude in Dhankuta district of the Province 1, Nepal. The watershed covers an area of 73 km$^2$ which extends from the Gurase Dada in the northern part to the Phujuluk village in the southern part of the watershed. The watershed is heart-shaped consisting of wards 1, 2, 3, 4, 5, 6, 7 and 8 of Dhankuta Municipality and wards 2 and 3 of Chhathar Jorpati Rural Municipality. Ward 8, a downstream area, is directly impacted by water use in the upstream area while Ward 7 (Dhankuta town) is a major water consumption area from this watershed. Dhankuta town is the nearest city in the watershed. The watershed's maximum north-south and east-west aerial distances are 11.06 km and 8.16 km, respectively. The longest length of the Nibuwa Khola (maximum length of travel of the water) is about 8.26 km while it is about 7.77 km for Tankhuwa Khola, and 4.43 km for Madhuganga Khola. This watershed has narrow stream channels in the upstream while most valleys are deeply incised. The slope of the valleys is steeper in the north than in the south.

## 3.3 Soil and geology

The watershed area consists of rocks of the Higher Himalayan Crystalline Group and Phongsawa Group, which are separated by the Main Central Thrust (MCT) (Dhital 1992). Due to enormous tectonic activities, rocks in the watershed are highly deformed (see Figure 5). Higher Himalayan Crystalline is composed of dark grey, blue grey, and green grey kyanite schists, garnetiferous schist, actinolite schist and quartzite with banded and augen gneiss. Near the watershed of the Phujuluk village, the Higher Himalayan Crystalline and Phongsawa group of the Lesser Himalaya is separated by the Main Central Thrust. The Phongsawa Group is further divided into different formations: The Guthitar Formation, which consists of black graphitic schist, garnet schist and fine grained, white quartzite (see Photo 7), and Okhre Formation, which consists of dark greenish grey crenulated phyllite with sporadic greenish grey quartzite and crenulated chlorite schist.

**PHOTO 7: DEFORMATION OF ROCKS IN AAITABARE AND GURASE (RESPECTIVELY)**

**FIGURE 5: GEOLOGICAL MAP OF STUDY AREA**




Source: Modified from Dhital (1992)

## 3.4 Climatic patterns and drainage network

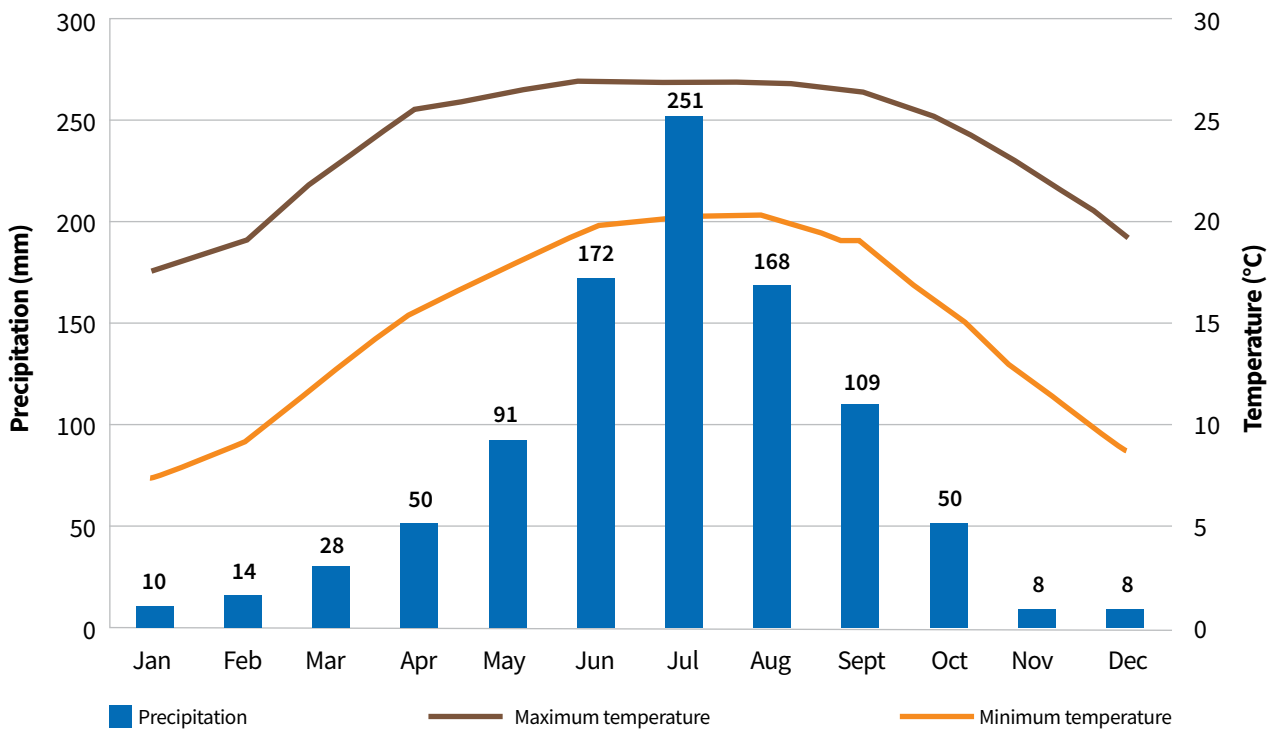
### 3.4.1 Climate and historic climate trends

The study area represents a typical climate for a mid-hill region in Nepal. The maximum and minimum temperature in the study area has shown a significant increasing trend in the last 40 years. The temperature-based indices also show a significant increasing trend. However, the precipitation and precipitation-based indices have not shown any significant trend. The analysis was done using observed data from the station and the report published by DHM (DHM 2017). There is one DHM synoptic station, Station no. 1307 (Dhankuta station), which lies within the watershed. Based on the station's precipitation data from 1947, the average precipitation for the station is about 960 mm per year out of which most of the precipitation falls during the monsoon season, which comes to 73 % of the total annual precipitation. There is very low precipitation from November to March. Based on the stations' temperature data from 1987, the average annual maximum temperature at the station is about 24˚C with a low of 17.6˚C during January and a high of 27˚C during August. The average minimum temperature is about 15˚C with a low of 7˚C during January and a high of 20˚C during July (see Figure 6).

According to the DHM (2017) report, between 1971 and 2014, no significant change was observed in the seasonal and annual precipitation of the Dhankuta district (see Annex 6) while the annual maximum temperature has increased significantly at a rate of 0.059˚C/year. During the last 40 years, the annual maximum temperature has increased by almost 2.4˚C while the minimum temperature, for the same period, has increased by 0.72˚C (0.018 ˚C/year) (see Annex 6). Thus, the rate of increase in maximum temperature is roughly four times that of the minimum temperature. This shows the increase in the diurnal variation of the temperature in recent years in comparison with the past.

The DHM (2017) study also analysed 11 climate extreme indices, 5 for precipitation and 6 for temperature, for all the districts of Nepal. Among the precipitation indices for Dhankuta district, the rainy days are increasing at 0.3 days/year with a 12 day increase in the last 40 years. The number of consecutive wet days has also increased at 0.4 days/year. However, the number of very wet and extremely wet days is declining at 0.1 days/year. The very wet and extremely wet days have decreased by 4 days in the last 40 years. Among the six temperature indices for Dhankuta district, the warm days are increasing significantly at the rate of 1.5 days/year. This is

**FIGURE 6: CLIMATOLOGY OF MONTHLY PRECIPITATION AND TEMPERATURE FOR DHANKUTA STATION (1307)**

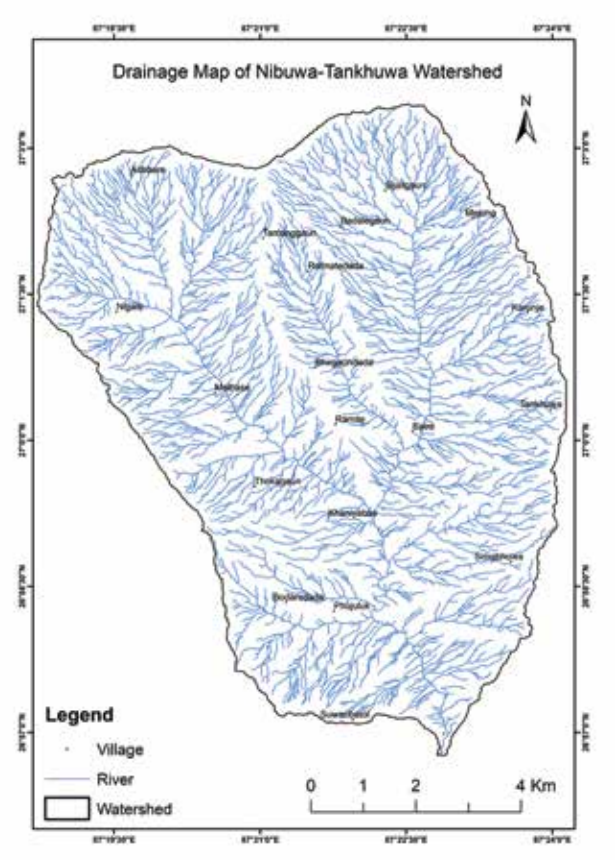


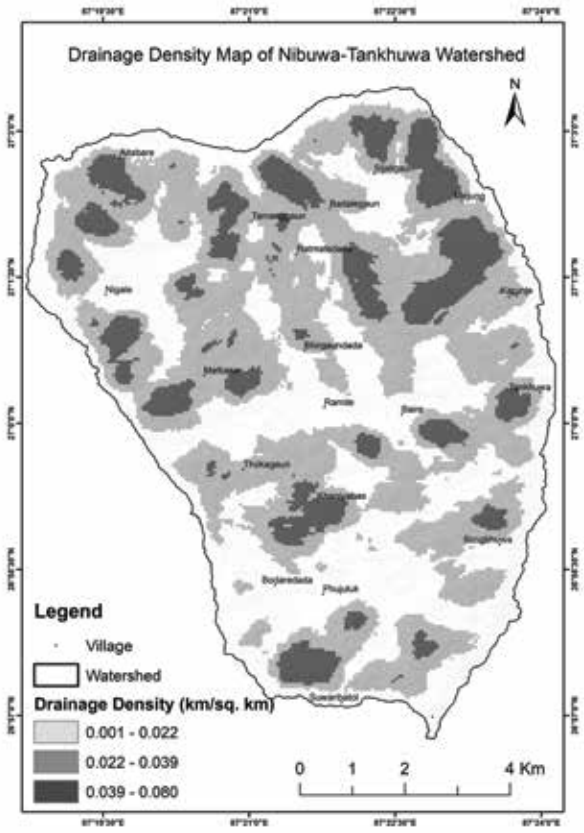
equivalent to an increase of 60 warm days in the last 40 years. The number of cool days has similarly decreased over the same period by 44 days (1.1 days/year). The increase in warm days is accompanied by an increase in the warm spell duration. The warm spell duration, which looks at a period of consecutive 6 days or longer when the maximum temperature is higher than the 90th percentile, has increased at the rate of 0.3 days/year amounting to 12 days in the last 40 years. Similarly, the warm nights are on the rise at the rate of 0.6 days/year amounting to 24 days in the last 40 years. In contrast, the number of cool nights has significantly decreased by 12 days in the last 40 years at 0.3 days/year. This analysis shows that all temperature indices and the two precipitation indices have become more extreme in recent years in comparison to the past. This also means that extreme events are becoming more frequent and severe. These are bound to have serious impacts on agriculture, water supply, irrigation, biodiversity, and livelihoods of communities in Dhankuta.

### 3.4.2 Drainage networks and drainage density

Drainage density is a measure that analyses the length of different streams per unit area. It is obtained by dividing the total stream length by the total watershed area. It is an important factor in slope instability as higher the drainage density, lower the infiltration and faster the movement of the surface flow (Pachauri et al. 1998). Drainage density helps to identify landscape dissection, runoff potential, infiltration capacity of the land, climatic conditions, and vegetation cover of the basin (Verstappen 1983; Macke 2001; Reddy et al. 2004). In the NT Watershed, the lowest drainage density is less than 0.001 km/km$^2$ whereas the highest is 0.080 km/km$^2$. Most of the areas in Gurase, Malbase, Bhirgau and Chulachuli villages have high drainage density (see Figure 7). According to Patton (1988), the areas of high drainage density are a result of erosion resulting in intense superficial mass wasting and dissection by overland flow whereas low drainage density areas are the product of the runoff process dominated by infiltration and sub-surface flow. NT Watershed has the lowest drainage density of 0.001km/km$^2$ and the highest of 0.080km/km$^2$. Some areas in Aitabare, Nigale, Khaniyabas and Malbase villages of Nibuwa

**FIGURE 7: DRAINAGE MAP AND DRAINAGE DENSITY MAP OF NIBUWA-TANKHUWA WATERSHED**



and most areas of Gurase, Bhirgau, Karunje and Chulachuli villages of Tankhuwa watershed have a high drainage density within the NT Watershed (Figure 7). These areas have a high probability of soil erosion and landslides as most of the rainfall coverts to overland flow in these areas.

## 3.5 Land use change and land capability

### 3.5.1 Landform and land systems of the watershed

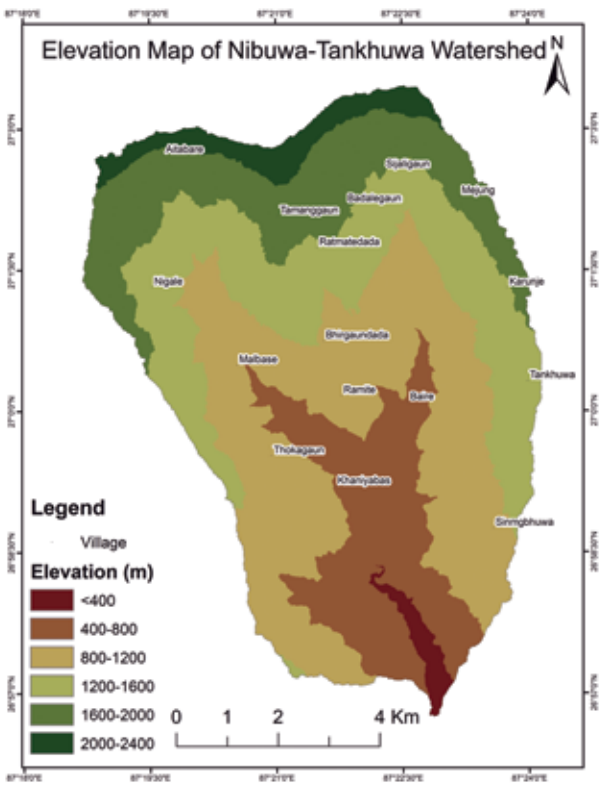
The curvature of the slope affects the accelerations and decelerations of the flow across the surface. The upwardly convex flow will decelerate whereas the upwardly concave flow will accelerate. As shown in Google Earth, the landform of the watershed has flood plains, natural levees and terraces. The elevation of the NT Watershed varies from 243m to 2239m asl (see Figure 8, left). The shape of slope affects the overall rate of movement downslope. In the watershed, the linear slope is dominant (65.82%) where the flow is parallel while the upwardly concave slope (5.22%) represents the concentration of flow and the upwardly convex slope (28.97%) represents the dispersed flow (see Figure 8, right). Higher the concentrated flow, higher will be the moisture content in soil and infiltration.

The valley is highly dissected in the top right ridge part and the botttom most part whereas it is moderately dissected in the middle section. The Tankhuwa valleys are gentler than the Nibuwa valleys while the Madhuganga valleys are less dissected than the other valleys.

### 3.5.2 Slope and aspect classes of the watershed

Slope is the measure of an angle between a location on the ground surface and the horizon (Ohlmacher 2000) and plays an important role in controlling the amount of material available for landslides, erosions, vegetation, etc. (Chen et al. 2015). The slope was classified into 5 different classes following the Watershed Management Planning Guideline (DoSCW 2016). The slope map (Figure 9) shows that the region around the water divide and settlement area has a level or nearly level slope whereas the slope near the rivers is very steep. Approximately, 49.83% of the area in the watershed has a steep slope and 49.83% of the area have a very steep slope while approximately 21.57 % of the area has a moderately steep slope (Table 1). Thus, implementation of a proper land use plan is essential in the watershed.

**FIGURE 8: ELEVATION (LEFT) AND CURVATURE (RIGHT) MAP OF NIBUWA-TANKHUWA WATERSHED**



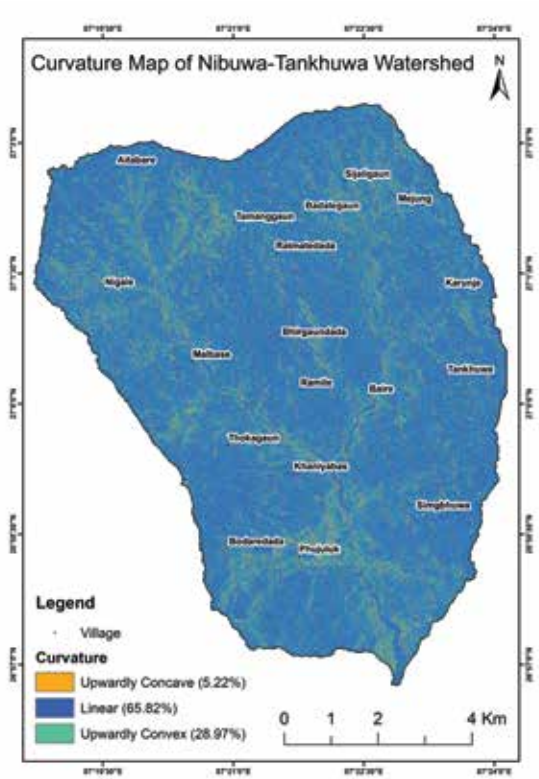



**TABLE 1: SLOPE CLASS AND AREA COVERAGE OF SLOPE**

| Slope class | Slope in % | Area in hectare | Area in percentage |
|---|---|---|---|
| Level /nearly Level | < 3 | 19.96 | 0.27 |
| Gently sloping | 3-15 | 371.30 | 5.07 |
| Moderately steep | 15-30 | 1579.88 | 21.57 |
| Steep | 30-60 | 3650.18 | 49.83 |
| Very steep | >60 | 1703.45 | 23.25 |

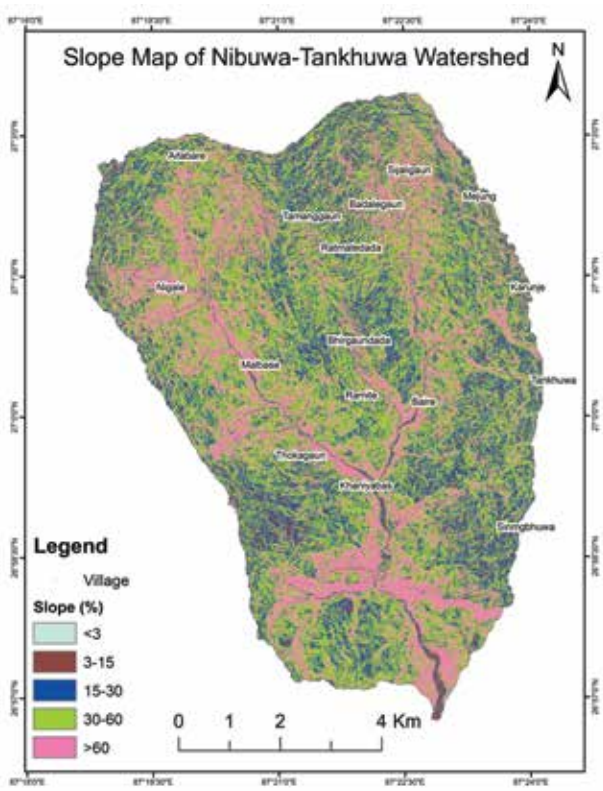
The aspect class was divided into eight different classes: north, northeast, east, southeast, south, southwest, west and northwest. Much of the study area lies in the southwest (18.99%) followed by south (16.02%), southeast (15.80%), east (13.47%), northeast (11.86%), west (11.44%), northwest (6.33%), north (5.09%) and flat (1%), respectively (Figure 9). The watershed area has greater coverage of the southern aspect of the slope than the northern aspect of the slope. South-facing slopes tend to be sunnier and drier than the nearby north-facing slopes because the sun is always in the southern sky for those in the northern hemisphere. Hence, the sun's rays strike a south-facing slope more directly than a north-facing slope.[1]

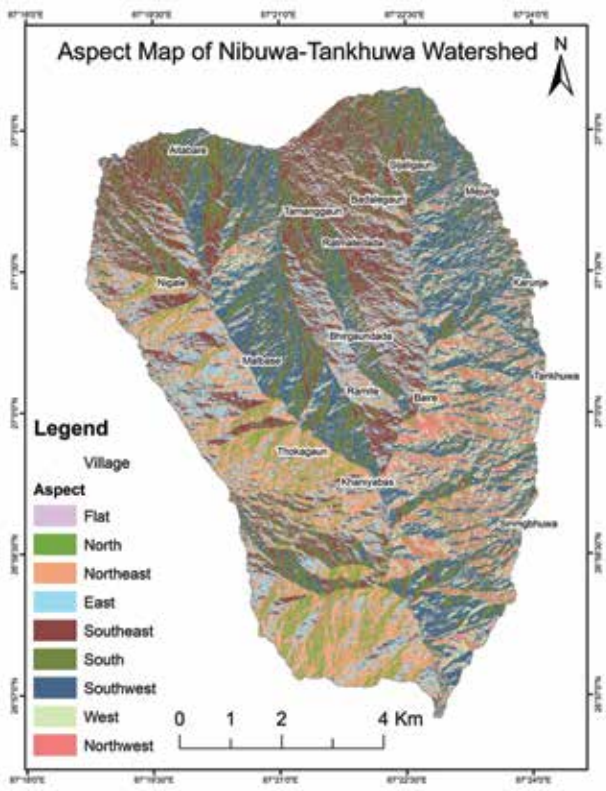
### 3.5.3 Land use and Land cover (LULC)

Land cover change is a significant contributor to environmental change. The conversion of forest land to other land cover and degradation of forest have a substantial effect on biodiversity of ecosystem services while contributing also to the soil erosion risk. The loss of the top soil due to land cover change has both a direct and indirect effect on human life and livelihoods (Uddin et al. 2016). For the NT Watershed, land cover was developed based on a cloud-based platform of Google Earth Engine using Landsat images in combination with other thematic layers. The land cover mapping followed six essential phases: i) Defining the land cover classification systems, ii) gathering land cover training samples, iii) selection of Landsat images and preparation of composites, iv) collection of supplementary thematic data and formation of image indices and covariates, v) utilization of supervised machine learning algorithms and creation of land cover primitives, and vi) generation of customized land cover maps by modifying the assemblage logic using a decision tree and validation(Saah et al. 2020).

Land cover for 2000, 2010 and 2018 are presented in Figure 10 and the statistics for the three years

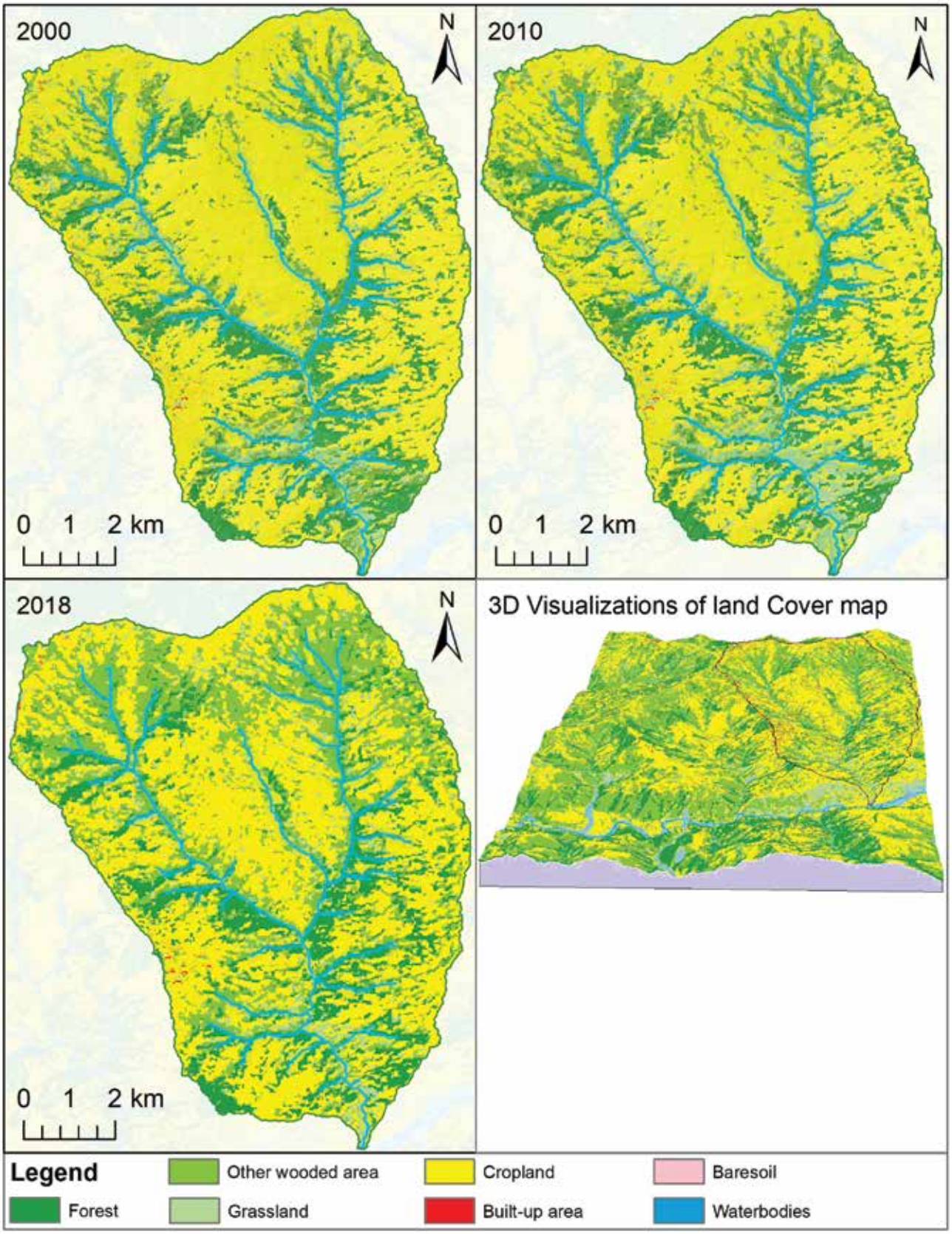
**FIGURE 9: SLOPE AND ASPECT MAP OF NIBUWA-TANKHUWA WATERSHED**



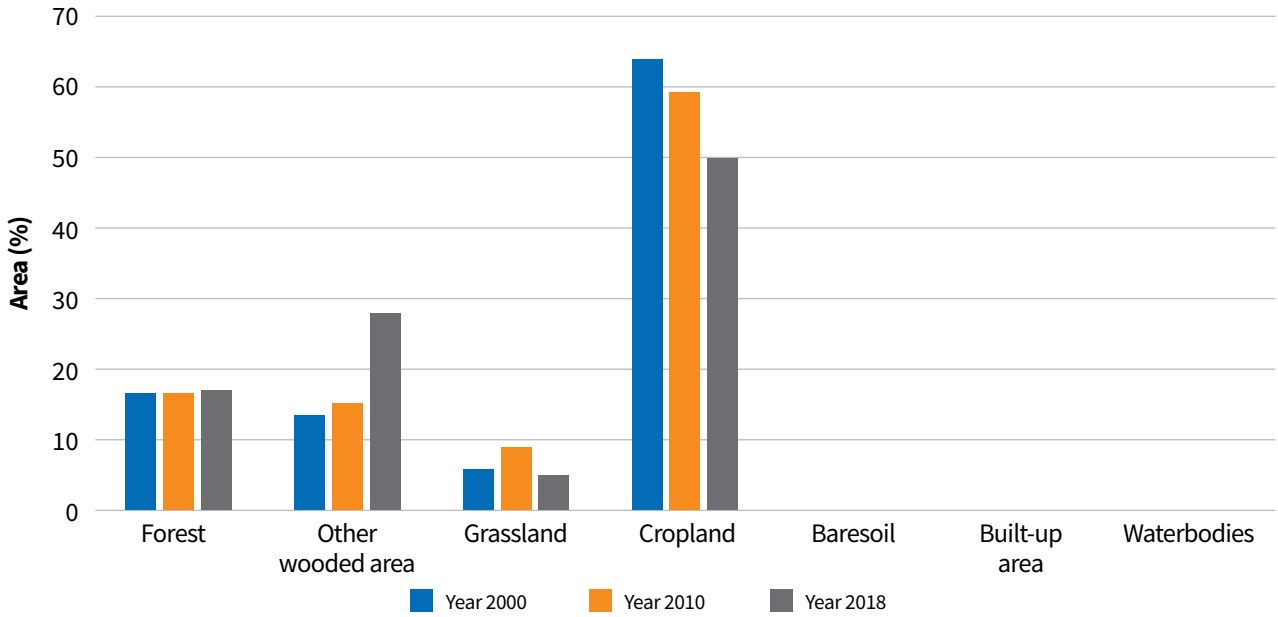

[1] https://explorenaturalcommunities.org/ecology-basics/physical-setting/topography#:~:text=South%2Dfacing%20slopes%20will%20tend,strike%20a%20north%2Dfacing%20slope

**FIGURE 10: LAND USE AND LAND COVER CHANGES, 1990-2018**




Source: ICIMOD (2000, 2010 & 2018)

**FIGURE 11: GRAPHICAL PRESENTATION OF LAND USE AND LAND COVER CHANGES, 2000-2018**




Source: ICIMOD (2000, 2010, 2018)

for different types of land cover areas are shown in Figure 11. The results show that cropland was the most significant land cover in 2000 covering 63.75% of the total area of the watershed while in 2010 it was 59.23 % and in 2018 49.94%. This was followed by forest area with 16.65% in 2000, 16.64% in 2010 and 17.03% in 2018. Forest cover was mostly distributed in the northern part and along the streamline of the watershed. Other wooded land (OWL) was also to be found in a significant area of the adjacent area of the watersheds, with 27.83% of cover in 2018. Other wooded land (OWL) mostly defines tree covered areas, including forest, spanning more than 0.5 ha, having at least 20m width and a tree canopy cover between 5% and 10%. In this watershed, grassland areas were comparatively a less significant land cover with 5.99% in 2000, 8.91% in 2010 and 5.08% in 2018. Considering Figure 11, it can therefore be concluded that there has been a significant change in land cover between 2000 and 2018. While forest areas has increased by 0.38% between 2000 and 2018, cropland has shown a decreasing trend. Between 2000 and 2018 cropland decreased by 13.81%.

### 3.5.4 Soil loss prediction from the watershed

The mean annual soil loss for the entire watershed area was estimated at 9.70 t/ha/yr and the annual erosion rate was found to be around 57,132 tons using RUSLE (see Chapter 2 for explanation). The northern parts of the watershed were found to have less soil erodible areas while the middle part of the study area was found to be highly erodible. The estimated soil erosion map control can be seen in Figure 12. The distribution of erosion according to land cover reveals that cropland contributes around 35,866 ton with the mean erosion rate at 9.81 t/ha/yr, followed by other wooded areas with 11,866 ton with the mean erosion rate at 5.82 t/ha/yr. In contrast, forest area has low soil erosion rate at 3.64 t/ha/yr and 4,538 tons of soil loss annually.

### 3.5.5 Landslide susceptibility analysis

A total of 66 landslides were mapped using the RDS database of ICIMOD (1990, 2000 and 2010), Google Earth, and field verification. Most of the area in the watershed lies in the medium susceptible zone (39%) followed by high (33%), very high (13%) and low (15%) (see Figure 13). Analysis of data using the frequency ratio model shows that the drainage density, geology, and distance to road have a strong weightage with regard to the landslide occurrence in the area. Roads built on slopes cause loss of toe support which leads to changes in topography and in turn leads to increase in strain behind the slope and development of cracks resulting in landslides. This watershed consists of rocks of the Higher Himalayan Crystallines Group and Phongsawa Group, which are separated by the Main Central Thrust (MCT). Enormous tectonic activities result in highly deformed rocks in the watershed (see details in section 3.3). Erosion is also a contributing factor to the landslides. A comparison of the erosion

**FIGURE 12: SOIL EROSION RISK MAP (2018)**

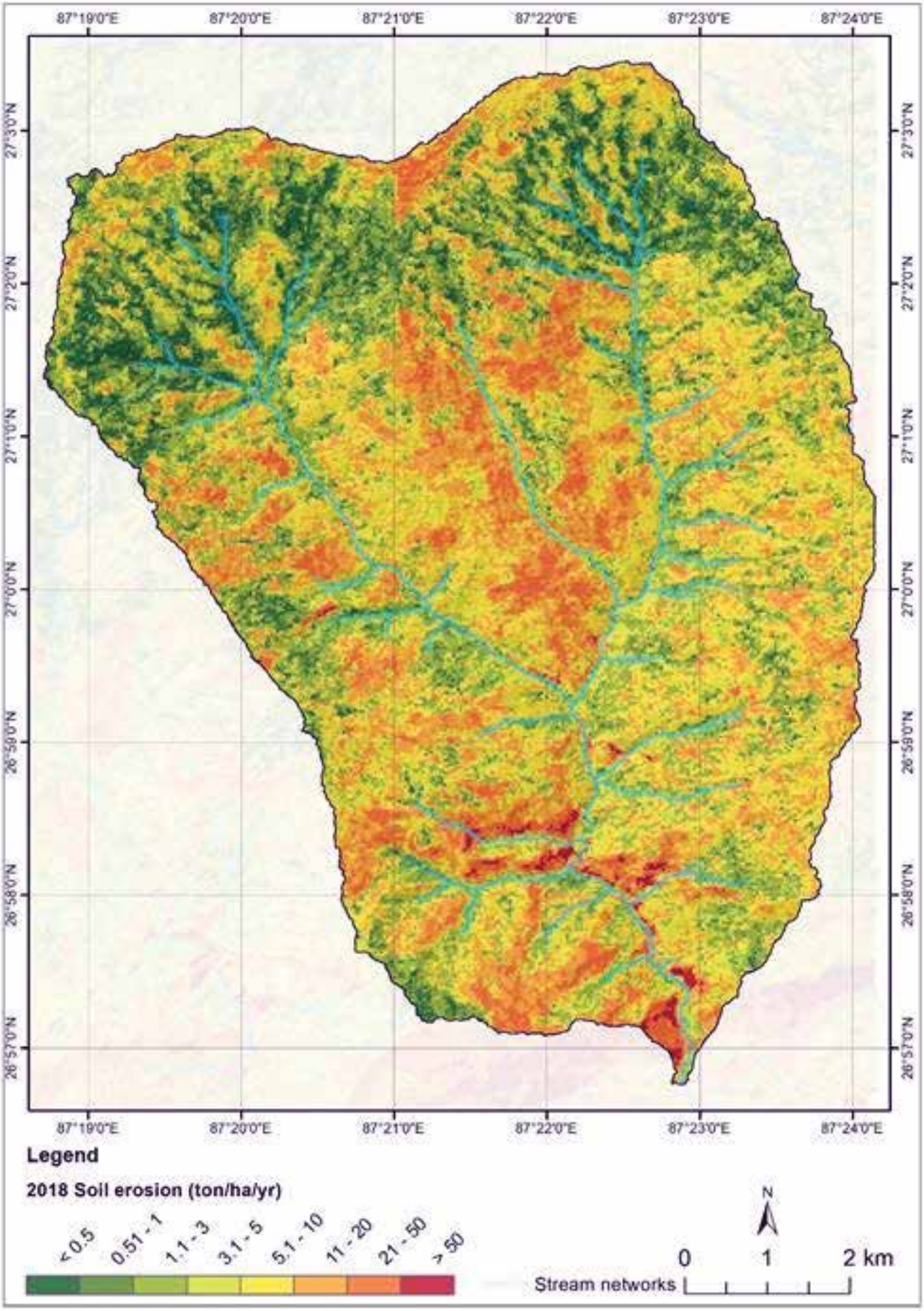
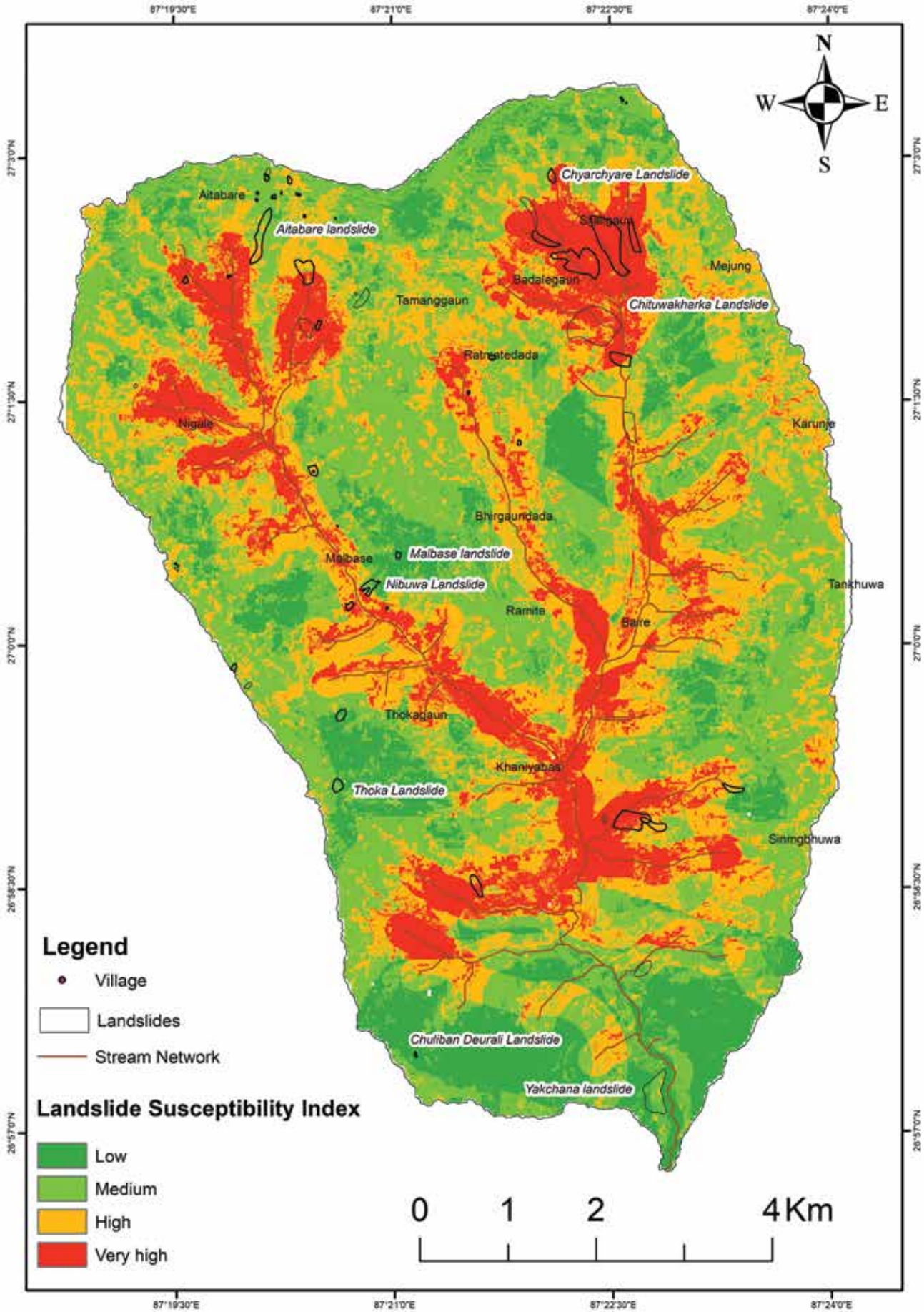


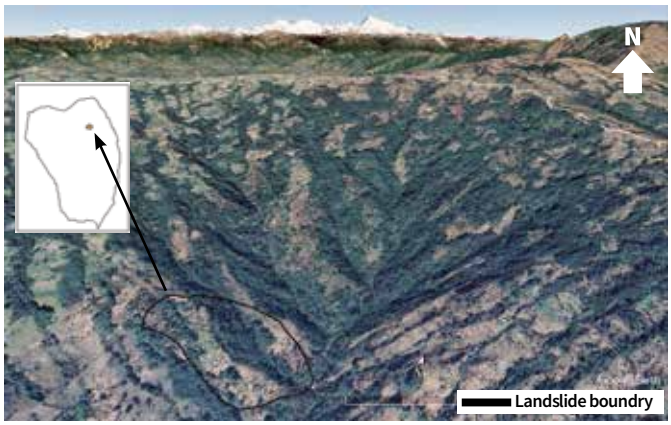
**FIGURE 13: LANDSLIDE SUSCEPTIBILITY MAP**



analysis with the landslide susceptibility map reveals erosion rates near the river and along the higher flow of the river (Figure 13). Similarly, from the susceptibility map, the high susceptible zone of the landslide has also been observed near the river showing the strong weightage of "drainage density" "geology" and distance to road parameter in the analysis.

#### A FEW PROMINENT LANDSLIDES IN THE WATERSHED WERE AS FOLLOWS

*Chituwakharka Pahiro:* The landslide zone is in the Chitwakharkharka village (Ward 2, Dhankuta Municipality), which is made up of a fragile form of deformed Higher Himalayan Crystalline composed of dark grey, blue grey schists and unconsolidated residual sediments. Road construction in vulnerable areas is also a factor in providing stress and subsidence of land. There has already been a massive landslide in the area in 2060 BS and 2068 BS. According to the local communities, every year the land has shifted downward because because of the poor drainage management and haphazard road construction in the area with highly fractured rocks. Altogether 21 houses are affected due to this landslide, out of which 2 households have already migrated (see Photo 8A).



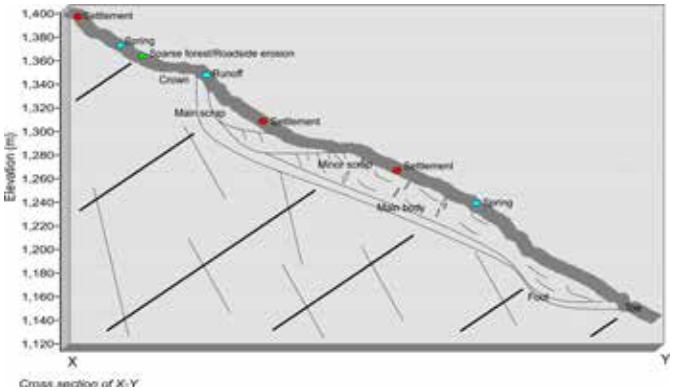




**PHOTO 8A: CHITUWAKHARKA LANDSLIDE**

*Yakchana Landslide:* This landslide is located in ward-8 of Dhankuta municipality which is widespread. The road construction and fragile geology of the area has been a major factor triggering the landslide. The landslide is causing a deposition of the sediment directly in the river and also has the possibility of blocking the Tankhuwa river as the landslide is in the corridor of river (see photo 8B).

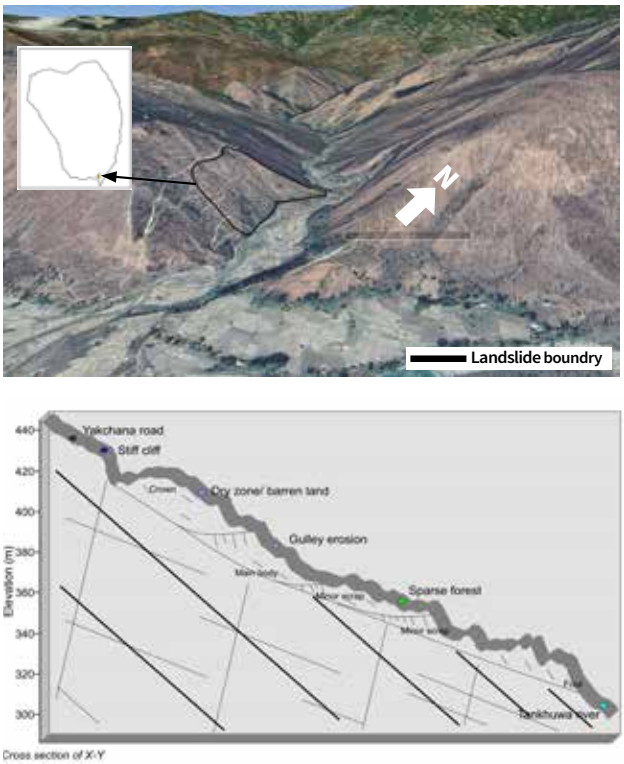



**PHOTO 8B: YAKCHANA LANDSLIDE**

*Chyarchyare Pahiro:* The landslide is located in Chyarchyare Khola. Field observation showed that landslides occurred due to the presence of highly weathered rock fragments and residual boulders in between the unconsolidated sediments. Landslides occur due to heavy rainfall in the months of May-June. In 2019, it led to the destruction of the water tank (Photo 9).

**PHOTO 9: DESTROYED WATER INTAKE TANK DUE TO LANDSLIDE**

## 3.6 Water resources status

### 3.6.1 Water availability

The major source of streams in the NT Watershed is groundwater in the form of springs and seepages, which ultimately drains into the Tamor River. In the watershed, the main source of available water during the dry season is groundwater through springs. In most of the cases, spring water is tapped directly from the source. In total, 6 ponds, 23 dried springs, 63 flowing springs and 11 see pages were mapped and studied (see Figure 14 and Annex 10) and the seasonal discharge of 29 springs among them were measured (Annex 7). The discharge of Nibuwa Khola and Tankhuwa Khola for the year 2020 (February) was measured using two methods: salt dilution and area velocity (float) methods. The individual area of Nibuwa Watershed and Tankhuwa Watershed were calculated as the Nibuwa Khola and Tankhuwa Khola are major water sources of NT watershed. The precise measurements are tabulated in Table 2. However, it is necessary to note that not all the water from springs flow towards the river as it has been tapped in the upstream areas for domestic and agricultural use.

The monthly river discharge hydrographs were prepared using the medium irrigation project (MIP) method for the Nibuwa and Tankhuwa rivers (see Figure 15). The coordinates of the river outlet, area of watersheds and actual river discharge measurement at a certain time period are required to predict the monthly discharge using this method. These graphs show the monthly discharge of both rivers for the year 2020, according to which the highest river discharges were observed during August (990 lps for Nibuwa and 1121 lps for Tankhuwa) and the least in February

**FIGURE 14: WATER BODIES IN AND AROUND NIBUWA-TANKHUWA WATERSHED**

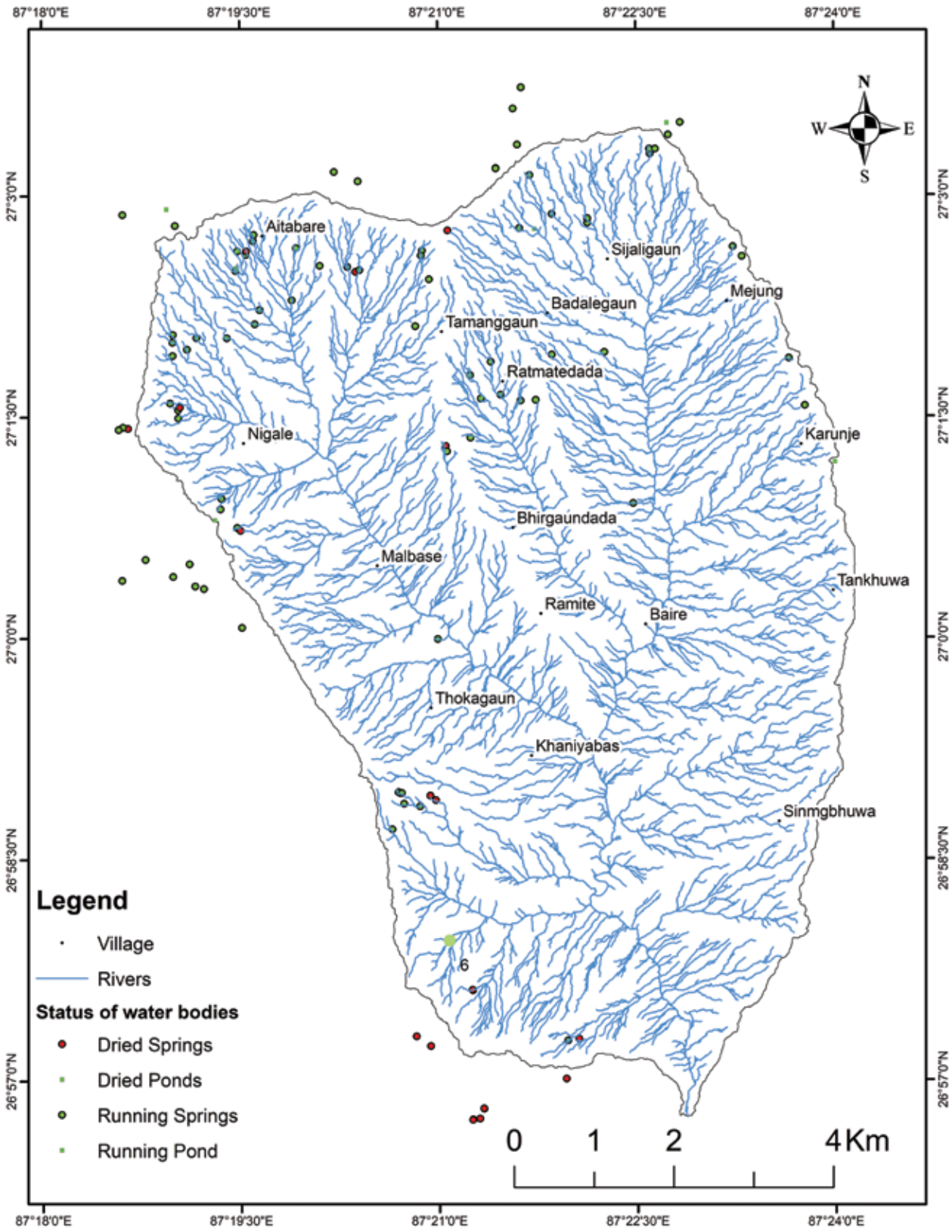


**FIGURE 15: ANNUAL DISCHARGE HYDROGRAPH OF NIBUWA AND TANKHUWA KHOLA OF YEAR 2020**

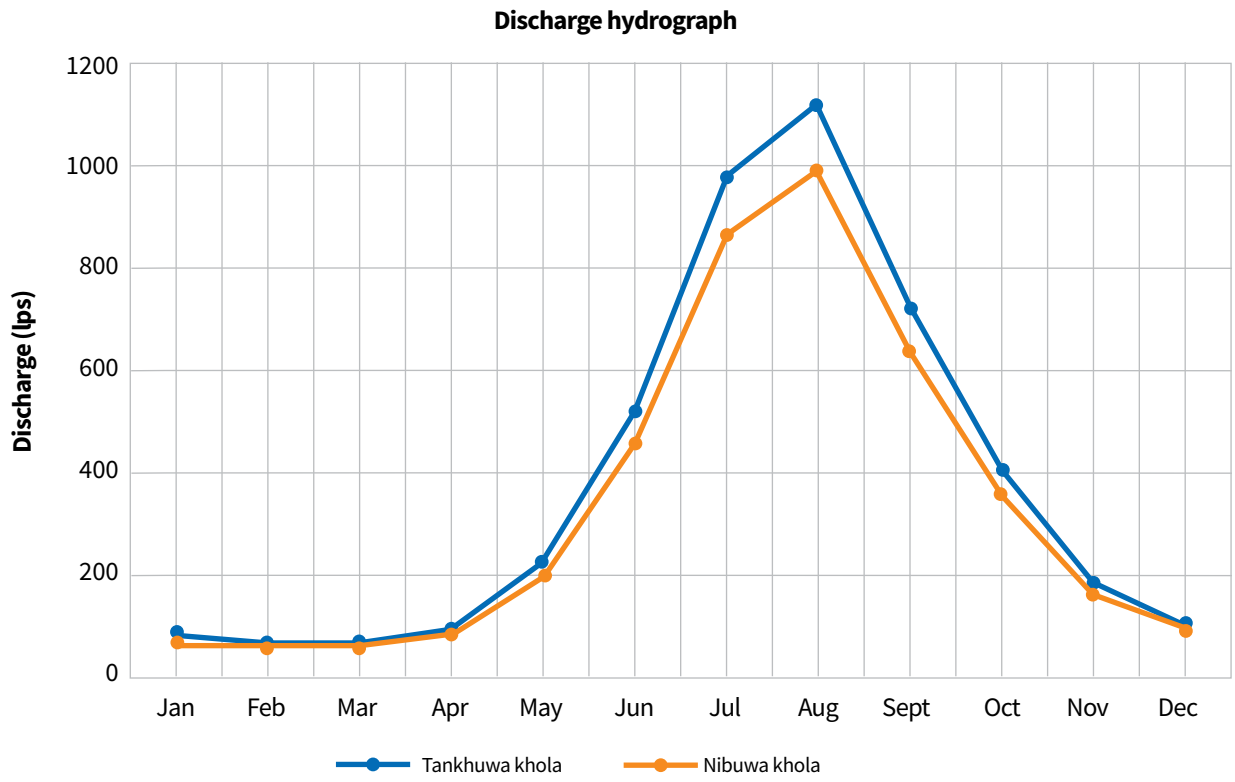



**TABLE 2: RIVER DISCHARGE OF NIBUWA AND TANKHUWA KHOLA IN 2020**

| Measured date | Discharge of Nibuwa Khola (lps) | Discharge of Nibuwa Khola ($m^3$/day) | Discharge of Tankhuwa Khola (lps) | Discharge of Tankhuwa Khola ($m^3$/day) |
|---|---|---|---|---|
| Feb 2020 | 60.39 | 5,217.70 | 56.39 | 4,872.10 |
| Coordinates of river outlet | 26.98837°N, 87.36855°E | | 27.00051°N, 87.3775°E | |
| Area of watershed | 24.2 $km^2$ (only Nibuwa sub-watershed) | | 24.6 $km^2$ (only Tankhuwa sub-watershed) | |

source: Fieldwork (2020)

(57 lps for Nibuwa and 65 lps for Tankhuwa). During fieldwork, both the salt dilution and float-area methods were applied since Nibuwa has laminar streamflow and Tankhuwa has turbulent streamflow at the location of the measurement.

### 3.6.2 Water supply and demand

Information on water supply and demand is crucial for the efficient management of water. It will help the municipal government to equalize the water end-user price with the marginal cost that includes the shadow price of water for different sectors. Hence, the status of water demand for domestic use, livestock and agriculture was estimated (see Tables 5 and 6). But a rigorous derivation of the demand function is beyond the scope of this work as it requires many parameters and coefficients of the different water demand sectors while data unavailability is a main constraint of the study. Hence, the present water demand is an estimate based on the various water uses. According to the Dhankuta Municipality and Chhathar Jorpati Rural Municipality profiles (2018), most of the households (HHs) have piped tap connections inside their compounds for drinking purposes (Table 18). The major drinking water source for the watershed is tap water (piped water connections inside household compounds) followed by spring water, wells, rivers and other sources, respectively.

Nibuwa and Tankhuwa rivers are the major water sources for Dhankuta Municipality and Chhathar Jorpari Rural Municipality. The water from Tankhuwa River is collected in the Tankhuwa tank (DHK-TNK) and transported to pumping station 1 of Nibuwa River (DHK-PST1) (gravity flow). Pumping station 1 collects

the water from the Tankhuwa and Nibuwa rivers, which is then pumped to station 2 (DHK-PST2) and 3 (DHK-PST3), respectively. At pumping station 1, a Rapid Sand Filter unit has been constructed to minimize the suspended sediment. The pumped water is collected in the School dada system and Salleri system and supplied to different wards of Dhankuta municipality (see Table 3, Figure 16). These drinking water systems have playing a vital role in distributing drinking water in wards 2, 3, 4, 5,6, 7, 8, 9 of Dhankuta Municipality whereas other wards are more dependent on spring sources. Besides rivers, springs have also played a vital role in fulfilling the water demand in the NT Watershed.

To calculate water demand for domestic use and livestock, we followed the guideline from the Government of Nepal (GoN 2016). Water demand of hotels was calculated based on two KIIs. The reference crop water requirement was obtained from previous studies (Haavisto et al. 2018; FAO 2018; Nepal et al. 2019) and those coefficients were used to calculate water demand for major crops in the given watershed.

Our calculation shows that the total water demand of this watershed is about 114 MCM in which domestic and livestock demand constitute 3.3 MCM (3% of the total demand) (see Table 4, 5, and 6) whereas agricultural water demand constitutes 110.8 MCM (97% of the total demand) (see Tables 4, 5, and 6). Converting all the rain-fed land into irrigated land (which is practically unfeasible) may add 103 MCM of additional water demand in the watershed (Table 6).

Owing to multiple reasons, the increasing demand for drinking water accompanied by reduced water quality is likely to exacerbate water distribution problems in the NT Watershed.

Although the community members shared their willingness to pay for improved drinking water quality and quantity, people's ability to pay is not considered in planning and decision-making.

**TABLE 3: WATER SUPPLY SYSTEM OF DHANKUTA MUNICIPALITY**

| S.N. | Systems | Source | Supply |
|---|---|---|---|
| 1 | School Dada system (DHK-SCH) | From Nibuwa pumping station 3 | Ward 3,4 |
| 2 | Salleri system (DHK-SAL) | From School Dada system | Ward 5,6,7 |
| 3 | Nigale system (DHK-NIG) (treatment plant) | Collection of spring water | Ward 2,3 |
| 4 | Chuliban system (DHK-CHU) | Collection of river water (Teen dovaney) | Ward 8,9 |

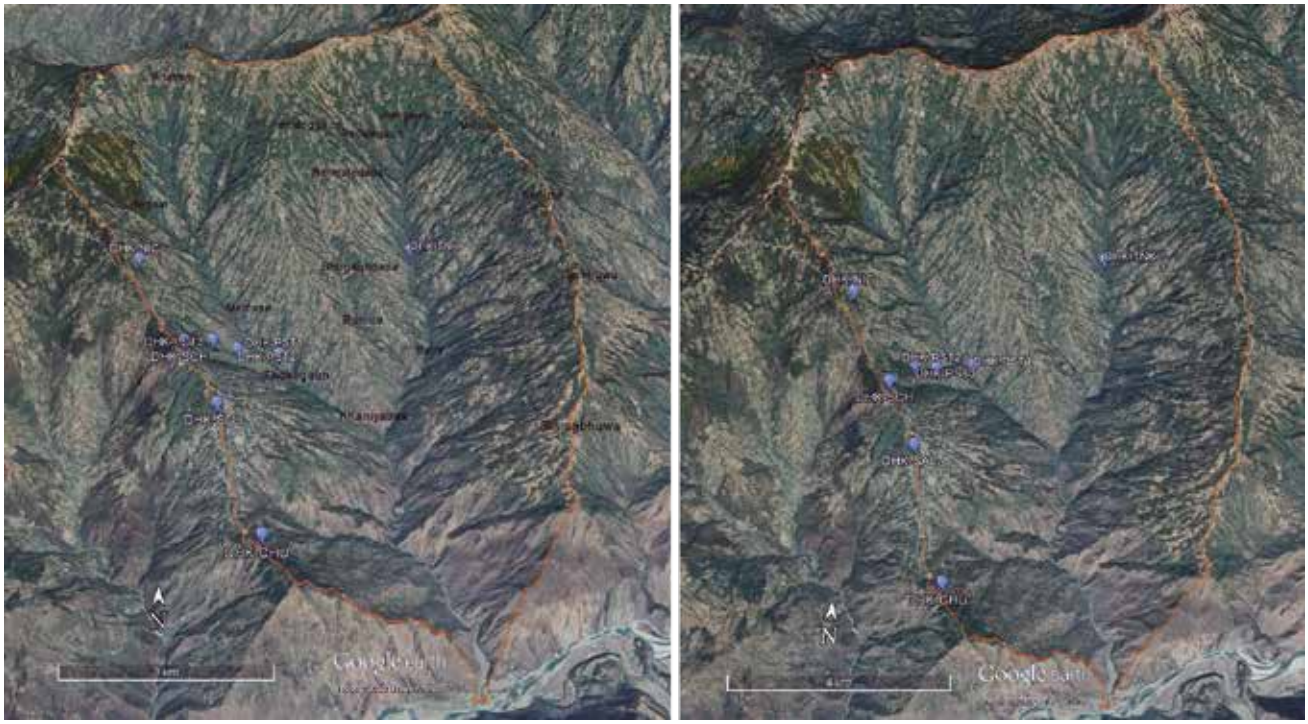
Field observations showed that in the watershed, the

**TABLE 4: DOMESTIC AND LIVESTOCK WATER DEMAND**

| Water uses by sectors | Population/ number | Water requirement (litre/day) | Total water requirement (million litre/day) | Annual demand (million $m^3$) |
|---|---|---|---|---|
| Population | 33,561 | 45 | 1.51 | 0.55 |
| Population in the school/colleges and offices | 12,158 | 10 | 0.11 | 0.04 |
| Hotel/lodges | 25[2] | 8,000 | 0.20 | 0.07 |
| Domestic total | | | 1.8 | 0.66 |
| Livestock | | | | |
| Buffalo | 20,422 | 40 | 0.81 | 0.29 |
| Cattle | 94,711 | 45 | 0.42 | 1.55 |
| Sheep/goat | 198,274 | 10 | 0.20 | 0.72 |
| Chicken | 671,543 | 0.15 | 0.10 | 0.03 |
| Dogs | 19,733 | 1.5 | 0.02 | 0.01 |
| Livestock total | 1004683 | | 7.20 | 2.62 |
| **Total (domestic & livestock)** | | | **9.02** | **3.30** |

[2] A hotel needs 1 tanker of water per day. A medium-sized tanker contains 8000 lit of water.

**FIGURE 16: LOCATION OF DIFFERENT WATER SUPPLY SYSTEM IN DHANKUTA MUNICIPALITY**



Source: Field visit (2019)

usage of water for irrigation and drinking purposes is not approached from a gender perspective although water for drinking purposes is associated with household/domestic needs and thus remains part of a woman's ascribed roles (Cleaver 1998b). But sectoralisation of water based on women's and men's traditional roles is problematic as it can shape their involvement in water management (Cleaver 1998a; Joshi & Fawcett 2001; Joshi 2011) and also inhibit the process of creating a level playing field between women and men with regard to access and control of resources and decision-making.

### 3.6.3 Water quality

#### LABORATORY TEST

Maintaining good water quality is high priority in this plan as the water user community has reported the supply of impure water (muddy water) during the monsoon season. Water quality has significant implications on human health and the economy of households which will disproportionately affect women as they take on the burden of caring for the sick and meeting health care expenses through loans from financial institutions. The lab test of water samples (see

**TABLE 5: CROPS AND SEASONS**

| | |
|---|---|
| Summer crops | Chaite rice, maize, buckwheat |
| Summer vegetables | Pumpkin, summer squash, sponge guard, chayote, bean, okra, eggplant and chili |
| Monsoon crops | Rice, maize and millet |
| Monsoon vegetables | Tomato, cabbage, cauliflower, carrot, chilli (these are normally winter vegetables in the rest of the country |
| Winter crops | Wheat, barley, buckwheat; winter potato and legumes such as bean and peas |
| Winter vegetable | Cabbage, tomato, cauliflower, mustard, radish, carrot, and chili |
| Oilseed crops | Sunflower, mustard, soybean and sesame |
| Perennial spices and condiments | Cardamom, ginger and turmeric |
| Plantation crops | Tea and coffee |
| Perennial fruits | Orange, lemon, mango, avocado, papaya and banana |

**TABLE 6: ANNUAL AGRICULTURE WATER DEMAND BASED ON CROP CALENDAR**

| Seasons | Crops | Irrigated area (ha) | Average water requirement/ ha(cubic meter/ ha) | Total water requirement (MCM) | Non-irrigated area (ha) | Water requirement if converted to irrigated area (MCM) |
|---|---|---|---|---|---|---|
| **Summer crops** | | | | | | |
| | Paddy (Chaite) | 1,024 | 11,000 | 11.264 | 400 | 4.4 |
| | Summer Maize | 4,231 | 5,000 | 21.155 | 1,194 | 5.97 |
| **Monsoon crops** | | | | | | |
| | Main season paddy | 3,284 | 5,500 | 18.062 | 4,536 | 24.948 |
| | Monsoon maize | 5,625 | 2,500 | 14.0625 | 7,160 | 17.9 |
| | Millet | 3,300 | 1,500 | 4.95 | 4,500 | 6.75 |
| | Monsoon potato | 523 | 2,500 | 1.3075 | 677 | 1.6925 |
| | Monsoon vegetables (cucumber, pumpkin, gourds, okra, radish, tomato, etc.) | 1,334 | 3,500 | 4.669 | 1,643 | 5.7505 |
| | Pulses | 1,300 | 2,800 | 3.64 | 1,128 | 3.1584 |
| **Winter crops** | | | | | | |
| | Wheat | 615 | 8,100 | 4.9815 | 785 | 6.3585 |
| | Winter potato | 325 | 5,000 | 1.625 | 485 | 2.425 |
| | Vegetables | 1,334 | 7,000 | 9.338 | 1,643 | 11.501 |
| **Oilseed crops** | Sunflower, mustard, soybean, sesame | 482 | 7,000 | 3.374 | 530 | 3.71 |
| **Perennial** | Sugarcane | 30 | 16,000 | 0.48 | 20 | 0.32 |
| **Perennial** | Plantation crops | 500 | 5,000 | 2.5 | 480 | 2.4 |
| **Perennial** | Spices/condiments | 502 | 5,000 | 2.51 | 503 | 2.515 |
| **Perennial** | Fruits | 1,375 | 5,000 | 6.875 | 701 | 3.505 |
| **Total** | | **25784** | **5775** | **110.7935** | **26385** | **103.3039** |

Notes: Normally, two crops are grown in a year. Summer and monsoon seasons overlap normally in rain-fed conditions. The total cropped area is higher than the total cultivated area. Higher the cropping intensity, greater the cropped area with the total cultivated area as constant.

Annex 9) from different sources and springs was found to be within the NDWQS standards (Annex 18).

An in-situ water quality test of the 29 springs (Annex 8) was also conducted during the field visit and the values indicate that the water is within drinkable limits (see Table 7). Haphazard road construction and deforestation in the upstream area were found to contribute to eroded materials, which were the major cause of water pollution in streams and springs.

## 3.7 Major ecosystems and ecosystem services

The major ecosystems of the watershed are forest, cropland, water bodies, shrubland and grassland. The services provided by these ecosystems are the basis of subsistence livelihoods and contribute to the overall wellbeing of the people living in and beyond the watershed. Forest occupies almost 41% of the total land while cropland and grassland cover about 49.89% and 5.73% of the total area, respectively (see figures 10 and 11). According to MEA (2005), ecosystem services, defined as "the benefits people derive from nature", are categorized into provisioning, regulating, supporting and cultural services. Provisioning describes the direct services people derive while the supporting, regulating and cultural services are indirect services provided by ecosystems. The major forest provisional services of the watershed are timber, fuelwood, fodder, wild food and litters for animal bedding. There is a high dependence on fuelwood for cooking in the watershed with more than 50% of the households dependent on it for energy (see section 3.8.3). Habitats for biodiversity and pollination are among the important supporting services while carbon storage, soil formation and water and air purification are the regulating services provided by the forests of the watershed. Equally important are the cultural services provided by forest such as tourism, forest walks, picnics and others.

**TABLE 7: WATER QUALITY PARAMETERS**

| | Tempera-ture | pH | Electrical conductivity (µS/cm) | Total dissolved solids (TDS) (ppm) |
|---|---|---|---|---|
| Average | 16.98 | 7.28 | 74.46 | 52.12 |
| Maximum | 20.4 | 8.6 | 299 | 211 |
| Min | 13.4 | 6.28 | 23.6 | 16.9 |
| NDWQS reference value | | 6.5-8.5 | 1500 | 1000 |

The major services provided by these ecosystems are detailed in Table 8 below.

### 3.7.1 Forest and its types

The NT Watershed has both planted and natural forest covers. The forest in the watershed is divided into three eco-zone as per Lilleso et al. (2005): tropical forest, sub-tropical forest and warm temperate forest. Nearly 40.84%, 16.30% and 42.86% of the forest cover is covered by tropical forest, sub-tropical forest and warm temperate forest, respectively. The forests are governed and managed as community forest, government forest, religious forest and private forest. There are 36 community forests which cover 1060.23 ha consisting of 2,891 households (DFO 2018) (see Annex 16 for the list of CFs). Community forests are managed and utilized by a community as per their operational plan, which is prepared with the technical support of the Forest Division Office. In the NT Watershed, there is just one national forest named the Salleri National Forest, which covers an area of 43.73 ha, and is located in Wards 4 and 6 of Dhankuta Municipality (DFO 2018). The forest is managed by the Department of Forest and is guided by the Salleri National Forest Management Plan 2071 (DFO 2018). Community and private forests are the main sources of fuelwood and fodder to local communities. While only 6.609 ha of land is registered as private forest, there are two religious forests, named Gaiya Devi and Bachala Devi of 0.074 ha extent in the watershed. A majority of water sources are located within the forest. However, either the water sources are drying or the water quantity is decreasing gradually. According to the local people, unplanned road construction, landslides, changes in climate and lack of water source conservation are the major causes of the changes in water sources and water availability. Any change in water quality and quantity impact, in particular, the vulnerable groups, including the poor, women, and marginalized communities.

The role of women is very important when it comes to conservation and preservation of natural resources, such as water, land and forest. Women are often the primary custodians of these resources while utilizing them in their daily lives and bridge intergenerational traditional knowledge associated with the conservation and protection of such resources. For instance, a closer look at the traditional division of labour between women and men in everyday agricultural practices shows that activities such as transporting manure and spreading it in the field are done by women whereas men are found to use inorganic fertilizer and heavy mechanical tools in agriculture. Yet women continue to be represented as proxy participants in institutions and are denied access to and control over natural resources.[3]

**TABLE 8: THE MAJOR ECOSYSTEMS AND THEIR SERVICES AS PER MEA (2005) CATEGORY (FIELD DATA 2019)**

| Major ecosystem | Provisioning | Supporting | Regulating | Cultural |
|---|---|---|---|---|
| Forest | Wild food, timber, fodder, fuelwood, litter, | Biodiversity, habitat, pollination | Water purification, climate regulation, carbon storage and sequestration | Tourism, forest walks, bird watching, education |
| Cropland | Agricultural products, livestock products | Soil formation | Nutrient regulation, nitrogen fixation | Research and education |
| Grassland and shrubland | Grass litter | Biodiversity, soil support, micro-nutrients, water purification | Water flow regulation, climate regulation | Bird watching |
| Water bodies | Water for drinking and irrigation | Biodiversity | Water and air regulation | Religious tourism, research and education |

[3] "Access to resources implies that individuals can use and benefit from specific resources (material, financial, human, social and political), while control over resources implies that individuals can not only obtain access but can also make decisions about a resource. For example, control over land means that the individual can not only use the land, they can also own the land (as legal title holder) and can make decisions about whether to sell or rent it. The vulnerability and capacity of individuals is shaped by who has access to and control over a resource. Therefore, to manage resources effectively and sustainably, it is essential to understand the differential needs and priorities of women and men, which are based on their roles, responsibilities, and their access to and control over resources " (Nepal et al. 2019, p.55).

### 3.7.2 Flora and faunal diversity

Given the altitudinal and climatic variations, a diversity of flora and fauna is found within this watershed. The watershed has a mixed vegetation type with the major species being *Shorea robusta, Pinus roxburghii, Schima wallichina, Castanopsis indica, Alnus nepalensis* and *Acacia catechu*.

The lower region of the watershed area is dominated by *Symplocos ramosissima, Schleichera oleosa* and *Acacia catechu* with associated species *Acer obleongum* and *Holarrhena antidysenterica*. The main species of commercial value in this region is *Acacia catechu*. In the south-western area of the watershed, *Shorea robusta* along with *Pinusroxburghii* are also found. Associated species such as *Syzygium cumini, Dalbergia latifolia, Semecarpus anacardium, Lagerstroemia parviflora* are also found in this region. The middle region of the watershed area is dominated by *Pinus roxburghii* while other species such as *Bombax ceiba, Schima wallichii, Alnus nepalensis, Albizia lebbek, Engelhardtia spicata* and *Acacia catechu* too are found. The upper region of the watershed area is covered by *Rhododendron arboreum, Pinus roxburghii* and *Alnus nepalensis*.

The major non-timber forest products (NTFPs) available in the watershed are *Thysanolaena maxima, Artemisia vulgaris, Pinus roxburghii, Sapindus mukorossi, Phyllanthus emblica and Lycopodium clavatum* (DFO 2018). In addition, the CFUGs of the Aaitabari Community Forest mentioned that the forest also contains *Elaeocarpus ganitrus, Acorus calamus, Ocimum tenuiflorum, Syzygium cumini and Zanthoxylum alatum*. In the lower region, *Terminalia bellirica, Terminalia chebula, Aegle marmelos and Phyllanthus emblica* are available. But communities lack detailed knowledge of available NTFPs. The major fauna reported in these watersheds are *Canis aureus, Rhesus macaque, Bonnet macaque, Hystrix indica, Lepus nigricollis Sus scrofa, Axis, Hirundo rustica, Luscinia megarhynchos, Gallus gallus, Streptopelia chinensis, Passer domesticus, Pavo cristatus, Martes flavigula* (*malsapro*) crow, snail, millipede, lizard, snake, gohoro, negalye, butterfly, malsapro, cockroach and mosquito. This area also harbours one endangered species, *Manis crassicuadata*, and two species of vultures which are listed as endangered and near threatened (i.e., *Nephron percnoptreus and Gyps bengalensis*), respectively. The detailed list of flora and fauna is given in Annex 17.

### 3.7.3 Cropland ecosystem

Three distinct types of cropland ecosystem were observed in the watershed. The upper part is more suitable for production of vegetables such as cauliflower, cabbage, tomato, potato, radish and turnip while leafy vegetables can be produced year-round in this belt. Off-season vegetables produced during the monsoons are sold in the lower lands of Nepal at higher prices. Additionally, some of the vegetables produced are also exported to India and Bangladesh. Many traditional farmers who were previously dependent on traditional crops such as maize, wheat, barley and millet have shifted to vegetable production.

The middle part of the watershed is suitable for fruits such as citrus, avocado and plantation crops like tea and cardamom. Citrus spp., particularly the mandarin orange (*Citrus reticulata*) was the predominantly grown species in the past but there is a sharp decline in citrus production now due to an outbreak of Citrus Pysilla- a viral disease. Hence, these areas have been replaced by avocado plantations. However, avocado being a non-native fruit with high water demand, it might further increase water scarcity or disease outbreaks may eliminate this fruit too from cultivation in future. So, during KIIs, officials from the Agriculture Knowledge Centre, Dhankuta, stressed that such challenges need to be acknowledged along with solutions in the integrated watershed management plan. Similarly, although a tea plantation was started in Dhankuta during early 2040 (BS), both tea production and area under cultivation are now decreasing due to fluctuating prices and water scarcity. Therefore, the government officials suggested that sustainable solutions to such challenges need to be sought in the upcoming integrated watershed plan.

The lower part of the watershed consists of flat terrain, the soil type ranging from sandy loam to clay loam, which is more suitable for cereal crop production. Unlike upstream, farmers in the downstream commonly grow rice, wheat and maize. Some farmers have switched to vegetables, mainly tomato and potato, in irrigated land where three croppings are possible unlike in rain-fed land where farmers mostly grow one crop in the monsoon and keep the land fallow in the dry seasons. Upland paddy, maize and legumes are the main crops cultivated on rain-fed land. But farmers have started to grow hybrid maize, rice and wheat in the irrigated land as well. Due to the severe water scarcity and labour shortage, fallow land is very common, especially in summer or winter.

## 3.8 Socio-economic profile and responses

### 3.8.1 Population and demographic

The total population of the watershed is 33,349 (Dhankuta Municipality and Chhathar Jorpati Rural Municipality – wards 2 and 3). While the female population is 52.69%, the male population is 47.30% (see Table 9). The watershed has an average family size of 4.302 with a total of 8432 households. The ward-wise classification of the population given in Figure 17 shows that wards located in urban centres have a higher population as compared to wards located in the peripheries of the towns (Hile and Dhankuta). Except for Ward 3 of Chhathar Jorpati Municipality, all wards in both the municipalities have a higher proportion of females. Significantly, wards located in the upstream (Wards 1 and 2) of the watershed have a higher population as compared to those downstream (e.g., Ward 8 of Dhankuta Municipality, which is also a drought-prone area).

In the watershed, there is a greater heterogeneity in terms of religion and language. Figure 18 shows that the majority of the population in the watershed are Hindu (59.7%), followed by Kirat (23.9%), Buddhist (14.4%), Christian (1.5%), Islam (0.14%) and others (0.29%) (Dhankuta Municipality and Chhathar Jorpati Rural Municipality Profiles 2018).

The people in Dhankuta Municipality speak different languages: Nepali (67%), followed by Rai (10.7%), Newari (2.6%), Tamang (1.5%), Magar (6.7%), Bhojpuri (1.8 %), Limbu (6.7%) and others (3.1%) (see Figure 18).

With regard to water use and water source conservation, religious practices are found to play a significant role in Dhankuta watershed management. The water sources are worshipped by indigenous communities which prohibit any pollution at source. An example would be the Gurung community from Ward 2 (Dhankuta Municipality) who worship water sources as part of their religious practices and take protective measures against water pollution.

#### EDUCATION

Figure 19 shows the educational status for those above 4 years in the watershed. It indicates that 3 % of students are enrolled in pre-primary, 44% of are enrolled in primary (class 1-8), 40% are enrolled in secondary (Class 9-12), 9% enrolled in higher education, 1% in informal education followed by 3% enrolled in adult education. The literacy rate was found

**TABLE 9: PERCENTAGE-WISE GENDER DISAGGREGATED POPULATION DISTRIBUTION OF THE WATERSHED (DHANKUTA MUNICIPALITY & CHHATHAR JORPATI RURAL MUNICIPALITY PROFILES 2018)**

| | Male | Female | Total |
|---|---|---|---|
| Dhankuta | 12,353 (46.58%) | 14,625 (50.62%) | 27,378 (82.09 %) |
| Chhathar Jorpati | 3,023 (53.41%) | 2,948 (49.37%) | 5,971 (17.9 %) |
| **Total** | **15,776 (47.30 %)** | **17,373 (52.69%)** | **33,349** |

**FIGURE 17: WARD-WISE GENDER DISAGGREGATED POPULATION DISTRIBUTION OF THE WATERSHED**

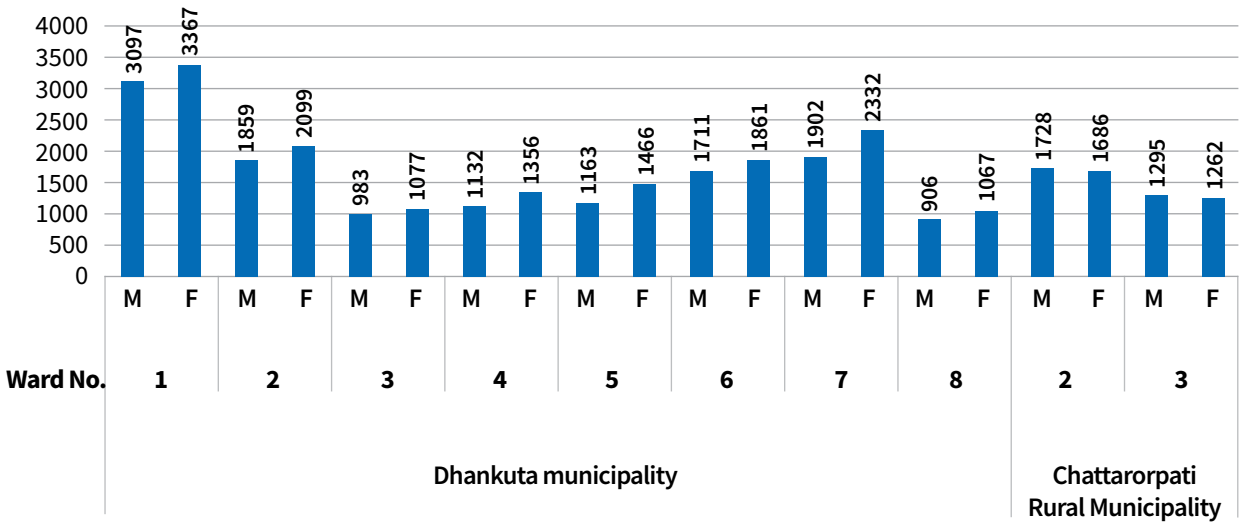
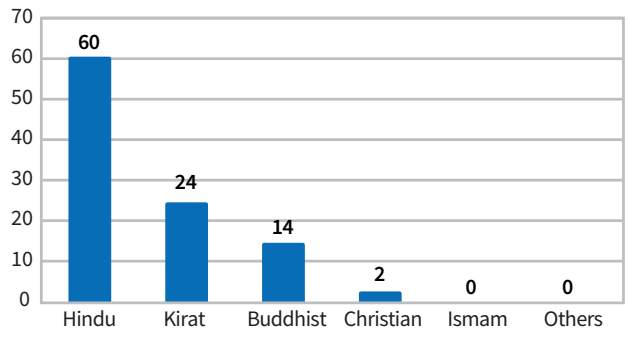
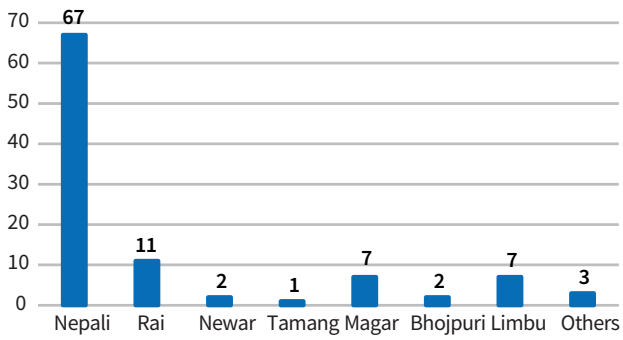


**FIGURE 18: PERCENTAGE-WISE POPULATION DISTRIBUTION OF WATERSHED ON THE BASIS OF RELIGION (LEFT) AND THE BASIS OF LANGUAGE (RIGHT) (DHANKUTA MUNICIPALITY & CHHATHAR JORPATI RURAL MUNICIPALITY PROFILES 2018)**




to be higher in Dhankuta Municipality at 84.15% than the national literacy rate, which is 57% (Code for Nepal 2017). However, the male and female literacy rates stand at 88 % and 79%, respectively. But the female literacy rate in the Dhankuta Municipality of the watershed is higher (79%) than the national literacy rate (at 65%) (Dhankuta Municipality and Chhathar Jorpati Rural Municipality Profiles 2018). However, gender disaggregated data on literacy rate for Chhathar Jorpati Rural Municipality were not available.

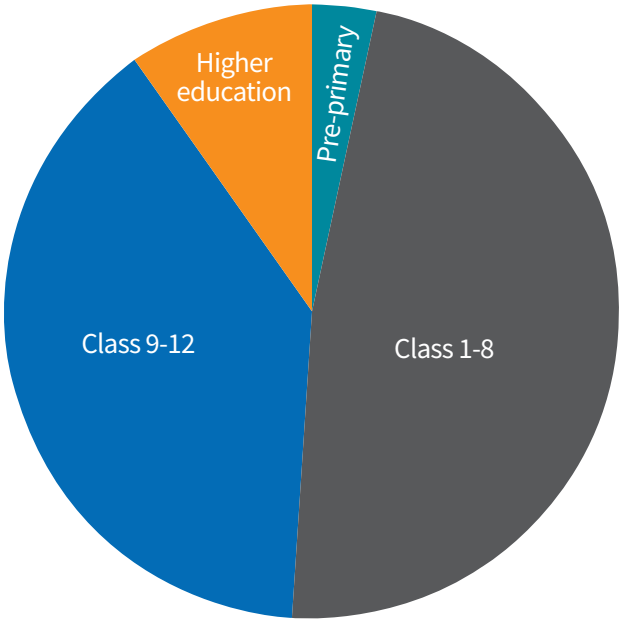
The gender disaggregated data from the Dhankuta Municipality Profile (2018) reveal a higher dropout rate among girls (57%) as compared to boys (43%). The reasons for the high dropout rate were related to marriage (36%), the feeling that the desired education was completed (21%) and work at home (19%). In the gender-wise classification of reasons for dropping out, Figure 20 reveals that boys dropped out due to unaffordability of schooling (64%) while others indicated that they had completed their education (56%), followed by the need to work at home (53%).

In the girls' category, the reasons are marriage (83%), followed by parents' lack of interest in sending girls to school (62%) and the distance to school (59%). The data lead to the conclusion that a majority of girls as compared to boys drop out from schools because of discriminatory social and cultural norms and values and social attitudes to girls' education that prevent young girls from educational attainments (Vogel & Korinek 2012).

### HOUSING PATTERN

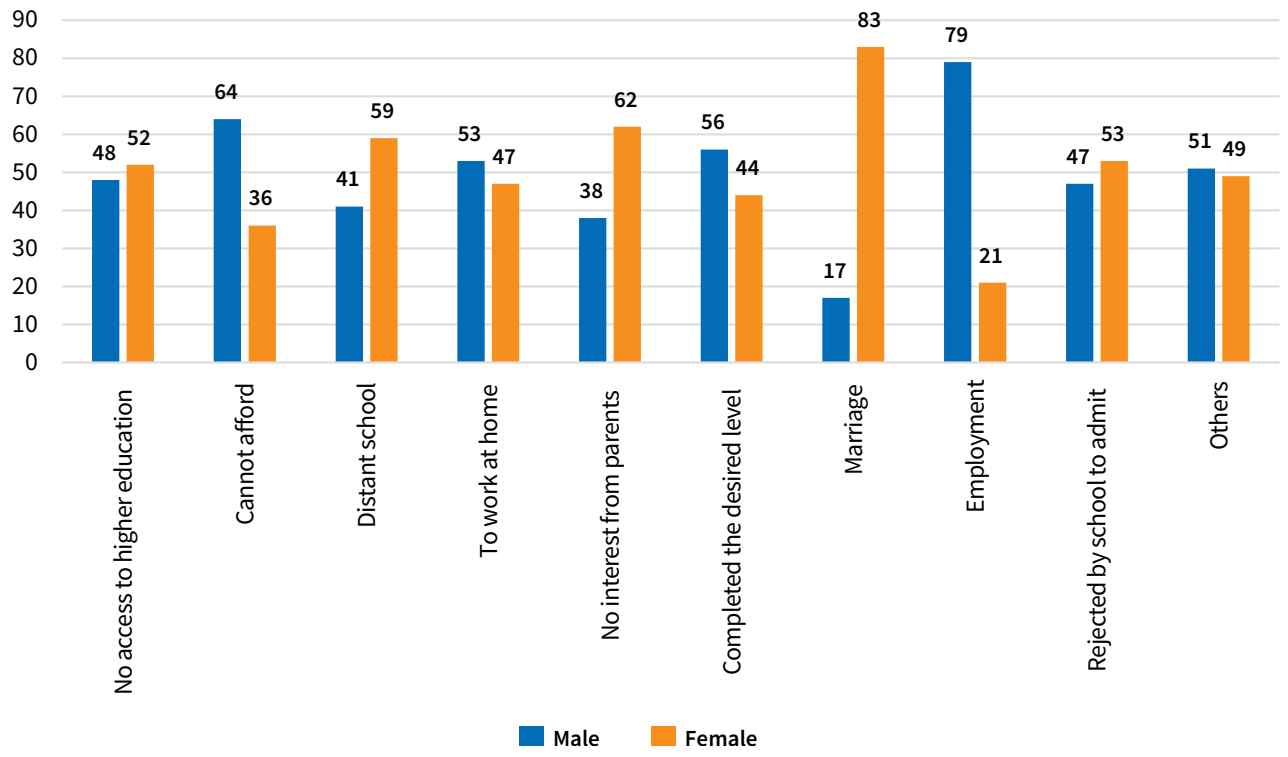
People in the watershed have different types of houses. The household types are categorized differently in Dhankuta Municipality (on the basis of type of wall and roof) and Chhathar Jorpati Rural Municipality (on the

**FIGURE 19: EDUCATION LEVEL OF WATERSHED AREA**




basis of wall and foundation of house). In Dhankuta Municipality, a majority of houses are kacchi (57.52%), followed by 22.48% cemented and 12.88% as semi-cemented houses (see Table 10). Similarly, a majority of houses in Chhathar Jorpati Rural Municipality had zinc sheets (82.07%), followed by straw and hay thatched houses (11.79%). The foundations of houses in Chhathar Jorpati Rural Municipality were mostly made of mud/stone/bricks (84.73 %), followed by cemented foundation (9.95%), wooden pillar (3.66%) and frame structure (1.64%) (see Table 11). The watershed management plan should, therefore, consider the household characteristics and their possible water demands during its formation. Studies have found that domestic water needs are directly influenced by the size of household and other socioeconomic indicators such as income, age, and household preference towards water use and conservation (Arbues et al.

FIGURE 20: PERCENTAGE-WISE DISTRIBUTION OF REASONS FOR DROPOUT IN DHANKUTA MUNICIPALITY




2003).

### 3.8.2 Economic activities, production, and food sufficiency

Agriculture is the mainstay of the economy in the watershed area. A bare majority (54%) of the population is found to rely on agriculture as the main source of household income (see Figure 21). The aggregated data on income sources indicate that there is a lower reliance on agriculture compared to the trend nationally (81%). There is also visible trend of switching from subsistence-based traditional farming to commercial farming across all wards in the watershed. However, while commercial farming may increase income, it has implications on water availability (quantity and quality), including other environmental services and health issues. There are many other emerging off-farm livelihood options observed in the watershed such as migration (income generation), business, and hotel and tourism industries, among other thingswhich have an implication on water resource use and management. For instance, a study by Maharjan et al. (2013) highlights that migration has both positive and negative impacts on the watershed and land management systems. Furthermore, it is evident that increasing hotel and tourism industries in the upstream and mid-stream towns (Hile and Dhankuta Bazar) have brought economic opportunities for the watershed population. This has led to an increasing demand on the water supply that has caused depletion of water sources, for e.g., the drying of borewells in Hile town.

#### Agricultural practices

There has been a switch in farming systems within the watershed, driven by the rural road network, increasing demand for seasonal vegetables from high altitude places, changing lifestyles and changing precipitation patterns (see Table 12). Consequently,

FIGURE 21: PRIMARY SOURCES OF INCOME

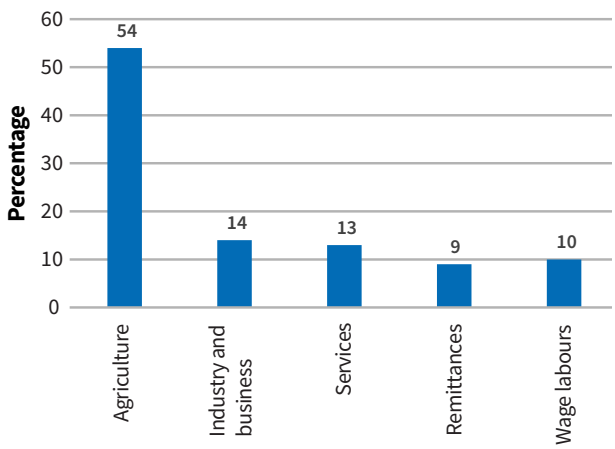


**TABLE 10: TYPES OF HOUSE IN DHANKUTA MUNICIPALITY OF THE WATERSHED AREA**

| Types of house in Dhankuta Municipality | | | | | | |
|---|---|---|---|---|---|---|
| **Ward no.** | **Cemented** | **Semi-cemented** | **Kachii** | **Jhupro** | **Others** | **Total** |
| 1 | 504 | 248 | 760 | 127 | | 1,639 |
| 2 | 15 | 26 | 857 | 63 | 1 | 962 |
| 3 | 54 | 40 | 357 | 55 | | 506 |
| 4 | 101 | 55 | 460 | 39 | 2 | 657 |
| 5 | 197 | 111 | 361 | 48 | 2 | 719 |
| 6 | 204 | 221 | 465 | 99 | | 989 |
| 7 | 517 | 193 | 394 | 53 | 5 | 1,162 |
| 8 | 3 | 20 | 426 | 10 | | 459 |
| **Total households** | **1,595** | **914** | **4,080** | **494** | **10** | **7,093** |
| **Percentage** | **22.48** | **12.88** | **57.52** | **6.96** | **0.14** | **100** |

**Note:**

Cemented: Wall made of bricks and cement and roof made of galvanized iron roof, stone or RCC

Semi-cemented: Wall made of bricks and roof made of tiles (soil) or straw or hay

Kachii: Wall made of mud and roof made of tile (soil) or straw or hay

Jhupro: Small hut

**TABLE 11: TYPES OF HOUSES IN CHHATHAR JORPATI ON THE BASIS OF ROOF AND FOUNDATION**

| Types of houses in Chhathar Jorpati on the basis of roof and foundation | | | | | |
|---|---|---|---|---|---|
| **Roof** | | | | | |
| **Ward no.** | **Straw/hay** | **Galvanized iron roof** | **Tile/stone** | **RCC** | **Total** |
| 2 | 25 | 680 | 3 | 69 | 777 |
| 3 | 133 | 419 | 1 | 9 | 562 |
| **Total households** | **158 (11.79%)** | **1,099 (82.07%)** | **4 (0.29%)** | **78 (5.82%)** | **1,399 (100%)** |
| **Foundation** | | | | | |
| | **Mud/stone/brick** | **Cement/stone** | **Frame structure** | **Wooden pillar** | |
| 2 | 626 | 110 | 0 | 41 | 777 |
| 3 | 506 | 23 | 22 | 8 | 559 |
| **Total households** | **1132 (84.73%)** | **133 (9.95%)** | **22 (1.64%)** | **49 (3.66%)** | **1336 (100%)** |

Note: Figures in the parenthesis are in percentage

commercial vegetable farming has increased the economic wellbeing of the farmers by increasing farm income. On the other hand, it has also decreased food diversity and compromised nutritional food security. Traditional food sources such as millet, barley, maize and oats which are rich in nutritional value are not the priority of farmers. The current change in the cropping systems/practices therefore has to be analysed from the lens of the Water-Food-Energy nexus while developing the water management plan of the watershed.

The following figure 22 shows a typical crop calendar of the watershed.

The field data indicate that the upstream farmers (Ward 2) grow more vegetables, particularly in irrigated land. In the rain-fed regimes, the farmers grow maize after the first shower of rain in Chitra-Baisakh, followed by millet (see Figure 22). The data indicating

the periodic change in farming systems indicate that 30 years ago almost 90% of the land in the upstream were irrigated while the major crops grown were rice, maize, wheat and maize (see Table 12). But, now, farmers in the upstream have stopped cultivating cereal crops and have switched to vegetables farming for commercial purposes, relying on the market for food grains such as rice, wheat and other cereals. Similarly, the farmers suffer from the price fluctuation of vegetables in the local and national markets, which has threatened the food security of the rural poor. The data lead to the conclusion that the change from subsistence farming to commercial farming could result in nutritional deficiency.

The switch in cropping patterns has increased the demand for agricultural inputs such as High Yielding Varieties (HYVs), fertilizers and pesticides. These agricultural inputs have a direct impact on the quality and quantity of water resources as well as land resources leading to soil erosion and soil degradation. From the FGD, it was found that upstream farmers grow vegetables in irrigated land round the year (three vegetable crops per year) using HYV, fertilizer (mostly urea, DAP and Potash) and pesticides (frequent use of pesticides for tomato cultivation).

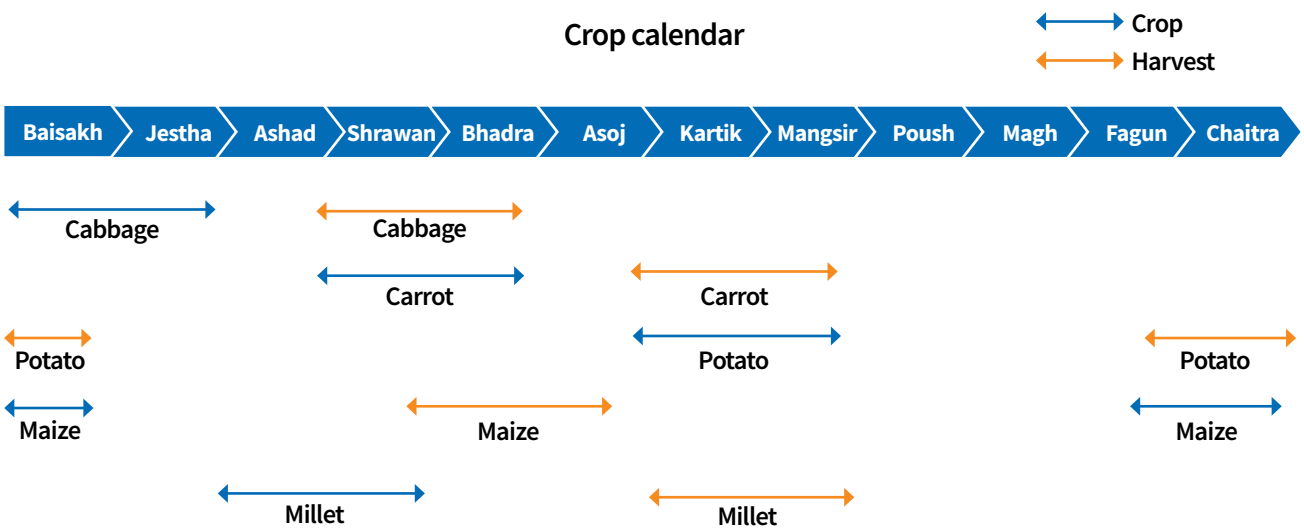
With the increase in commercial farming, an increase in the use of fertilizer and agrochemicals and a reduction in Farm Yard Manure (FYM) and compost were observed.[4] The incidence of fertilizer use in the upstream communities such as wards 1 and 2 of Dhankuta Municipality was found to be high compared to downstream communities in Ward 8. The findings indicate that the downstream communities are more likely to be affected by the increasing use of chemicals in agricultural production which causes water pollution.

In Ward 8 of Dhankuta Municipality, during the field visit, the villagers reported that the downstream communities witnessed extreme water scarcity

**TABLE 12: SITUATION AND TREND ANALYSIS OF THE CROPPING PATTERN IN WARD 1 (DHANKUTA MUNICIPALITY)**

| Situation – agriculture practice | Trend | Insights |
|---|---|---|
| 30 years back:<br>Maize, soybean, millet, rice, wheat, nursery for leafy vegetable (saag), mustard, ginger, and vegetables for self-sufficiency ["personal consumption"?] | ↓ | |
| 15-10 years back:<br>Leafy vegetable, cauliflower, green peas, beans and other vegetables mostly for commercial purposes<br>Commercial cardamom farming started | ↑ | Last 5 years:<br>Decline in cardamom production (pest and scarcity of water), decrease in millet, wheat, maize production; abandonment of rice plantation |
| Participant: Unatti Kumari Rai<br>Facilitated by: Sijal Pokhrel, Aditya Bastola, Nilhari Neupane | | |

**FIGURE 22: TYPICAL CROP CALENDAR FROM UPSTREAM AREA**




[4] FGD in Wards 1 and 2 and Agriculture Trend Analysis with women's group I in Ward 1.

throughout the year, including water for drinking, as a result of which they grew a single crop, mostly cereal crops in the summer (that are rain fed), and left the land fallow in winter.

### HOUSEHOLD EXPENDITURE AND FOOD SUFFICIENCY

The average per capita income in the watershed is NPR 95,136[5] (USD 831) which is slightly less than the national per capita income of 1,034.118 USD (World Bank 2019). The in-depth analysis of the household distribution of income and their self-dependency in the Dhankuta Municipality indicates that around 63% of the households can sustain their livelihoods for more than twelve months while around 4% can sustain their livelihood for 9 to 12 months (see Annex 12). Nevertheless, a major proportion of the household income and loans is spent on household expenditure (24%), construction of household (17%) and commercial agriculture (16%) (see Table 20).

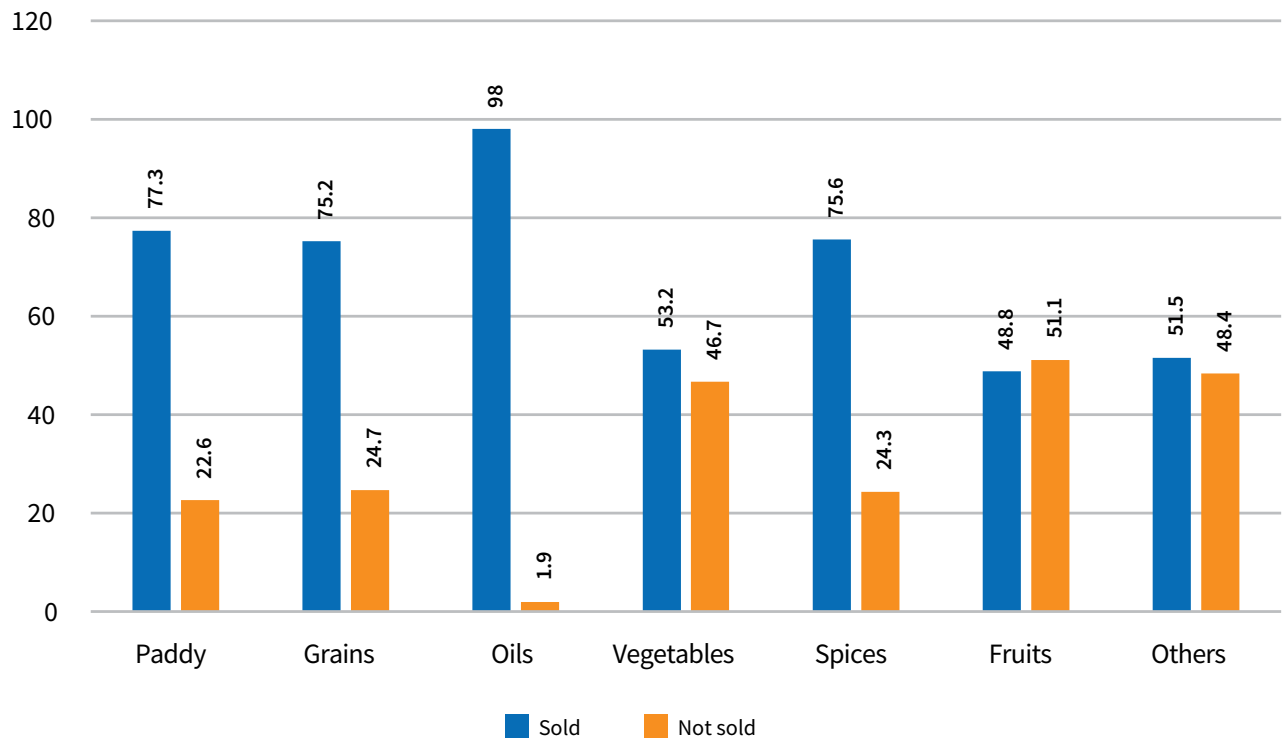
The Dhankuta watershed area is known for its commercial farming and serves as a market hub for eastern Nepal. A majority of the crops grown are sold (68.5%) in the market except for fruit (see Figure 23). This signifies significant water demand to grow agricultural produce in the watershed. Cereals are mostly grown for household consumption and the surplus is sold in the local market. The field survey reveals that a farmer earns up to 3 lakhs/ropani from vegetables per year if proper market prices are available.

### SOCIOECONOMIC STATUS

The economic status of Dhankuta Municipality shows that a majority of the people fall under the poor and average category (see Table 13). The economic status of those in Chhathar Jorpati Rural Municipality is somewhat evenly distributed in terms of socioeconomic class with very poor (20.5%), poor (25.5%), average (18.59%), good (21.5%) and very good (14.33%).

The gender-wise classification of household data in Dhankuta Municipality reveal that a majority of female-headed household falls under the very poor (4.2%), poor (58.2%) and average category (36.03%) (see Figure 24). Male headed households show a slightly improved socio-economic status with the following distribution: very poor (4.1%), poor (54.69%) and average (38.32%).

**FIGURE 23: PROPORTION OF THE CROPS GROWN AND SOLD IN THE MARKET**




[5] Average per person annual income of the Watershed.

There is a general tendency for poor households to have a direct relationship with poor land management practices and accelerated soil erosion due to excessive tillage to grow more food (Barbier 1997). During the field visit, it was observed that marginal holders are more focused on growing food grains whereas big land holders are adopting agro-forestry, fodder, fruits and plantation crops. The data highlight the marginal land holders as the ones relying on subsistence farming as compared to bigger farmers. Thus, the watershed management plan needs to consider the differential usage of water as per household landholding size.

### 3.8.3 Energy consumption and fuelwood demand

The traditional sources of energy in the watershed area is fuelwood and animal waste while kerosene, solar and LPG are the commercial ones. Traditional sources such as fuelwood supplies 55.7% of energy for cooking food. The remaining 44.26 % of energy demand is met by LPG along with an insignificant number of other commercial sources such as solar and electricity. In Dhankuta Municipality, about 41% of the households depend on fuelwood. In Chhathar Jorpati Rural Municipality, more than 50% of the households depend on fuelwood to meet the energy needs.

More than 96% of households in the watershed depend on electricity for lightning followed by solar (2.4%) and kerosene (0.5%). Households are increasingly using LPG gas for cooking which is good for the conservation of the watershed. Yet a significant number of households depend on biomass, particularly in Wards 1, 2, 3 and 8. Use of biomass for cooking will not only negatively impact the watershed but is also detrimental to women's work burden and health as it is they who normally spend long hours in search of fuelwood.

## 3.9 Spatial structure (infrastructure and services)

Infrastructure such as roads, telecommunications and markets are vital for economic development but it may have an impact on watershed management. So it is important to balance infrastructure development with watershed development.

### 3.9.1 Telecommunications

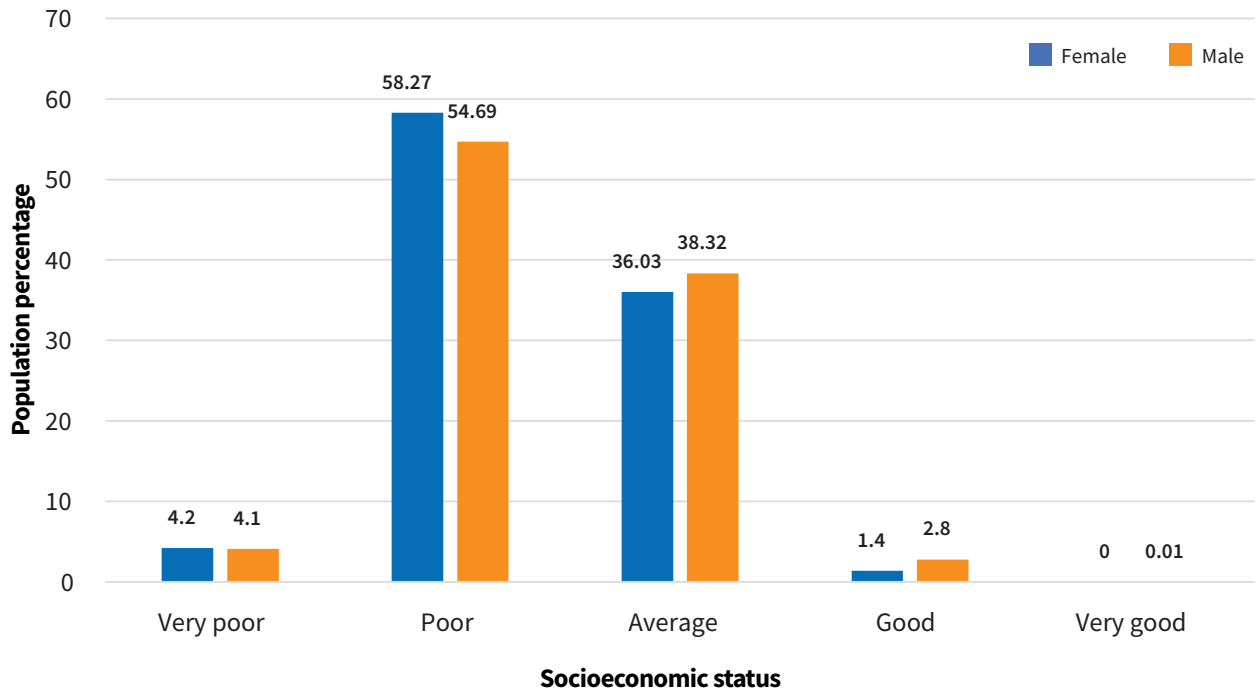
With regard to the communication sector, services like landline, CDMA, ADSL and mobile phone are provided by Nepal telecommunications and Ncell. However, this facility is not evenly distributed in the watershed area as geographical and technical difficulties exist

**TABLE 13: HOUSEHOLD CATEGORIZATION[6] ACCORDING TO ECONOMIC STATUS OF THE WATERSHED**

| | Wards | Very poor | Poor | Average | Good | Very good |
|---|---|---|---|---|---|---|
| Dhankuta Municipality | Ward no. 1 | 36 | 846 | 721 | 36 | |
| | Ward no. 2 | 49 | 658 | 254 | 1 | |
| | Ward no. 3 | 30 | 312 | 157 | 7 | |
| | Ward no. 4 | 19 | 346 | 283 | 9 | |
| | Ward no. 5 | 20 | 290 | 377 | 31 | 1 |
| | Ward no. 6 | 22 | 510 | 412 | 45 | |
| | Ward no. 7 | 19 | 522 | 565 | 56 | |
| | Ward no. 8 | 82 | 330 | 47 | - | |
| | **Percentage** | **3.90** | **53.77** | **39.70** | **2.60** | **0.01** |
| Chhathar Jorpati Rural Municipality | Ward no. 2 | 224 | 202 | 106 | 125 | 120 |
| | Ward no. 3 | 51 | 134 | 143 | 162 | 72 |
| | **Percentage** | **20.5** | **25.09** | **18.59** | **21.43** | **14.33** |

[6] The definition of economic category is different for Dhankuta Municipality and Chhathar Jorpati Rural Municipality.
For Dhankuta Municipality, not having big farm animals and unemployment other than daily wages and labour; Food insufficiency (3 months sufficient to sustain from own income); socially and economically marginalized family like *dalits* and *janjatis;* family indebtedness with loan (for daily basic requirement such as food, shelter, general medication) are considered when categorizing economic classes.
For Chhathar Jorpati Rural Municipality, household income, assets, household characteristics and crop production are considered when categorizing economic classes.

FIGURE 24: GENDERED DISAGGREGATED SOCIOECONOMIC STATUS IN DHANKUTA MUNICIPALITY




in doing so. Rural houses are sparsely distributed and it is very expensive to extend services throughout the rural areas. This difficulty however might increase the vulnerability (in developing social cohesiveness in the events of disasters) among the rural dwellers. However, a majority of households are found to have mobile phones and televisions in the watershed area which ensures visual information and communication as well as music for entertainment. Moreover, watershed-management-based awareness programmes can reach everyone through these types of media. It can also be used as an efficient means of paying water-bills and fees for other watershed services.

### 3.9.2 Road connections

Connectivity is a key factor in mountain development. It helps to link hinterlands with the market centres so that mountain farmers can easily transport agricultural inputs and sell their produce in the market at reasonable prices. With the improvement in connectivity, there is a clear switch in farming systems from subsistence to commercial production. Tables 14 and 15 show that almost every ward is connected to a road network in the watershed with at least rural and seasonal roads.

There is wide recognition in the mountain communities that construction of a road is a significant indicator of development. In recent times, there has been an increase in the expansion of rural road networks across the mountains. But most of these roads are muddy and seasonal. For example, Dhankuta Municipality has about 150 km of seasonal roads, which is 7 times higher than black-topped roads. Giving more emphasis to seasonal roads without consideration of bio-engineering and stabilization may negatively impact water resources and overall watershed management. During the field visit, there were occasions when communities linked the drying of a local spring to the haphazard construction of a seasonal road. Balancing this trade-off between developmental priorities and watershed management is imperative in mountain watersheds.

However, with the increase in rural road networks and commercialization of agricultural practices, farmers have increased agricultural inputs such as fertilizer, pesticides and improved seeds on their farms.

### 3.9.3 Health facilities

The data from the household survey show that more than half of the population relies on private health care service providers. This indicates household preference for meeting their health care needs via the private sector. Interestingly, there is no emergency obstetric care provided by either the private or the

**TABLE 14: ROAD NETWORK OF DHANKUTA MUNICIPALITY**

| SN | Road division | Length (Km) | Average breadth) | Reached wards |
|---|---|---|---|---|
| 1 | Koshi highway | 38 | 6.5 | 1,2,3,4,6,7,9,10 |
| 2 | Secondary highway | 9 | 6.5 | 1,2 |
| 3 | Concrete and black topped | 20.66 | 4.5 | 1,2,3,4,5,6,7,8,9,10 |
| 4 | Gravel road | 3.65 | 4.5 | 4,6,8 |
| 5 | Rural and seasonal road | 149 | 4.5 | 1,2,3,4,5,6,7,8,9,10 |

**TABLE 15: ROAD NETWORK OF CHHATHAR JORPATI RURAL MUNICIPALITY**

| | Chhathar Jorpati Rural Municipality | | | | | |
|---|---|---|---|---|---|---|
| | Ward 2 | | | Ward 3 | | |
| | Distance | HH connected with road | HH not connected with road | Distance | HH connected with road | HH not connected with road |
| Koshi highway | 4 km | 510 | 267 | - | 241 | 321 |
| Gravel road | 17 km | | | 83 km | | |

government sector within municipal jurisdictions. The lack of such facilities is one of the factors leading to increasing maternal mortality in these municipalities. Significantly, the major health-related issues are found to be exacerbated by lack of knowledge on diseases and their symptoms. The community strongly believes in traditional healing while certain superstitions practices are also evident. In addition, some of the primary health posts lack adequate human resources such as qualified medical personnel. A few wards in far-flung areas of the municipality are unable to meet their health care needs in a timely manner. Hence, consideration should be given to new health posts in line with population growth.

### 3.9.4 Educational institutions

In the NT Watershed, there are about 120 educational institutions: 112 in Dhankuta Municipality (83 government and 29 private) (see Table 16) and 8 in Chhathar Jorpati Rural Municipality (7 government and 1 private) (see Table 17).

The Dhankuta Municipality has a total of 339 teachers. The gender-disaggregated data for the teachers in the educational institutions of pre-primary, primary, and secondary schools suggest a higher proportion of female teachers (65%) as compared to male teachers. Chhathar Jorpati Rural Municipality has a total of 75 employed as teachers, of whom 64% are male and 36% are female.

**TABLE 16: DETAILS OF EDUCATIONAL INSTITUTIONS IN DHANKUTA MUNICIPALITY**

| S.N. | Details of educational institutions | Government & community Schools | Private schools | Total |
|---|---|---|---|---|
| 1 | Child development centre | 48 | 11 | 59 |
| 2 | Primary school | 23 | 2 | 25 |
| 3 | Lower secondary school | 8 | 5 | 13 |
| 4 | Secondary school | 8 | 11 | 19 |
| 5 | Campus | 4 | 2 | 6 |
| 6 | Veda Vidyaashram | | | 0 |
| 7 | Madarsa | | 1 | 1 |
| 8 | Gumba | | | 0 |
| 9 | Others - technical institutions | 1 | 1 | 2 |
| | Skill development training centre | 1 | | 1 |
| | **Total** | **93** | **33** | **126** |

Source: District Education Office

**TABLE 17 : DETAILS OF EDUCATION INSTITUTION IN CHHATHAR JORPATI RURAL MUNICIPALITY (WARDS 2 AND 3)**

| S. N. | Details of educational institutions in the municipality | Total |
|---|---|---|
| 1 | Primary level | 5 |
| 2 | Secondary level | 2 |
| 3 | Private boarding school | 1 |
| | **Total** | **8** |

# Chapter 4: Gender equity and social inclusion (GESI) in watershed management

## 4.1 Introduction

Globally, women and girls are the ones most responsible for the collection of water and fuel for their households (Geere & Cortobius 2017; Regmi & Fawcett 1999). Thus, any change caused by anthropogenic activity and climate variation in water availability disproportionately affects women (Denton 2002). There are increasing disputes due to competing uses of water resources, which have led to several water conflict situations (Roth et. al. 2014), including in the NT Watershed. The well-off and influential members of the community achieve individual water goals at a cost to collective water rights and such unequal practices have worsened gender inequality with regard to water and access to and control over resources[7] (Meinzen-Dick & Zwarteveen 1998). Such water conflicts get further aggravated through structural disparities in gender, caste, class, ethnicity, location, physical abilities, age, and power relations.

In a watershed, women and men have distinctive roles in the management of resources and there are unequal power relations based on gender and social factors. Women and the marginalized have either no role or only a limited role in decision-making processes (Wani et al. 2015; Resurrección et al. 2019). The issue of gender and social inclusion in water resource management is, unfortunately, one given least priority. Hence, gender is often missing from water management policies and absent from decision-making (Meinzen-Dick & Zwarteveen 1998; Ahmed 2005). Due to repressive socio-cultural norms and practices, women and the marginalised groups are allotted limited rights, assets, resources, and power leaving them poorer and less educated as well as excluded from decision-making and development processes at various scales.

To mainstream gender within development activities, the Dhankuta Municipality has focused on three gender dimensions – inclusiveness, mainstreaming and empowerment. The municipality has also prioritized achieving gender equality, reproductive health, education, self-sufficiency and empowerment of women (Dhankuta Municipality Profile 2018). However, from a watershed management perspective, there is a need to understand the distinctive roles of women and men relating to usage, distribution, regeneration, and conservation of resources, and to recognize women's experience and knowledge as critical for environmental management and for addressing gender inequality. For this, the watershed plan needs to focus on strengthening the meaningful participation of women and the marginalized, promote leadership at all levels within institutions, create a level playing field for equal access and control of resources, and regularly conduct gender and social inclusion analyses at all levels, including monitoring and evaluation of watershed management plans.

In a watershed, there are different dimensions of gender and social inclusion issues related to water, energy and food security. This section analyses the available gender disaggregated data as part of a gender focused strategy for watershed management relating to income, labour performed at households, access and control of water resources, property-ownership rights of farmlands, and financial institutions and gender implications. The other important gender and social inclusion issues, from the perspective of a gender mainstreaming strategy, relating to water (quality and quantity), education, housing (types), energy needs, food security, and governance have been analysed in the preceding sections of the management plan.

[7] Women and men have different access to resources (water, finance, forest and others) needed to fulfil their work as well as control to use or manage that resources. Here access refers to rights and opportunities to make use of the resources while control over resources refers to rights and power over the productive resources (Paul & Meena 2016; UNDP 2001).

## 4.2 Gender-wise distribution of annual income of households

The socio-economic status of the population in the watershed, in Dhankuta Municipality, reveals that the majority belong to the poor and average category, which however is not the case in Chhathar Jorpati Municipality (see section 3.8.2).

The gender-disaggregated data on the individual annual income of households in Dhankuta Municipality[8] (see Figure 25) show that male-headed households have a higher annual income (63%) than female-headed households (37%).

Interestingly, in the income category, when the annual income of households increases, the proportion of the number of male-headed households is reduced as compared to female-headed households. The data reveal that with an increase in the annual income of households from 60,000-120,000 to 120,000-180,000 and above, the proportion of female-headed households also increases from 57% to 76% and 90%, respectively Figure 25.

There are several reasons for this in the case of the Dhankuta Municipality. First of all, these are only de facto female-headed households[9]. The reasons are:

The high rate of male out-migration which has increased female-headed households. Thus, remittances have an important role in increased annual income of the households (also cited in Dhankuta Municipality Profile 2018 & Gartaula et al. 2010);

Women's active engagement in commercial farming for improved livelihoods, which contributes to improved economic conditions;

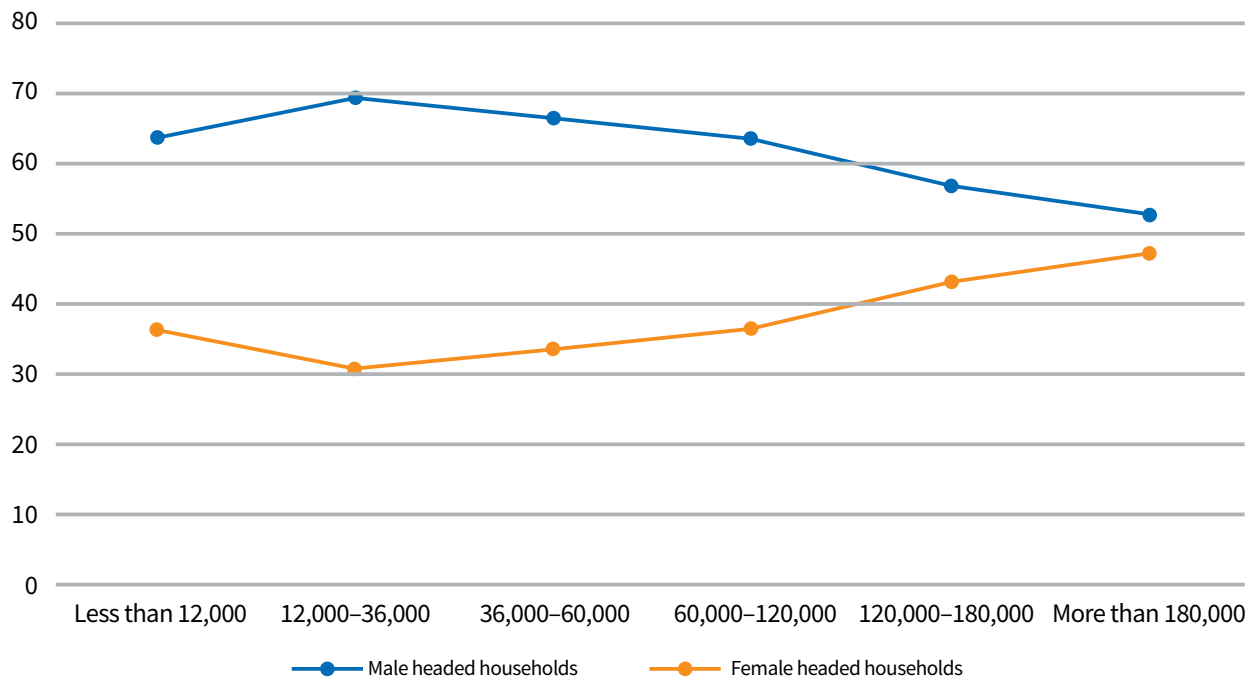
The increasing number of women entrepreneurs in Dhankuta Municipality[10] that can have a positive impact on increased female-headed household income.

- Thus, the data lead to the conclusion that women who have higher decision-making power and control of resources can bring about changes in their economic status

## 4.3 Gender division of labour

The watershed has an increasing proportion of female population as compared to male population (see Table 9). Women in the watershed are responsible for household activities in contrast to men (see Annex 14). A detailed gender disaggregated listing of work ranging from agricultural, livestock and household activities

**FIGURE 25: GENDERED PER CAPTIA INCOME RANGE OF HOUSEHOLDS AT DHANKUTA MUNICIPALITY**




[8] The Household Annual Income data consist of all the 10 Wards of Dhankuta Municipality (Source: Dhankuta Municipal Profile, 2018).
[9] De facto households occur when women's male partners are absent due to migration, widespread civil conflict or desertion and the male partner contribute to economic maintenance. De facto heads of households are a temporary process due to out-migration of male members (Joshi Rajkarnikar and Ramnarain 2020).
[10] Field observations.

indicates that a majority of the agricultural activities are carried out by women. Most men are engaged in ploughing, application of pesticide and fertilizer and only some of them support women in transplanting crops. The trend within this classification shows that the activities requiring energy, from preparing the field for irrigation to decision-making activities such as marketing, are handled by men. Women take on labour-intensive activities such as harrowing, weeding, planting, threshing, screening of seeds, litter collection, seed collection and corn shelling.

With regard to livestock management, activities such as fodder collection, feed preparation and feeding livestock are handled by women. But the preparation of livestock feed, transportation of manure and application, and herding livestock are jointly handled by women and men. Thus, both these activities (agricultural and livestock management), which come within the productive sphere of gender roles, indicate that though men have key roles, women perform major roles for livelihood purposes.

Within the household, activities related to cooking, fetching water and collecting forage among others are undertaken by women. Detailed distribution of gender roles within productive and reproductive spheres is listed in Annex. 14.

Hence, the gender division of labour within the productive and reproductive spheres shows that an increasing proportion of women's work is extended to the productive spheres. The field visit and FGDs in Dhankuta municipality reveal that almost every household has a male member who has out-migrated for employment. Due to this, women's work has extended to agricultural production. Hence, an increasing feminization of labour is observed across the Dhankuta municipality.

## 4.4 Access to drinking water

Across the watershed (Dhankuta and Chhathar Jorpati – wards 2 and 3), about 87% of the households have access to drinking water through a piped tap water connection inside the compound whereas about 14% of the households depend on public taps, wells, local springs and rivers.

Interestingly, Table 18 shows that though 87% of the households had piped connections inside their compound, 33% of the total households still travel outside their homes to fetch drinking water (see Table 19). The qualitative data (KIIs and FGDs) reveal that this was because the pipeline water supply was not regular during the summer season while it was muddy in the monsoon season. Hence, household members had to find alternative water sources to ensure safe drinking water due to which they travelled long distances for domestic water needs.

Travelling long distance to fetch drinking water was mostly observed in Wards 8 and 3. This was because in these wards only about 28% and 17% of households, respectively, had piped water connections inside their compound. The gender division of labour (see

**TABLE 18: DISTRIBUTION OF DRINKING WATER SOURCES IN DHANKUTA AND CHATTARJORPATI MUNICIPALITIES**

| Municipality | Ward | Piped tap inside compound | Public tap | Covered well | Uncovered well | Spring water | River | Other Sources | Total |
|---|---|---|---|---|---|---|---|---|---|
| Dhankuta | 1 | 1521 (93) | 0 | 6 (0.4) | 28 (1.7) | 74 (4.5) | 2 (0.1) | 8 (0.5) | 1639 (19.7) |
| | 2 | 885 (92) | 0 | 12 (1.2) | 26 (2.7) | 33 (3.4) | 4 (0.4) | 2 (0.2) | 962 (11.6) |
| | 3 | 383 (76.6) | 0 | 7 (1.4) | 23 (4.6) | 34 (6.8) | 47 (9.4) | 6 (1.2) | 500 (6) |
| | 4 | 584 (89) | 0 | 4 (0.6) | 62 (9.5) | 3 (0.5) | | 3 (0.5) | 656 (7.9) |
| | 5 | 685 (96.2) | 0 | 15 (2.1) | 3 (0.4) | 3 (0.4) | 5 (0.7) | 1 (0.1) | 712 (8.6) |
| | 6 | 953 (96.4) | 0 | 2 (0.2) | 11 (1.1) | 22 (2.2) | 1 (0.1) | 0 | 989 (11.9) |
| | 7 | 1103 (94.9) | 0 | 0 | 13 (1.1) | 36 (3.1) | 8 (0.7) | 2 (0.2) | 1162 (14) |
| | 8 | 373 (81.3) | 0 | 6 (1.3) | 53 (11.5) | 20 (4.4) | 6 (1.3) | 1 (0.2) | 459 (5.5) |
| Chattarjorpati | 1 | 247 (31.8) | 481 (61.9) | 0 | 12 (1.5) | 8 (1) | 27 (3.5) | 2 (0.4) | 777 (9.3) |
| | 2 | 458 (99.6) | 0 | 0 | | | | 2 (0.4) | 460 (5.5) |
| **Total** | | **7192 (86.5)** | **481 (5.8)** | **52 (0.6)** | **231 (2.8)** | **233 (2.8)** | **100 (1.2)** | **27 (0.3)** | **8316 (100)** |

* Note: Figures in the parenthesis include percentage

**TABLE 19: WARD-WISE DISTRIBUTION OF TIME TO FETCH WATER IN DHANKUTA MUNICIPALITY**

| Dhankuta Municipality | Do not travel | Travel less than 15 mins | More than 15 mins to 1 hour | More than 1 hour | Not specified | Total |
|---|---|---|---|---|---|---|
| Ward no. 1 | 1063 (65)* | 131 (8) | 364 (22) | 81 (5) | 0 | 1639 (23) |
| Ward no. 2 | 555 (58) | 240 (25) | 88 (9) | 79 (8) | 0 | 962 (14) |
| Ward no. 3 | 142 (28) | 68 (13) | 248 (49) | 48 (9) | 0 | 506 (7) |
| Ward no. 4 | 420 (64) | 86 (13) | 63 (10) | 88 (13) | 0 | 657 (9) |
| Ward no. 5 | 691 (96) | 13 (2) | 7 (1) | 1 (0.1) | 7 (1) | 719 (10) |
| Ward no. 6 | 619 (63) | 122 (12) | 207 (21) | 41 (4) | 0 | 989 (14) |
| Ward no. 7 | 1062 (91) | 49 (4) | 15 (1) | 36 (3) | 0 | 1162 (16) |
| Ward no. 8 | 79 (17) | 180 (39) | 164 (36) | 36 (8) | 0 | 459 (6) |
| **Total** | **4631 (65)** | **889 (13)** | **1156 (16)** | **410 (6)** | **0** | **7093 (100)** |

* Note: Figures in the parenthesis include percentage

Annex 14) with regard to collection of water shows that women are responsible for fetching water to meet the household water needs. The data reveal that women are responsible for fetching water and that they travel long distances to ensure water needs in households. According to a woman respondent from Hile town, women in general spend hours every day traveling and queuing up to collect water several times within a day[11] The data lead to the conclusion that there has been no change in gender roles and responsibilities and that women continue to travel to far-flung places in search of safe drinking water to meet household needs.

Thus, the increased time spent in fetching water on a daily basis could result in reduced time to engage in educational activities, participate in institutional meetings (resource management institutions) and engage in entrepreneurial activities (Cleaver 2003; Wijk 1995).

## 4.5 Land ownership and access

In Nepal, most livelihoods revolve around land and land-based resources and the access to and control of these resources have an inextricable influence on the economic well-being of the household. The entitlement of land ownership is also considered a determinant of the socio-economic status of the population (Campus 2016). From a gender perspective, women's entitlement to land have shown with the increased entitlement to land has led to an enhancement in women's decision-making capabilities, better health outcomes, and overall empowerment (Allendorf 2007; Mishra & Sam 2016; Meinzen-Dick et al. 2019).

The gender disaggregated data from the Dhankuta Municipality show that more men continue to hold land rights (about 63%) than women (37%) in the watershed (Dhankuta Municipality Profile 2018). However, comparatively speaking, at a national level, the Municipality has a higher percentage of women owning land as compared to the national figures (19%) (Mishra & Sam 2016).

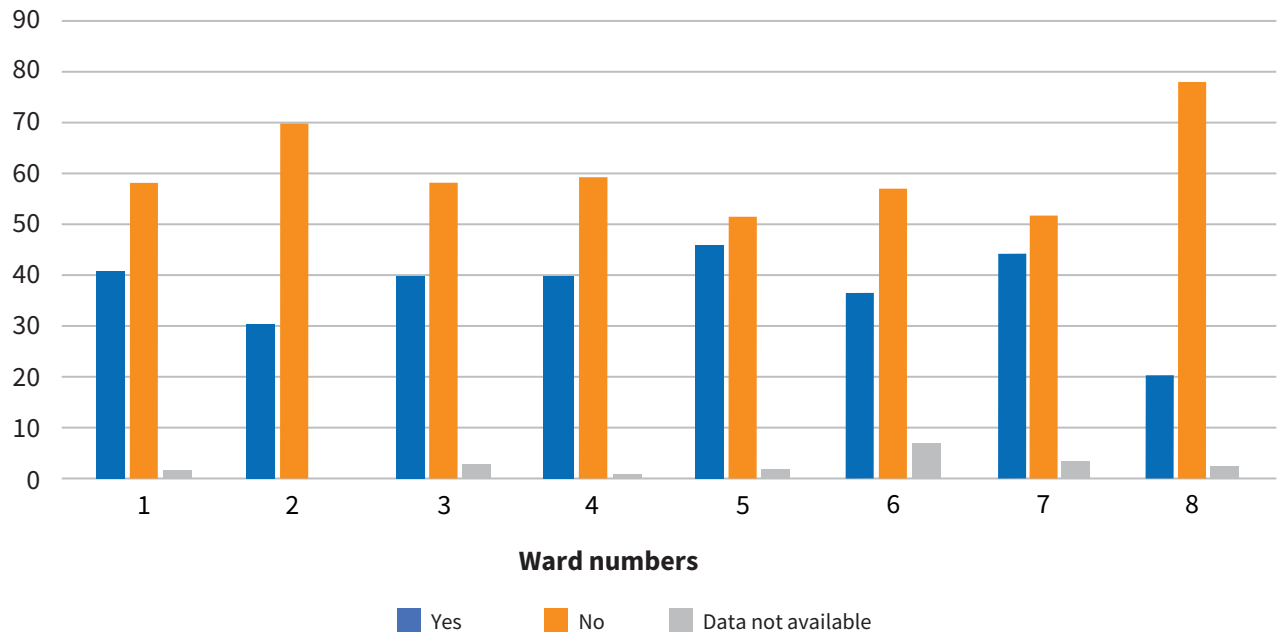
At ward level within Dhankuta Municipality, the highest proportion of women owing land was observed in Ward 5, followed by Ward 7 and Ward 1 (46%, 44% and 41%, respectively) and the lowest percentage of women owing land was found in Ward 8 and Ward 2 (20% and 30%, respectively) (see Figure 26) (Source: Dhankuta Municipality Profile 2018).

It is interesting to note that most of the wards in Dhankuta Municipality, which had a higher proportion of women's land ownership, come within the township area rather than wards 8 and 2. Thus, the data lead to the conclusion that the higher percentage of women's land ownership depends on proximity to the urban centre which may have to do with increased awareness, information and education status. Other factors responsible would be the changes in government policies to promote women's empowerment through entitlement of land rights (Nepal Constitutional Amendment of 2002 and 2007) and the out-migration of male members for longer durations (Chapagain 2015; Gartaula et al. 2010).

However, if trends such as increasing male out-migration and increased women's entitlement to land are an opportunity to empower left-behind women, there are also challenges that these women have to deal with such as the work burden (Gartaula et al. 2010) and gender discriminations that still persist (Campus 2016).

[11] In-depth interview with a local woman in Hile Town.

**FIGURE 26: WOMEN'S OWNERSHIP OF LAND RIGHTS**




## 4.6 Financial institutions and gender implications

In Dhankuta Municipality, the secondary data (2018) show that about 42% of the total households have taken loans for different purposes such as business, agriculture, construction of a house, purchase of land, social activities (festivals and rituals), meeting health needs, education, household expenses, and loans for foreign employment procedures (see Table 20).

Within the expenditure category, there is a large number of households (24%) who spend the loan amount in meeting their household expenditure, followed by the construction of house and purchase of land (17%) and commercial agriculture (16%). The data reveal that meeting household expenditure is the priority for most households. The expenditure pattern indicates that loans are used to ensure food security at the household level.

The primary source of loans for households in Dhankuta Municipality is from microfinance institutions in the Dhankuta and Hile towns (32%), followed by loans from person (individuals) (28%) and commercial banks (23%).

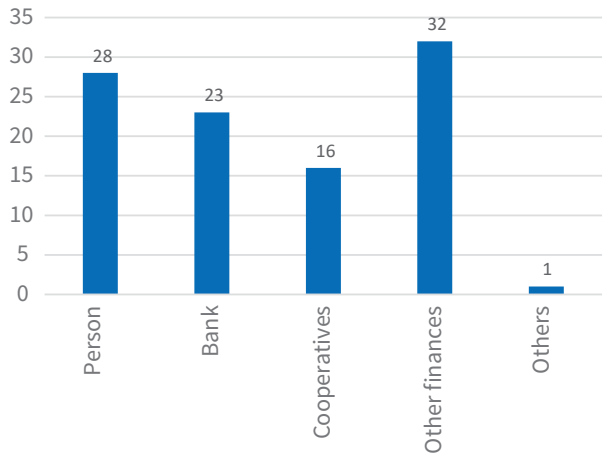
**TABLE 20: WARD-WISE DISTRIBUTION OF LOAN EXPENDITURE AT HOUSEHOLDS**

| Wards | Household expenditure of loan | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Business | Commercial agriculture | Construction of house and purchase of land | Birth/ death/ social activities | Religious/ cultural activities | Health | Educa-tion | Household expenditure | Sending family members abroad | Others | Total |
| 1 | 183 (18)* | 128 (23) | 225 (23) | 21 (2) | 7 (1) | 116 (12) | 78 (8) | 170 (17) | 53 (5) | 12 (1) | 993 (100) |
| 2 | 13 (2) | 217 (25) | 94 (11) | 44 (5) | 36 (4) | 101 (12) | 25 (3) | 284 (33) | 39 (5) | 5 (1) | 858 (100) |
| 3 | 42 (8) | 138 (27) | 82 (16) | 8 (2) | 4 (1) | 81 (16) | 38 (7) | 99 (19) | 17 (3) | 0 | 509 (100) |
| 4 | 44 (11) | 30 (8) | 74 (19) | 9 (2) | 11 (3) | 77 (20) | 25 (6) | 100 (26) | 16 (4) | 1 (0.3) | 387 (100) |
| 5 | 77 (20) | 42 (11) | 77 (20) | 7 (2) | 5 (1) | 27 (7) | 23 (6) | 93 (24) | 24 (6) | 10 (3) | 385 (100) |
| 6 | 63 (14) | 82 (18) | 64 (14) | 5 (1) | 21 (5) | 50 (11) | 25 (6) | 115 (26) | 16 (4) | 3 (1) | 444 (100) |
| 7 | 73 (15) | 44 (9) | 140 (29) | 12 (2) | 25 (5) | 45 (9) | 30 (6) | 92 (19) | 17 (3) | 10 (2) | 488 (100) |
| 8 | 9 (2) | 49 (12) | 19 (5) | 30 (7) | 29 (7) | 56 (13) | 34 (8) | 111 (27) | 76 (18) | 4 (1) | 417 (100) |
| **Total** | **504 (11)** | **730 (16)** | **775(17)** | **136 (3)** | **138 (3)** | **553 (12)** | **278 (6)** | **1064 (24)** | **258 (6)** | **45 (1)** | **4481 (100)** |

* Note: Figures in the parentheses include percentage of the population that take loans.

The secondary data in Figure 27 reveal that households' preference for loans is from local financial institutions (commerical and other financial institutions). During the field visit, it was observed that a large number of micro-credit institutions had mushroomed in the area providing easy access to credit to households. Women, as members of these credit groups, had easy access to the loan facilities.

**FIGURE 27: PERCENTAGE-WISE DISTRIBUTION OF SOURCE OF LOAN**




During the FGDs and KIIs, women who were part of savings groups at the community level reported that easy access to loans has resulted to an increase in the number of households with debt[12]. Such conditions as high interest rates and the inability to repay have increased stress among women and men in the villages. Increased stress in households has also resulted in rising incidences of violence against women[13]. Women, during the in-depth interviews, highlighted incidents of suicide among women at the community level due to increased domestic violence and inability to repay the debt. The Dhankuta Municipality Profile (2018) has reported the following cases for the Dhankuta Municipality in BS 2075: domestic violence (18), intimate partner violence (39) and sexual abuse (3). There is limited information on how the phenomenon of micro-credit institutions is increasing women's vulnerability when it comes to ensuring food security and addressing mental health problems. The Nibuwa-Tankhuwa watershed management plan needs to pay attention to these issues.

## 4.7 Results

Given that women and men have distinctive roles in the management of the watershed, the repressive socio-cultural norms and practices have limited women as well as marginalized men from participating in decision-making, having their voices heard, and in access to and control over resources. Hence, there is a need to consider the differential needs of women and men, Dalit communities and households that live in remote villages of the municipalities. Often communities that live in remote areas of the watershed have limited opportunities and benefits from the development activities. The gender-disaggregated data obtained from Dhankuta Municipality was analysed to understand the differential needs and opportunities for women and men in the watershed. The findings from gender-disaggregated data show a positive effect from male out-migration due to increase in women's engagement in economic activities. Commercial agriculture in particular has enhanced the income of female-headed households in the sub-basin of the watershed.

Although male out-migration may contribute to bringing changes in women's decision-making and access to and control over resources, it has not changed women's work burden. With the added labour, women continue to struggle to manage household chores and to perform productive roles (agriculture). They travel and queue up for long hours to fetch drinking water on a regular basis. Whether they have a piped water tap connection or not, households do not receive a regular water supply with the water that is supplied muddy in the monsoon season. These conditions have forced women to travel to far-flung places in search of safe drinking water from different water sources. Women's role in fetching water has reduced the time they have to engage in economic activities and education and to participate in decision-making within institutions.

Nevertheless, there is an increasing number of financial institutions in the watershed that have provided loans to women for business, agriculture, construction of houses, purchase of land, household expenditure and meeting health and education needs. For many households, the loan is primarily to meet household expenditure. The increased loan amount and high interest rates have caused women to suffer more than the men resulting in an increase in domestic violence in Dhankuta Municipality. Domestic violence has also given rise to mental health problems among women within the watershed.

[12] FGD in Ward 2 and an in-depth interview in Ward 5 reveal that the average loan taken by women is Rs 50,000 per household.
[13] In-depth interviews – Wards 2 and 7 – including in urban centres. There is high alcohol consumption among men.

# Chapter 5: Strengthening institutions in the watershed

## 5.1 Introduction

The watershed is often considered a unit for integrated water resource management (IWRM) where the management is not merely limited to land, water, forestry, and other natural resources but also involves an integration of people in building self-reliance and development. Watershed programmes are often considered people-oriented because they factor in the differential needs, constraints, and practices of women and men (Dash et al. 2011). Sustainable management of watershed resources requires collective action among stakeholders (government, civil society, academia and private sector) at different levels. Given the interconnectedness of sectors such as the food-water-energy nexus, there is a need to move beyond the sectoral approach to understanding the inter-linkages between these resources for human development and environmental conservation. This requires bringing institutional arrangements for the management of common-pool resources such as pastures, irrigation systems, and rain-water harvesting ponds into a single platform in the development of watershed policies and plans.

Such an approach requires a set of rules and regulations for the better management and governance of natural assets and structures and mechanisms for conflict resolution; regulation of unsustainable behaviour; and agreed upon norms for equitable sharing of benefits and costs. Along with institutions, inclusive organizational arrangements in the form of watershed management committees, resource user groups, and other such mechanisms for coordinating and implementing watershed management interventions and convergence among different sectors (forest, soil and water conservation, agriculture, water and sanitation, energy, infrastructure and social welfare among other things) to solve the shared problems and co-develop solutions are also necessary. Given the current understanding of the institution (watershed management preparation committee) and issues identified through observations in the field, special emphasis needs to be given to inclusion and participation. Currently, it seems that participation is passive in nature. Thus it would require women and the socially excluded to go higher in the structure for decision making and implementation.

Given the changing precipitation pattern and temperature, the demand for commercial agriculture and livelihood enhancement and haphazard infrastructure construction, the scarce water resources are becoming competitive as well as creating grounds for conflict within the watershed. This brings about the need to bring all the stakeholders on board. In order to make the implementation of the watershed management plan more inclusive, the section below highlights the current state of governance within the watershed, the need for inclusive planning and implementation, and ways in which this could be achieved.

## 5.2 Current state of governance in watershed management

Since the watershed spreads across Dhankuta Municipality and Chhathar Jorpati Rural Municipality, the watershed consists of a large array of institutions ranging from government, municipality and ward to community. At the district level, government institutions include District Coordination Committee (DCC), Soil Conservation and Watershed Management Office (SCWMO), Divisional Forest Office, Agriculture Knowledge Centre (AKC), and Division Road Office (DRO) to name a few (see Table 22). Each of these institutions has its own set of plans and mandates with SCWMO being responsible for watershed management.

The watershed has about 5 NGOs focusing on social development, women's empowerment, capacity building and skill development, family and youth health, social justice, peace promotion, human rights, poverty eradication and homes for the elderly among others. There are more than 1900 individuals trained on topics such as savings and loans, organizational leadership, gender development, health, family planning, drinking water management, forest management, waste management, and skill development (Dhankuta Municipality Profile 2018).

In the process of developing the watershed management plan, the Dhankuta Municipality officials in collaboration with Chhathar Jorpati Rural Municipality set up the Watershed Management Plan Committee. The committee has a total of 24 members. Out of this number, nine were women representing water-scarce/affected areas (see Table 21). While the committee has been established, it needs to be revisited and discussed in consultations of making the committee inclusive and also on the roles and responsibilities of other institutions and stakeholder (see Table 22) in the watershed management committee. This will help in have a solid mechanism for implementation of the management plan.

Nominal[14] or passive[15] participation of women would not bring about changes in their positions or even challenge the existing gender differentials, power and culture that have traditionally subordinated women (Agarwal 2010). Instead, there should be meaningful participation of women as it would involve confronting the dominant gender and social norms and practices. Achieving meaningful participation is difficult but before the implementation of the Watershed Plan document, addressing such gender and social issues is essential. If not, the activities designed in the plan will continue to focus on practical gender needs (such as addressing basic needs to fulfil women's ascribed roles like in any other development project) and may not lead to gender transformative change[16]. Therefore, activities that inhibit the process of women's empowerment need to be addressed with utmost care during the planning or implementation of the watershed management plan document.

### CONVERGENCE AND COORDINATION AMONG STAKEHOLDERS

While the Dhankuta Municipality and Chhathar Jorpati Rural Municipality are the main stakeholders of the watershed management plan, other stakeholders need to be represented in the watershed management committee to ensure convergence. Each of these institutions have their jurisdiction, plans, funds and mandates. Hence, ensuring their meaningful participation and equal representation will ensure good coordinated results. A list of possible stakeholders with their potential roles is suggested in Table 22. Once on board, these institutions can contribute to the watershed management plan depending on the interventions required as proposed in the Chapter 7. Their engagement can be in the form of a broader coordination or in the form of a technical committee, with the watershed management committee developing a clear mechanism for coordination and communication with the wider group of stakeholders. The model of collaboration needs discussion through

**TABLE 21: GOVERNANCE STRUCTURE WITHIN THE NT WATERSHED MANAGEMENT COMMITTEE**

| Gender disaggregated structure of the Proposed NT Watershed Management Committee | | | |
|---|---|---|---|
| **Members** | **Female** | **Male** | **Total** |
| Local government Mayor and Deputy Mayor from Dhankuta Municipality | 1 | 1 | 2 |
| Local government Chairperson and Vice-chairperson from Chhathar Jorpati Rural Municipality | 1 | 1 | 2 |
| Ward chairperson from Dhankuta Municipality ward no. 1 to ward no. 8 | 1 | 7 | 8 |
| Ward chairperson from Chhathar Jorpati Rural Municipality ward no. 2 and ward no. 3 | | 2 | 2 |
| Soil Conservation and Watershed Management Office, Dhankuta | | 1 | 1 |
| Chief Administrative Officer from Dhankuta Municipality | | 1 | 1 |
| Women from affected areas | 6 | | 6 |
| ICIMOD (PC-Koshi Basin Initiative) | 1 | | 1 |
| Contact Person | | 1 | 1 |
| **Total** | **10** | **14** | **24** |

[14] Nominal participation – membership in the group.

[15] Passive participation – being informed of decision ex post facto; or attending meetings, and listening in on decision making, without speaking up (Agarwal, 2010, p.101). If this is a direct quotation, place within double quotes.

[16] Gender tranformative change goes beyond identifying and exploring the symptoms of gender equality and addressing socially constructed norms, attitudes, and relations of power that underline them. It is a more towards transforming the power dynamics and structures that serve to reinforce gendered inequalities.

**TABLE 22: NIBUWA-TANKHUWA WATERSHED LEVEL STAKEHOLDERS AND THEIR POTENTIAL ROLES**

| S.No. | Stakeholders | Potential roles and responsibilities |
|---|---|---|
| **Government institutions** | | |
| 1 | Dhankuta Municipality | Overall planning, coordination and implementation |
| 2 | Chhathar Jorpati Rural Municipality | Overall planning, coordination and implementation |
| 3 | Watershed management Committee | Coordination, implementation and monitoring |
| 4 | Ward offices | Ward level planning and development |
| 5 | District Coordination Committee (DCC) | Support for watershed management plan |
| 6 | Division Forest Office (DFO); | Forest area planning and development |
| 7 | Soil Conservation and Watershed Management Office (SCWMO), Dhankuta | Expertise and capacity building, implementation |
| 8 | Urban Development and Building Construction Office (UDBCO) | |
| 9 | Agriculture Knowledge Centre (AKC) | Dissemination of knowledge and capacity building; Action research |
| 10 | Veterinary Hospital and Livestock Service Centre (VHLC) | Improved fodder production |
| 11 | Small and Cottage Industry Office (SCIO) | Support for small enterprises and tourism |
| 12 | Division Road Office (DRO) | Prevention of landslides and soil erosion |
| 13 | Water Resources and Irrigation Development Division (WRIDD) | Water resources management<br>Water distribution for drinking and irrigation |
| 14 | Water Supply and Sanitation Division Office (WSSD) | Water resources management |
| 15 | National Agricultural Business Research Centre (NABRC) | Dissemination of knowledge and capacity building; green enterprises |
| 16 | National Citrus Research Programme | Support for livelihood activities |
| 17 | Department of Hydrology and Meteorology | Capacity building on measuring the rainfalls |
| **Community groups** | | |
| 18 | Mothers' Group | Participation in implementation of local plans<br>Awareness raising |
| 19 | Community Forest User Groups (CFUGs) | Conservation and management of forest area and the resources |
| 20 | Farmer groups | Participation and engagement in interventions; demonstration of good practices |
| 21 | Water user committee | Conservation and equitable management of water sources and groundwater recharge zones |
| **NGOs/INGOs** | | |
| 22 | Federation of Community Forestry Users Nepal (FECOFUN); | Overall coordination of CFUGs in the watershed, supporting the management of groundwater recharge areas |
| 23 | Red Cross | DRR preparedness and capacity building |
| 24 | Alternative Energy Promotion Centre (AEPC) | Promotion of alternative energy in the watershed |
| 25 | International Centre for Integrated Mountain Development (ICIMOD) | Technical inputs and support, including knowledge exchange |
| 26 | Social Organization for Liberal Volunteers Engagement (SOLVE), Nepal | |
| 27 | Human Rights, Social Awareness and Development Centre (HUSADEC) | |
| 28 | Poverty Alleviation & Rural Development Program | |
| **Academia** | | |
| 29 | Agriculture Research Station | Dissemination of knowledge and capacity building; action research, evidence generation |
| 30 | Universities | Research-practice-validation |
| **Private Sector** | | |
| 31 | Cooperatives | |
| 32 | Hotel Association | Participation and investment in the plan |
| 33 | Financial institutions | Easy access to credit and low interest rates |
| 34 | Federation of Nepalese Chambers of Commerce and Industry (FNCCI) | |
| **Media** | | |
| 35 | Federation of Nepali Journalists (FNJ). | Dissemination of information and awareness |
| 36 | Local radio/FM | Dissemination of information and awareness |

stakeholder consultation. In addition, the committee needs to follow the principles of good governance ensuring meaningful participation and inclusiveness, transparency and accountability and follow the rule of law (agreements, rules, regulations and responsibilities).

#### UPSTREAM – DOWNSTREAM LINKAGES

The watershed has an existing example of a successful institutional mechanism that has been established as an Incentive for Ecosystem Service (IES). As many of the water sources are located in the upper section of the watershed, activities upstream definitely impact communities living downstream. As per the current setup, communities downstream from Ward 7 pay Nepalese Rupees (NPR) 400 per household as a minimum water tariff to the Drinking Water User Committee, out of which NPR 25 is allocated for conservation and management of water resources upstream. Such models should be revisited and could be replicated in other parts of the watershed that would help determine water availability, willingness to pay and ability to pay for the service(s). The mechanism (agreement) needs to be clear highlighting the roles and responsibilities of upstream and downstream with concrete rules and a regulation set benefitting both communities. This should include a conflict resolution mechanism through which any issues arising can be resolved.

## 5.3 Gender and social integration in the watershed management plan

The competing demands for water resources have always favoured the few enabling them to gain and expand power around water accessibility at the expense of the majority. The powerful men and women in terms of caste hierarchies, class, education, physical ability, political influence and other factors have access to water resources and exercised power to retain control over the resource and to secure its usage. On the other hand, access to water is a challenge for women and the marginalized men in society in particular (Goodrich et al. 2017; Dash et al. 2011). Therefore, decisions around water are gendered (Meizen-dick & Zwarteveen 1998; Goodrich et al. 2017). Although gender is an integral part of IWRM, it moves beyond the primary task of providing or managing water to considering gender intersectionality within which the services are delivered to bring about gender transformative change.

IWRM strongly emphasizes women's empowerment through active participation in decision-making and leadership positions. Although there is a higher proportion of women as compared to men in the watershed area, women's participation within these institutions and committees is disproportionately low vis-à-vis that number. Men continue to hold key positions and outnumber women with regard to representation. In total, there are 94 committees, mostly for agriculture and vegetable farming, and there are 177 community awareness centres in the watershed area (Dhankuta Municipality Profile 2018). Only about 10% of such centres have women as chairpersons. The case is no different in the watershed management plan preparation committee. When the committee was formed, most of the women representatives were not present.

While ensuring active participation, it is also important that, as changes occur in women's leadership roles within the committee, members ensure support for women to carry out their roles efficiently. Male committee members need to cooperate with the decisions made by the committee and not to instigate non-cooperation and also support these women leaders when there is unwarranted interference from family members.

NGOs, social groups and networks working in the area need to focus on issues beyond income generation to address increasing domestic violence faced by women and also promote gender-focused water management tools such as gender-disaggregated data, gender analysis, gender budgeting, and monitoring and evaluation. Gender-sensitive trainings too should be designed for government officials (in line departments), including municipal authorities. Management and staff should increase their understanding on the relevance of gender issues to water resources and conservation. Gender assessment training programmes with different line agencies can sensitize staff on the importance of gender equality for decision making. Incorporation of a gender lens in planning, implementation, monitoring, and evaluating is key to ensuring equity in the management plan. Before the incorporation of a gender lens, it is also essential to understand the attitudes and mind-set of these stakeholders, as it has a direct impact on gender responsiveness in the implementation of the watershed plan document.

Gender and social disaggregated data will support in understanding the inequalities between women and men, problems with access to and control over resources, and the emerging gender nuances related to water, food and energy (insecurities). The tool will highlight the hierarchical social order and the nature of gender inequalities in access to and control of water resources and ecosystem services.

A gender audit of the Dhankuta Municipality and Chhathar Jorpati Rural Municipality Annual Budgets is essential to promote gender-responsive budgeting. Opportunities for women to participate in decisions about environmental policies and programmes should be created, including capacity building training on gender, social mobilization, and inclusive development with both female and male groups at the ward and municipality levels.

## 5.4 Strengthening capacity through social mobilization

Social mobilization is a process wherein the poor women and men and the marginalized participate in local decision-making to enhance their lives and livelihoods through access to and use of resources available at the local level (Cleaver 1999; Molyneux 1985). In preparing the watershed management plan and drawing up its activities, it is essential to understand the socio-cultural dynamics, the differential gender norms and practices, the asymmetrical gender relations that limit access to resources, bureaucratic control over resources and opportunities, and the socio-economic characteristics of the communities living in the watershed. People's participation in the social mobilization process is an interactive platform which is an empowering process which organizations and partners implementing the watershed management plan could ensure through the following steps:

- Ensure efficiency by sharing responsibilities and engaging communities in the form of different social groups to decide on the effective use of resources and capacity shared by women, men, children, people with disabilities, ethnic groups and the marginalized communities.
- Increase self-reliance where local resources are utilized in the decisions taken by the local people themselves so that local problems faced by the people have local solutions at their levels. This will help increase awareness, build self-confidence and reduce dependence on external sources in the form of relief from government and non-government sources.
- When development benefits are monopolised by the non-poor, the elite and the powerful, the benefits from watershed management plans/ activities cannot be directed towards building the resilience of the poor, women, children, elderly, people with disabilities and the marginalized sections. Therefore, targeting such groups to cover the weaker sections is necessary. It is essential that access and control over resources are equitable for effective community mobilization process for implementing the activities of the watershed management plan.
- Engaging local people and utilizing local resources generate a sense of ownership by the community living upstream and downstream.

In the social mobilization process, focus on social obstacles such as gender inequality and domination of the local elites that hinder people's participation will help address the structural discriminative norms and practices (see Box 1). Although communities have long acquired coping strategies and capacities to reduce vulnerabilities caused by resource depletion and adverse impacts of changing environment and other drivers of change (such as political environment and market), other factors interplay to create a complex web of societal conditions, factors, and processes. Therefore, priority in the watershed management plan should be given to the most vulnerable groups. It will help address the conditions, factors, processes, and causes of vulnerabilities brought about by poverty, social inequalities and environmental resource depletion and degradation. There is also the need to combine local knowledge with science and technology with support from external agencies. The priority of the water resource management plan is to overcome the structural, technical and financial challenges, where people can organize themselves to identify their needs, influence the direction of designing the activities, and strengthening the local institutions for equitable distribution of resources.

**BOX 1: SOCIAL MOBILIZATION PROCESS FOR WATERSHED MANAGEMENT PLAN, DHANKUTA****

| Community/village level | Ward level & municipality level representatives/ government institutions and NGOs/INGOs |
|---|---|
| Establishing linkages and rapport with community members and local institutions/committee members | Establishing linkages and rapport with different line departments (agriculture, livestock, irrigation, women and child, health) |
| Identifying the hierarchical organization of social structures along the lines of social status, caste, class, gender, religion, ethnicity, and the asymmetrical gender relations that limit access to resources, and bureaucratic control over resources and opportunities. | Engage the government officials/NGOs/INGOs in community mobilization |
| Community mapping - survey and identification of female-headed households, ethnic groups, Dalit families, and marginalized households at ward and hamlet levels (techniques – social mapping, wealth ranking, well-being ranking, time analysis tools) | Capacity building in the officials on gender sensitivity and women's empowerment process |
| Identify the source of water resources and protection/ rehabilitation/rejuvenation plan | Integration of gender disaggregated data with government data - data sharing, monitoring and evaluation of Watershed Management Plan |
| Capacity building of the community members to address issues of inclusion and equitable distribution of water resources | |

** Note: This process can be modified by social mobilisers, ward chairpersons, ward members, municipality members, government officials and I/NGO representatives for increased participation of multiple stakeholders in the planning process.

# Chapter 6: Problems identification and analysis

## 6.1 Introduction

This chapter provides an overview of the major issues related to the watershed with regard to water quantity and quality maintenance and other sectors of watershed management. The major problems and issues identified in the upstream of the watershed are haphazard road construction, landslide and soil erosion, use of pesticides and insecticides, high dependence on fuelwood for cooking and human-wildlife conflict while major problems identified in the downstream area are drought, spring drying, water inadequacy, increase in fallow land, increase in women's drudgery in search of safe drinking water and fuel, and the work burden. Limited awareness and capacity on spring management and sustainable management of upstream and downstream linkages were also observed as major problems in the watershed. All these problems directly or indirectly contribute to the decrease in water quantity and quality, thus ultimately impacting the livelihood of the local communities. This chapter is therefore important in planning solutions wisely for addressing the issues of the NT Watershed.

## 6.2 The Issues

### 6.2.1 Water source conservation and water supply management

Local communities of the Nibuwa-Tankhuwa watershed are highly dependent on natural springs and streams for drinking and non-drinking water, especially for agricultural use. But the increasing demand on water and haphazard road construction without considering the possible impacts on aquifers are leading to a rapid decrease in the water quantity and quality. In the NT Watershed, about 6 ponds, 23 dried springs and 74 running springs, including seepages, were mapped. However, the water sources are drying and water quantity is decreasing gradually. Local people have perceived the Nepal earthquake of 2015, road construction, landslides, changes in climate, lack of water source conservation initiatives, and use of chemical fertilizer and pesticides were the major causes for changes in water sources, water availability and water quality. The drinking water supply scheme of Dhankuta taps water from Nibuwa and Tankhuwa rivers but the presence of a high level of suspended sediments due to road construction, landslides and deforestation is a major issue in the water supply scheme.

Any change in water quality and quantity particularly impact the vulnerable groups, including the poor, women, and marginalized communities. About 33% of the total households in the watershed area still travel outside their homes to fetch water, thereby increasing women's and children's workload (See table 19).

Traditional ponds are important for recharging aquifers, but many ponds have been disappearing over the years and have caused the drying up of many springs and reduced the water quantity. Additionally, the growing trend of deep boring (see Annex 11) to extract groundwater, increase in temperature and rainfall variability have reduced water availability in the area. Furthermore, the increase in tourism in the Hile and Dhankuta Town has increased the urban water demand putting pressure on available water sources. Drying up of springs is already perceived as a major issue in Nigale, Okmalung, Bhulke, Kopche, Guranse Dada and Chulachuli villages. Lack of appropriate water source conservation measures – both technical and good governance – and lack of knowledge and capacity among local communities, particularly with regard to springshed management, accelerate the water quantity and quality degradation process.

### 6.2.2 Land use

Land cover change is a significant driver of environmental issues for any watershed as it directly deteriorates soil quality and causes water pollution. The watershed and the land cover are often inter-dependent. The assessment of the land cover pattern and its change is necessary to understand the present condition of the NT Watershed. Currently, as per the

land use map, around 50% of the watershed area is used for agricultural purposes. Till now, soil loss in the agricultural field has not been considered in the watershed. This is one of the reasons why NT Watershed has been facing cascading environmental issues. The mean annual soil loss for the entire watershed area is estimated to be around 10 t/ha/yr and annual erosion is estimated to be around 57,132 tons. These impact soil fertility and water quality. The northern parts of the watershed were found to have less soil erodible areas while the middle part of the study area was found to be highly erodible. This type of soil erosion at a micro-catchment can be solved by local-level interventions. Lacking regular information on soil erosion data and land use management plans at the watershed level hinders proper watershed management (Poudel 2005).

The use of machinery for road construction and agriculture in the watershed, in an area where roughly 60% has above 30° slopes and is already fragile and susceptible to erosion, was found to contribute to soil erosion and landslides. In addition, the haphazard road construction in the NT Watershed and the huge amount of collected debris are leading to sedimentation problems in the rivers affecting agricultural land and water quality.

Additionally, the traditional ponds are being abandoned and are being converted into settlement areas and playgrounds, ultimately leading to a decrease in water availability. Currently, fallow land is increasing which is due to water scarcity, labour shortage, human wildlife conflict and absentee landlordism. But barren land without vegetation cover increases runoff and induces soil erosion leading to soil degradation and water quality deterioration. As this watershed is susceptible to landslides, quarrying stones in the upstream area (Ward no. 2 of Dhankuta Municipality) can have negative consequences in the long term, such as soil erosion and landslides, with implications such as drying up of springs.

### 6.2.3 Agriculture

Agriculture is the mainstay of livelihood for the local communities in the watershed. However, over the years environmental and anthropogenic changes have triggered certain issues within the watershed. Climate change, increase in pests, water availability and markets affect agricultural productivity and cropping patterns. Changes in crop selection, from cereals and legumes (maize, millet and cowpea) to commercial vegetables, from citrus fruits to avocado, and from usage of local varieties to improved seeds or hybrid varieties have been found in the watershed. These changes in farming systems, while providing newer opportunities, pose new challenges to both women and men. For instance, a shift from subsistence to commercial farming of vegetables has resulted in increased use of water, fertilizer and agrochemicals in the upstream areas. This could pose challenges in the already water-stressed areas while also impacting water quantity and quality, leading to soil erosion and soil degradation both upstream and downstream. The changes in crop preferences have also decreased food diversity and compromised nutritional food security. Repeated tillage, frequent irrigation, and intensive use of chemical fertilizer and pesticides, and less use of compost/farm yard manure (FYM) results in a depletion in soil fertility and productivity in long run. People are shifting toward *Alnus nepalensis* cultivation from agriculture due to its high market value and lower demand on labour for farming. Alnus plantation in an agroforestry system is reported to increase the soil fertility and nutrient cycling.

Similarly, climatic factors such as droughts, erratic rainfall during monsoon, hailstorms, and occasional invasion of pests and diseases in the crops are impacting commercial farming in the area, which is increasing the work burden of women to ensure the household food basket. In addition, infertility in livestock, reduction in pasture size and quality, low animal productivity and water scarcity in the pasture are the some of the drivers that have reduced herd size in cattle and big ruminants in the watershed.

### 6.2.4 Forestry and biodiversity

Forest cover and floor vegetation strongly influence hydrological responses (Swank & Douglass 1974; Bosch & Hewlett 1982). Unplanned infrastructure development and tree felling affect hydrology with wide ranging impacts on ecosystem functioning and its services. The major problems related to forest and biodiversity that lead to a decrease in water quantity and quality are forest clearing around the water sources though the overall forest coverage has been reported to increase. Some of the prominent issues for this are discussed below.

***Overharvesting of trees in sensitive areas:*** Clear felling of trees for timber particularly in private land and

around water source areas is one of the major issues in the watershed. Alnus forests have huge commercial value which have lured the locals to shift to Alnus plantation on their private lands. Timber harvesting and log extraction without consideration of potential impacts have been reported to contribute to forest fragmentation and degrade the forest ecosystem. This has contributed to increased soil erosion leading to high sediment yield (see Photo 10).

*Over-extraction of forest resources:* Over-extraction of forest resources such as fuelwood for cooking is reported in the area. Around 55.7% of people use fuelwood for cooking. Similarly, many shrubs and herbs that are important for soil moisture retention such as sisno, dhokre, ful aiselu, among others, are removed from the forest floor often without a fallow period. This has not only reduced the water quantity but also increased human-wildlife interaction leading to conflicts.

*Human-wildlife conflict:* Human-wildlife conflict is one of the emerging issues of the watershed. Availability of food in the forest, and the increasing trend of converting abandoned land to forest has increased human-wildlife conflict. Local communities suffer from economic losses due to crop/livestock depredations by wildlife. Communities have experienced the increased incidence of human-wildlife conflict with the increase in the numbers of wild animals such as monkey, porcupine, deer and jackal, among others. This has directly impacted agricultural production and forced people to abandon agriculture in some parts of the watershed. For instance, communities from Chituwakharka reported that due to the increased number of monkeys in the forest, they have abandoned vegetables and cereal farming and shifted towards agroforestry (especially *Alnus neplanesis* and *Amomum subulatum*) or abandoned their land.

*Vegetation shift:* Communities noticed that vegetation, especially Shorea robusta, has been shifting upwards to higher altitudes and said that the warming climate could be a possible reason for the shift.

*Forest fire:* Occasional forest fires were also reported by the communities and they demanded action to control the fires.

### 6.2.5 Disaster risks

Drought, landslide and soil erosion are the major disasters in Dhankuta Municipality affecting the livelihoods of people. About 250 households are affected by drought in the region and facing water scarcity (see Table 23). A total of 150 households are affected by landslides causing them to migrate, an example being the Chituwakharka landslide (details in section 3.5.5). About 66 landslides were mapped in the watershed using Google Earth, RDS of ICIMOD and Field mapping (1990, 2000 and 2010). A few landslides like that of Chyarchyare Pahiro was water induced and Yakchana Landslide was occured due to fragile geology and road construction. Some other landslides that occurred in the watershed are: Rato Pahiro, Jaubari Pahiro, Bhalu Khola Pahiro, Tahari Pahiro, Kuibhir Pahiro, and Karunje Bhir Pahiro (based on discussions with the people). According to the geological analysis of the watershed, the watershed has steep and weathered/fractured geology in some of the region. The analysis of geological aspect thus highlights the importance of well-planned and designed road construction after doing the proper risk assessment of the area. The

**PHOTO 10: TAKHUWA KHOLA NEAR RESERVOIR TANK 1 A) DECEMBER 2018 B) MAY 2019**

**TABLE 23: NUMBER OF HOUSEHOLD AFFECTED DUE TO DISASTERS IN DHANKUTA MUNICIPALITY**

| Disasters | Ward 1 | Ward 2 | Ward 3 | Ward 4 | Ward 5 | Ward 6 | Ward 7 | Ward 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Drought | | 149 | | 4 | 25 | 29 | 4 | 39 | 250 |
| Community fire | 1 | 2 | | 12 | 16 | | 1 | | 32 |
| Forest fire | | 2 | 1 | 20 | 21 | 2 | 1 | 41 | 88 |
| Flood | | | | 4 | 13 | | 7 | 1 | 25 |
| Inundation | 1 | 8 | | 3 | 1 | 3 | 3 | 25 | 44 |
| Storm | | 2 | | 4 | 1 | | 2 | 1 | 10 |
| Thunderstorm | | 2 | | 3 | 1 | 2 | | 6 | 14 |
| Hailstorm | | | 1 | 1 | | 1 | | | 3 |
| Heavy rain | | | 1 | 1 | | | 1 | | 3 |
| Soil erosion | 7 | 10 | | 15 | 5 | 2 | 28 | 26 | 93 |
| Landslide | 20 | 19 | 1 | 12 | 27 | 1 | 36 | 34 | 150 |
| Cold wave | | 1 | | | | | | | 1 |
| Others | | 8 | | | 4 | 2 | 2 | | 16 |

Source: Household Survey – 2075 (Dhankuta Municipal Profile 2018)

susceptibility analysis of the landslide also showed that geology, the construction of roads and river cutting have a very strong influence in causing landslides in the area. Chituwakharka landslide is an example of How a unmanaged drainage and haphazard road construction in the area having highly fractured rock can cause a huge impact in the whole watershed (details in section 3.5.5). The ultimate result of the erosion and landslide problem is sedimentation issues in the river, which is the ultimate source of drinking water.

It is evident in Dhankuta Municipality that changing temperature and precipitation (see section 3.4.1) have increased drought conditions and the haphazard construction of roads has increased incidences of landslides (see section 3.5.5). Recurrent drought is a normal phenomenon in Dhankuta due to reduced water flow in the dry season. In Ward 8 of Dhankuta Municipality, it has pushed people to abandon agriculture and opt for migration as a source of livelihood.

When such disasters occur, it disproportionately affects women and men. More than the disaster, social stressors increase the vulnerability of the communities. As women and men do not have the same coping strategies, social conditions and fault-lines make certain groups of people, based on their caste, class, ethnicity, religion, physical abilities and geographical remoteness, more vulnerable than other groups (Goodrich et al. 2019). Studies have shown women, children, single mothers, people with disabilities, lower caste groups and other marginalized communities (including men) are the worst affected (Joshi et al. 2019; Sikandar & Khan 2019; Banerjee et al. 2019). However, due to lack of gender-disaggregated data, the comparative effect of the disaster on women and men could not be analysed.

### 6.2.6 Infrastructure development

With the establishment of local governments, development activities, especially road construction, have rapidly increased in the villages. As the road is the main development infrastructure that link villages with market, it is the first priority of local communities as well. However, constructing roads without Environment Impact Assessment/Initial Environmental Examination has led to negative effects such as increased soil erosion, reduced water availability and forest fragmentation, among other things. Sediments that are washed away by the monsoon rains from the earthen road to the river, which is the only source of drinking water in Ward 7, deteriorate the water quality.

In addition, growth in tourism has led to development of public and private infrastructure, which in turn competes for locally available natural resources. Unplanned tourism infrastructure development poses a high risk of depletion of natural resources, waste management and pollution in the watershed.

### 6.2.7 Institutional mechanisms

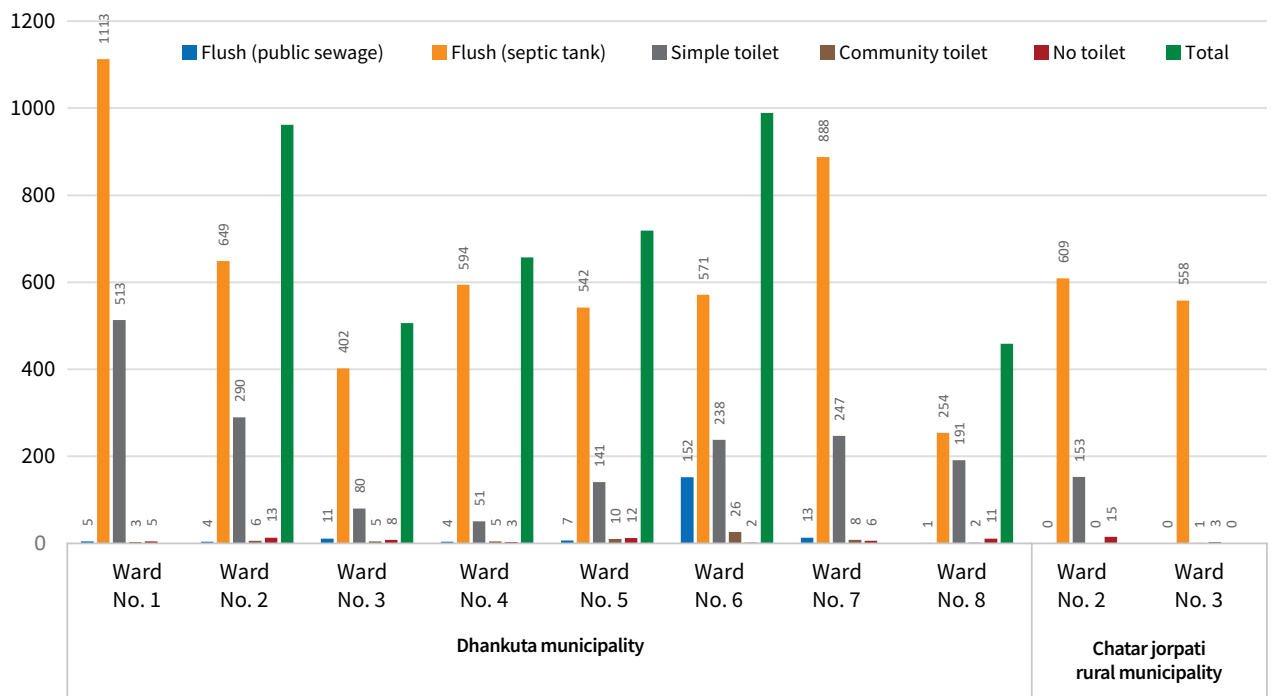
Institutional arrangements, formal agreements and participation are quite weak with regard to the watershed. Although a watershed management committee has been formed, there are no terms of reference (ToR) that sketch out their roles. A clear ToR of the watershed management committee needs to be drawn up with clearly defined roles and responsibilities. While this body will look into implementation and possibly monitoring and evaluation of the plan, roles and responsibilities have to be clearly defined. Furthermore, consultation will assist in drawing up capacity development needs in order to implement the watershed management plan. Hence, there is a need to conduct a stakeholder consultation which would help in identifying the key actors, defining the roles and responsibilities, and ensuring meaningful participation.

Similarly, the watershed management committee lacks representation and participation of women and other excluded groups. While the watershed management plan preparation committee was formed at a meeting of the Dhankuta Municipality and Chhathar Jorpati RM, the women included in the structure were proposed merely to conform with requirements for gender representation. The capacity buiding of these women representatives need to be emphasized.

Lastly, agreements or understandings between different stakeholders (upstream-downstream) are also missing. Moreover, existing formal or informal mechanisms like IES needs to be assessed and modified depending on the willingness and ability of communities to pay as water scarcity is increasing in the watershed. Lack of proper monitoring and periodic revision of IES mechanisms might imbalance harmony between upstream and downstream and deteriorate the supply of water quantity and quality. A way forward would be preparing an agreement between water user committees upstream and downstream highlighting the agreed upon payable amount and activities (both upstream and downstream) to ensure water availability and a mechanism for dispute resolution.

Additionally, there is little focus on waste disposal or management of wastewater or the sewer system. Proper waste disposal is very crucial in promoting good health. Throughout the watershed area, many people still do not have access to suitable sanitation facilities because of either inadequate or absent toilet facilities. Around 2% of the people (see Figure 28) in the watershed either use community toilets or have no built toilets at all. This situation has direct implications on the overall health of the community and water sources.

**FIGURE 28: HOUSEHOLD DETAILS ON THE BASIS OF TYPES OF TOILET**



### 6.2.8 Gender and social dimension

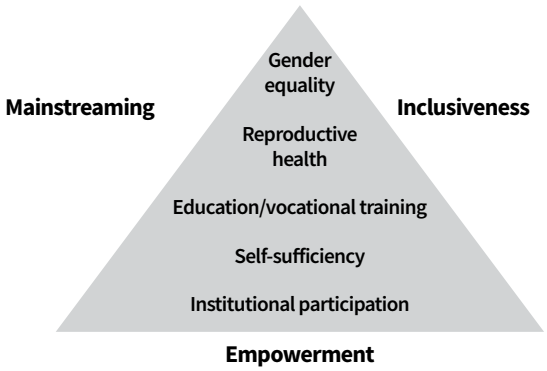
The Dhankuta Municipality adopts a multi-dimensional approach to addressing GESI issues within its development programmes through gender mainstreaming, inclusiveness and empowerment of women. In doing so, the priorities are to achieve gender equality, address issues of reproductive health, promote education and vocational training, ensure self-sufficiency through entrepreneurship development, and strengthen women's participation in decision-making within the institutions.

The gender envisioning process that has been incorporated into the Dhankuta Municipality Profile is an added-value to the watershed management plan. The process has already begun and the watershed management plan can help to draw out the interlinkages of these sectoral problems and support the development of gender-focused and gender-integrated action to achieve gender transformative change (see Figure 29).

#### 6.2.8.1 WATER

In the watershed, about 87% of the households have pipeline tap connections in households to meet the drinking water needs while roughly 33% of households depend on other different water sources. But the water supplied through the pipeline is muddy during the monsoon and irregular during summers, making women travel to far-flung places in search of alternative water sources and spending up to 1 hours in travel and long queues (see table 19). Given the changing temperature pattern (see section 3.4.1.), that has increased the incidences of drying up of water sources and frequent droughts (34%) in the watershed (see section 6.2.5.), these conditions are likely to worsen women's workload to ensure a supply of drinking water.

**FIGURE 29: GENDER DIMENSION AND PRIORITIES OF DHANKUTA MUNICIPALITY**




The long hours spent in fetching drinking water will reduce the amount of time women can spend on economic activities and also have a significant impact on the education of young girls and women's health. There was a high drop-out rate of young girls (57%) from schools in Dhankuta Municipality and their stated reasons were to support domestic work (16%). Since the water sources are drying up and water quality is decreasing (see section 6.2.1.), it would have serious implications on young girls and women as they would have to shoulder the responsibility of fetching water for domestic needs (see section 3.6 and Annex 14). Alternative water harvesting methods such as rainwater harvesting, recharge of ponds or construction of water tanks can be promoted to reduce the work burden and to ensure water for domestic needs.

The Dhankuta Municipality has subsidized water tariffs for the poor and the marginalized, but it is not clear how they get operationalized and whether women and men have equal access and control in municipal water management. The communities were willing to pay for increasing water tariffs so that there is a timely water supply. However, given that the majority of the population live in below-average economic conditions (see section 3.8.2.), it is essential to consider their ability to pay, which seems missing in planning and decision-making. It is important that the institutions in the watershed consider meaningful participation of women and men to achieve transformative change (see section 5.2.).

To address gender and social inclusion issues within watershed management, it needs robust gender and socially disaggregated data, first, to understand the differential needs and priorities of women, men, the marginalized and the social groups and, second, to strategize the action plan or intervention packages based on the capabilities of these groups.

#### 6.2.8.2 AGRICULTURE

Across the watershed, there is a shift in agricultural practice from subsistence farming to commercial agriculture. The switch to commercial farming has increased the demand for water and agricultural inputs. But price fluctuations of vegetables have threatened the food security of the rural poor (see section 3.8.2.) and the women entrepreneurs engaged in commercial farming. Any loss of income from agriculture is likely to affect the purchasing power of

the households, disproportionately affecting women and children.

Nevertheless, the change in cropping patterns has affected food diversity and compromised nutritional food security. The watershed is already vulnerable to malnutrition with high prevalence of stunting and underweight children during birth (7%) (Dhankuta Municipality Profile 2018). Women and children who lack decision-making in households will be the most affected with micronutrient deficiencies with the shift from cereal crops to commercial crops (Malapit et al. 2013).

There is an increasing number of women's ownership of land (compared to the national figures). This is also associated with the provisions made in the Constitutional Amendments of Nepal to promote women's empowerment and the easy access to commercial loans for women who have land entitlements. But the development initiatives have not challenged structural gender norms. Feminization of agricultural labour is a common phenomenon in both the municipalities due to high out-migration of male members. Women continue to struggle with the added work load, stress arising from having to repay debts and the gender discrimination that persists.

#### 6.2.8.3 FOREST AND ENERGY

Women are considered the custodians of natural resources – water, land and forest – with traditional intergenerational knowledge on conservation and protection of these resources. There are 28 Community Forest User Groups (CFUGs) in Dhankuta Municipality[17] and 7 CFUGs in Chhathar Jorpati[18]. Community forests have an essential role to play in meeting household energy needs. More than 50% of the households in Chhathar Jorpati Municipality and about 41% in Dhankuta Municipality depend on the forest to meet household energy needs (Dhankuta Municipality profile 2018 and Chhathar Jorpati Chhathar Jorpati Profile 2018). Women and children are responsible for ensuring fuelwood for domestic needs (see Annex 14). However, in both municipalities, there were no gender-disaggregated data to understand the required travel time to collect fuelwood and other forest resources. Moreover, data on institutional representation of women and men in the CFUGs and their decision-making body are also lacking.

Due to increasing human-wildlife conflicts and the practice of abandoning agriculture, food security has decreased at household level. Reduced agricultural production is likely to affect the household food basket, with significant impacts on women and young girls. Similarly, loss of income from agriculture can compromise the nutrition of women and children. It is important that awareness programmes be conducted at community level on nutrition and food security needs and also to consider compensation for wildlife damage that is funded by the municipalities. This is important given that women typically eat last and what is left over and are, therefore, at a higher risk of malnutrition due to the existing socio-cultural norms and gender-based discriminations when it comes to allocation of food at household level (Goodrich et al. 2017; Sugden et al. 2014).

#### 6.2.8.4 HEALTH

A watershed provides a physical basis for establishing linkages between the environment and human health. From a gender perspective, addressing human health in the watershed needs a multi-dimensional approach. The switch from subsistence farming to commercial crops has decreased food diversity and compromised the intake of micronutrients and nutritional food security of the population in the watershed (see section 3.8.2). Commercial agriculture has brought in increased use of fertilizers and pesticides with severe implications on water through chemical contaminations. These routes of exposure negatively affect the health of women and men and the nutritional status of communities in the watershed. Health problems related to water-borne diseases, nutrition deficiencies and non-communicable diseases are about 8% in Dhankuta Municipality and the figure is on the rise (Dhankuta Municipality Profile 2018). Women and young girls are the most likely to be affected, which have implications on their work burden, household finances, and participation in institutions.

However, the increasing commercialization of agriculture and entrepreneurship development in the watershed have also introduced a new dimension to health arising from psychological or mental health problems.

However, the increasing commercialization of agriculture and entrepreneurship development in the

[17] In total, there are 44 CFUGs in Dhankuta Municipality (a total of ten wards) and a total 28 CFUGs belong to Ward 1 to 8 (Source: Dhankuta Municipality Profile 2018 and Chhathar Jorpati Rural Municipality Profile 2075).
[18] Wards 1 & 2 of Chhathar Jorpati. In total, there are 23 CFUGs in Chhathar Jorpati Municipality.

watershed have also introduced a new dimension to health arising from psychological or mental health problems.

#### 6.2.8.5 ENTREPRENEURSHIP DEVELOPMENT

In the watershed, with the commercialization of agriculture, there is an increase in the number of women entrepreneurs engaged in commercial farming. The Dhankuta Municipality Profile (2018) reports 3 women-led agricultural cooperatives with 199 members and 5 savings and credit cooperatives with more than 750 women members.[19] In the Chhathar Jorpati Chhathar Jorpati Municipality, there are 4 agriculture cooperatives and 4 savings and credit cooperatives in Wards 1 and 2. In Ward 1 of Dhankuta Municipality, there were women entrepreneurs who have initiated hotel industries in the upstream town of the watershed but they are the most affected with reduced availability of water (see section 3.6). In such conditions, off-farm livelihood opportunities can be promoted in the watershed.

A large number of micro-credit institutions have mushroomed in the watershed, providing easy access to finance to address needs at the household level. Women as members of these savings and credit groups access the loan facilities. Although the interest rates are very high, the speedy process of loan disbursement makes these institutions a favourable choice for women and men. The data reveal that approximately 42% of households have taken loans and a major portion of the loan amount is spent on meeting household needs (see section 4.6).

Due to easy access to cooperatives and financial institutions, women prefer taking loan from these financial institutions though they lack safety nets. Women entrepreneurs also lack controls on price fluctuations in commercial agriculture production. These conditions make women entrepreneurs more vulnerable in the watershed. It is important therefore that social entrepreneurship schemes be promoted for women's empowerment through properly established incubation centres including training on financial management, and strategies for online marketing of the produce.

Furthermore, the inability to repay loans has increased stress among women and men in the villages. This has resulted in rising incidences of violence against women[20] worsening the psychological well-being of women, thus leading to reported cases of suicide at the community level. Health posts located at community level can be capacitated to handle psychiatric problems and provide psychosocial services to women and men. Unless these problems are addressed, women are likely to be worse-affected with increased incidences of domestic violence, thus adversely affecting the goals of gender equality, inclusiveness and women's empowerment in the watershed.

[19] Dhankuta Municipality Wards 1 to 8.

[20] In-depth interviews – Wards 2 and 7, including urban settlements. There is higher alcohol consumption among men.

# Chapter 7: Solutions package

The findings reveal that there are various issues and challenges in the watershed leading to unsustainability (see Chapter 6). However, explicit, evidence-based and cost-effective packages of intervention can address the issues and contribute to sustainable management of the watershed when appropriately implemented.

This chapter describes the intervention packages across key sectors (water, land, agriculture, forest, gender, disasters and institutions) for conservation and sustainable development of the watershed. The interventions include the actions that were listed and prioritized by the stakeholders of the NT Watershed (see Annex 2). A total of 30 stakeholders from government, private sector, community-based organisations, academia and representatives of NGOs and INGOs discussed the issues thoroughly and listed the actions for addressing the issues. The listed actions were then ranked based on the nature of the issue as well as the importance of the action for the watershed. The ranking was done in a participatory way where three groups were formed with 8-10 member in each group with equal representation of different sectors and departments from the watershed. The participants from each group were given coloured dots to place on activities based on their preferences. The participants were then invited to each other's groups to review and discuss the preferred activities. At the end of it, activities were ranked based on the number of dots.

The listed and prioritized actions are categorized into six components and provide guidance for implementing actions on the ground. For each component, specific implementation and monitoring partners are also identified (see Table 24). The roles and responsibilities in implementing the planned activities need to be discussed in consultation with the relevant local line agencies and stakeholders.

After a series of discussions with the municipality, rural municipality, government line agencies, and civil society organizations, a draft budget for each of the activities was prepared for five years. This was validated during a budgeting and handover workshop jointly organized with Dhankuta Municipality and Chhathar Jorpati Rural Municipality. Forty three participants (See annex 13 for participants list) took part in workshop. Participants were divided into five groups (one group each for intervention packages 1 to 4; intervention package 5 and 6 were allotted to another group) to review the plan and budget and this was shared with the rest of the participants for final validation. The validated budget for each component for a period of five years is presented below. It was also decided to develop a Terms of Reference for the Watershed Management Committee for implementation of the plan as well as guidelines for implementation. Given the critical role of various line agencies, civil society, academic institutions and other stakeholders in implementation of the plan, it was also decided to form a stakeholders group. The Watershed Management Committee would work closely with the stakeholders for implementation of the plan.

**TABLE 24: PACKAGE OF INTERVENTIONS ON KEY SECTORS**

*Component 1: Sustainable conservation, management and use of water resources*

Component 1 focuses on the conservation, management and use of water resources sustainably. The water resources are springsheds and ground and surface water which are envisaged to be managed through good governance mechanisms with equal access and benefits to all including men, women and marginalized groups. The major activities are focused on research, capacity building, infrastructure development, and enhanced institutional mechanisms. In doing so, this component aims to contribute to improved water security through innovative and sustainable water management practices.

**COMPONENT 1: SUSTAINABLE CONSERVATION, MANAGEMENT AND USE OF WATER RESOURCES**

**OUTPUT**

1. Quantity and quality of ground water and surface water improved through innovative approaches
2. Springs revived and springsheds conserved and managed
3. Institutional mechanisms based on good governance principles for water supply and demand established
4. Gender and social-inclusion related issues and solutions integrated within watershed management

| Activities/ Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **A. Data Generation, management and analysis** | | | | | | | | |
| 1.1. Assessment of water resources and water availability within the watershed area | **ICIMOD completed this activity** | | | | | | | |
| 1.2. Collecting, maintaining and analysing data from existing rain gauge/s and install new rain gauges (if required) – automatic or manual | 2 areas | Municipality, Rural Municipality, Dept. of Hydrology and meteorology, SCWMO & all wards | Municipality, Rural Municipality, Dept. of Hydrology and meteorology, SCWMO & all wards | No. of events | L/S | 500,000 | 500,000 | 1 municipality and 1 rural municipality |
| 1.3. Evaluation of water demand and supply after interventions | All wards | Municipality, Rural Municipality, SCWMO & ICIMOD | Municipality, Rural Municipality, SCWMO & ICIMOD | No. of events | L/S | 500,000 | 500,000 | |
| 1.4. Monthly assessment of water quality from drinking water sources, including springs | All wards | Municipality, Rural Municipality, SCWMO, ICIMOD and water user committee | Municipality, Rural Municipality, SCWMO & ICIMOD | No. of events | L/S | 200,000 | 200,000 | |
| 1.5. Detailed assessment of rainwater harvesting potential at household level, especially in dry areas | All wards | Municipality, Rural Municipality, SCWMO, ICIMOD & Water Supply and sanitation division | Municipality, Rural Municipality, SCWMO, ICIMOD & Water Supply and sanitation division | No. of events | L/S | 200,000 | 200,000 | |
| 1.6. Disaggregated analysis of access, based on gender and social status, to ecosystem services with a special focus on forest, water and financial resources | All wards | Municipality, Rural Municipality, SCWMO, ICIMOD, Environment, Social & finance division | Municipality, Rural Municipality, SCWMO & ICIMOD | No. of events | L/S | 600,000 | 600,000 | |

| Activities/ Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **B. Awareness and capacity building (at least 50% women participation)** | | | | | | | | |
| 1.7. Conservation of water resource and spring awareness campaign | Dhoje/Suke pokhari/Chul Dhunge | Municipality, Rural Municipality, SCWMO, ICIMOD & Water Supply and sanitation division | Respective rural municipality and municipality | No. of events | L/S | 2,500,000 | 2,500,000 | |
| 1.8. Responsible use of pesticides, herbicides and fertilizers awareness campaign | All agricultural areas | Municipality, Rural municipality, SCWMO, Agriculture division & AKC | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.9. Training on integrated pest management (IPM) in upstream and downstream area awareness campaign | All wards | Municipality, Rural municipality, Agriculture division & AKC | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.10. Wastewater use for irrigation of kitchen gardens awareness campaign | All wards | Municipality, Rural municipality, SCWMO, Agriculture division & AKC | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.11. Gender-friendly technologies to help women carry out their activities efficiently and effectively awareness campaign | All wards | Municipality, Rural Municipality, SCWMO, ICIMOD, Social Development division & NGOs | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.12. Gender sensitivity through community out-reach programmes such as local media (newspapers/radio/FM stations), local drama, etc. | All wards | Municipality, Rural Municipality, SCWMO, ICIMOD, Social Development division & NGOs | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.13. Exposure visits for women's and men's groups to promote gender friendly water conservation technologies and economic development | Representative from all wards | Municipality, Rural Municipality, SCWMO, ICIMOD, Social Development division & NGOs | Respective rural municipality and municipality | No. of events | L/S | | | |
| 1.14. Training community members (including women and men) and extension workers to address issues of inclusion and equitable distribution of water resources | All wards | Municipality, Rural municipality, SCWMO, ICIMOD, Irrigation division & Drinking water and sanitation division | Respective rural municipality and municipality | No. of events | L/S | 500,000 | 500,000 | |
| 1.15. Development and promotion of extension and communication materials on water resource and spring conservation, Integrated Pest management (IPM), upstream downstream linkages, etc., in local languages (i.e., flyers, brochures, local newspapers etc.) | All wards | Municipality, Rural Municipality, SCWMO, AKC & ICIMOD | Respective rural municipality and municipality | No. of events | L/S | 500,000 | 500,000 | Yearly at least one |
| 1.16. Training on rainwater harvesting and demonstration | al least two sites | Municipality, Rural Municipality, SCWMO & ICIMOD | Respective rural municipality and municipality | No. of events | 2 | 250,000 | 500,000 | |
| 1.17. Establishment of learning centre for water quality and quantity management (Soil, water, agronomy, rode side stablization, etc) | Dhoje/Suke pokhari/Chul Dhunge | Municipality, Rural Municipality, SCWMO, Drinking water, Irrigation & ICIMOD | Municipality, Rural Municipality, SCWMO, Drinking water, Irrigation & ICIMOD | No. of events | 2 | 2,000,000 | 4,000,000 | |

| Activities/ Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **C. Infrastructure development and maintenance** | | | | | | | | |
| 1.18. Construction of recharge ponds (community ponds/ reviving traditional ponds) and implementation of other structural, vegetative, agronomic and management measures at upstream water recharge area | Dhoje/Suke pokhari/Chul Dhunge | Municipality, Rural Municipality, SCWMO, Drinking water, Irrigation & ICIMOD | Municipality, Rural Municipality, SCWMO, Drinking water & Irrigation | No. of events | 2 | 1,450,000 | 2,900,000 | |
| 1.19. Stream water harvesting through construction of underground check dams, percolation pits and recharge shafts | Upper stream | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | L/S | 1 | | | |
| 1.20. Demonstration of roof rainwater harvesting systems for irrigation and domestic uses in selected households | All wards | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | No. of events | 10 | 115,000 | 1,150,000 | 1 in each ward |
| 1.21. Construction and maintenance of check dam and bioengineering measures above the water reservoir and on micro watersheds connected with Dhankuta water supply scheme | Water source, Collection centres and pipelines | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | L/S | 1 | 6,000,000 | 6,000,000 | |
| 1.22. Maintenance and construction of water tanks and pipelines | Collection centres and pipelines | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | L/S | 1 | 22,500,000 | 22,500,000 | |
| 1.23. Feasibility assessment and implementation of wastewater treatment facility, if applicable. | All wards | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | Municipality, Rural municipality, Drinking water, Dept. of Irrigation & SCWMO | L/S | 1 | 150,000 | 150,000 | |
| 1.24. Rules and regulations on deep boring to be formulated and applied | All wards | Municipality, Rural municipality, Drinking water, & SCWMO | Municipality and Rural Municipality | No. of events | 1 | 50,000 | 50,000 | |
| 1.25. Demonstration of water quality improving technologies/practices (water filters, SODIS, good agricultural practices, nature-based solutions) | All wards | Municipality, Rural municipality, Drinking water, & SCWMO | Municipality, Rural municipality, Drinking water, & SCWMO | No. of events | 5 | 50,000 | 250,000 | |
| 1.26. Efficient water use practices for water demand management (across all sectors – domestic, agriculture, industry) | all wards | Municipality, Rural municipality & Drinking water | Municipality, Rural municipality & Drinking water | L/S | 10 | 100,000 | 1,000,000 | |

| Activities/ Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **D. Institutional mechanisms and policy** | | | | | | | | |
| 1.27. Developing and implementing spring and its recharge area management plan jointly with local institutions with a particular focus on private and public land | Watershed areas | Municipality, Rural municipality & SCWMO | Municipality, Rural municipality & SCWMO | L/S | 1 | 500,000 | 500,000 | |
| 1.28. Regulating existing laws and policies to protect and conserve recharge areas and enforce (Dos and Don'ts in the springshed (e.g., discourage tree felling around recharge zones) provide incentives for adopting rainwater harvesting to HHs and business and industries | Watershed areas | Municipality &Rural municipality | Municipality &Rural municipality | L/S | 1 | | | |
| 1.29. Strengthening mechanisms to ensure meaningful participation, equal representation and contribution to decision making by women and marginalized communities in water resource management committees and subsidy plans | Watershed areas | Municipality &Rural municipality | Municipality &Rural municipality | L/S | 1 | | | |
| 1.30. Strengthening water user committees at local level to ensure participation of women, the poor and the marginalized, including the landless, based on a needs assessment and identification of capacity building interventions, and encouraging women and marginal groups to leadership positions of local committees and institutions | Watershed areas | Municipality, Rural municipality & Watershed Management Committee | Municipality &Rural municipality | L/S | 1 | | | |
| 1.31. Assessing the institutional arrangement for the management of common-pool resources such as forests, pastures, irrigation systems, rain-water harvesting ponds, stream banks | Watershed areas | Municipality, Rural municipality & Watershed Management Committee | Municipality &Rural municipality | L/S | 1 | 1,500,000 | 1,500,000 | |
| 1.32. Establishing institutional mechanism for Social Audits (Social Audit Committee) both for ward level and municipality for accountability and inclusive development | Watershed areas | Municipality, Rural municipality & Watershed Management Committee | Municipality &Rural municipality | L/S | 1 | | | |
| 1.33. Connecting government and community engaging government officials in community activities and including them in community institutions | Watershed areas | Municipality, Rural municipality & Watershed Management Committee | Municipality &Rural municipality | L/S | 1 | | | |
| TOTAL (Nrs) | | | | | | | 46,000,000 | |
| **OUTCOME**<br>Improved water security through innovative, inclusive and sustainable conservation and management of water resources. | | | | | | | | |

### *Component 2: Sustainable Land Use Management*

Component 2 envisages an improved ecosystem service through sustainable land use practices with equal access and benefits to men, women and marginalised. A landuse plan is proposed for the watershed suggesting sustainable management practices of different land uses including agriculture and forestry. The key interventions include research on pertinent issues, managing human-wildlife conflicts, capacity building, and managing land uses sustainably and plantation on the open and barren areas

**COMPONENT 2: SUSTAINABLE LANDUSE MANAGEMENT**

**OUTPUTS**

1. Landuse plan prepared and implemented
2. Agricultural land managed effectively and efficiently with equal benefits to all including men, women and marginal group.
3. Management of forest and biodiversity sustainably

| Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **A. Data generation and management** | | | | | | | | |
| 2.1. Assessment of water demand and supply for agriculture at household level | Municipality, Rural municipality & Agricultural lands | Municipality, Rural municipality & all wards | Municipality, Rural municipality, AKC & SCWMO | No. of events | 5 | 100,000 | 500,000 | Yearly one event |
| 2.2. Preparation of soil health inventory through testing for informed decision-making on nutrient management | Watershed area | Municipality/Rural municipality, AKC & SCWMO | Municipality, Rural municipality, AKC & SCWMO | No. of events | 1 | 150,000 | 150,000 | |
| 2.3. Preparation of inventory of the permanent fallow and seasonal fallow land | Watershed area | Municipality, Rural municipality, AKC, SCWMO, Survey department & Land revenue office | Municipality, Rural municipality, AKC & SCWMO | No. of events | 1 | 200,000 | 200,000 | |
| 2.4. Identifying abandoned and public land for forest plantation and fodder farming and multi-year crop (especially areas with 30 degrees or more slope) | Watershed area | Municipality, Rural municipality, AKC, SCWMO, Survey department & Land revenue office | Municipality, Rural municipality, AKC & SCWMO | No. of events | | | | |
| 2.5. Promoting agroforestry with fodder species in private lands | All wards | Municipality, Rural municipality, AKC & SCWMO | Municipality, Rural municipality, AKC & SCWMO | No. of events | 1 | 200,000 | 200,000 | |
| 2.6. Assessment of suitability of cultivation and value chain of high value products such as timur, tejpatta, large cardamom, and other such products available in the locality | All wards | Municipality, Rural municipality, AKC & SCWMO | Municipality, Rural municipality, AKC & SCWMO | No. of events | 1 | 150,000 | 150,000 | Yearly one event for 3 years |
| 2.7. Promotion of bamboo cultivation and assessment of bamboo products value chain. Collecting information and updating flora and fauna diversity and invasive species and its impacts on ecosystems and biodiversity. | All wards | Municipality, Rural municipality, AKC, SCWMO &Cottage industries | Municipality, Rural municipality, AKC, SCWMO & Cottage industries | No. of events | 3 | 150,000 | 450,000 | 2 events every year for 5 years |

| Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **B. Awareness and capacity building** | | | | | | | | |
| 2.8. Promoting agriculture-related advance training; drip irrigation, sprinkler, herbicide, compost manure, water conservation pond, improved terrace, integrated pest management, mobile based agromet advisories to women and men and marginalized communities. | All wards | Municipality, Rural municipality, AKC & SCWMO & NGOs | Municipality, Rural municipality, AKC, SCWMO & Cottage industries | No of events | 2 | 150,000 | 300,000 | |
| 2.9. Farming of high value products such as timur, chiraito, tejpatta, etc. | All wards | Municipality, Rural municipality, Cottage industries, AKC, DFO, SCWMO & NGOs | Municipality, Rural municipality, all wards & DFO | L/S | | 200,000 | 200,000 | |
| 2.10. Climate resilient large cardamom farming | All wards | Municipality, Rural municipality, Cottage industries, AKC & SCWMO & NGOs | Municipality, Rural municipality, All wards and DFO | L/S | | 250,000 | 250,000 | |
| 2.11. Introduction of legumes/cover crops and drought tolerant crop varieties | All wards | Municipality, Rural municipality, Cottage industries, AKC & SCWMO & NGOs | Municipality and Rural municipality | No. of events | 2 | 50,000 | 100,000 | 2 events, 1 in rural municipality and 1 in municipality |
| 2.12.Training on reduced impact logging (RIL) method to communities and line agencies | All wards | Municipality, Rural municipality, Cottage industries, DFO, AKC & SCWMO & NGOs | Municipality, Rural municipality | No. of events | 2 | 150,000 | 300,000 | 2 events (1 training and 1 refresher) |
| 2.13. Campaign on Forest for Youth | All wards | Municipality, Rural municipality, Cottage industries, DFO, AKC & SCWMO & NGOs | Municipality, Rural municipality & all wards | No. of events | 5 | 50,000 | 250,000 | one event every year |
| 2.14. Planting water conserving tree species on private and abandoned area with multipurpose broad leaf trees and others | All wards | Municipality, Rural municipality, DFO, AKC, SCWMO, Cottage industries & Irrigation department | Municipality, Rural municipality, all wards and DFO | No. of events | 1 | 300,000 | 300,000 | |
| 2.15. Affordable clean energy options for consumption and productive use | All wards | Municipality, Rural municipality, AKC, SCWMO, AEPC, Cottage industries & Irrigation department | Municipality and Rural municipality | No. of events | 1 | 300,000 | 300,000 | |
| **C. Agricultural practices, plantation and construction** | | | | | | | | |
| 2.16. Plantation of suitable species (Bioengineering) that controls soil erosion and conserve soil moisture in public and abandoned land in areas above 30 degree slopes (such as sisno, dhokre ful, aiselu etc.) | All open areas | Municipality, Rural municipality, DFO, SCWMO & local communities | Municipality , Rural municipality and all wards | Ha | 400 | 2,500 | 1,000,000 | |
| 2.17. Establishing nurseries for management of quality seeds and seedlings of species (broadleaf trees, native trees, etc.) | All open areas | Municipality, Rural municipality, DFO, SCWMO & local communities | Municipality, Rural municipality & DFO | No. of events | 1 | 2,000,000 | 2,000,000 | Land will be identified by the municipality |

| Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 2.18. Establishing seed bank, fertilizer bank, loan availability (including native species) and increased coordination with micro-financial institutions | All open areas | Municipality, Rural municipality, DFO, SCWMO, AKC, NGOs & local communities | Municipality, Rural municipality & DFO | No. of events | 1 | 500,000 | 500,000 | Local government should coordinate with the banks |
| 2.19. Establishment of forest fire mitigation and control mechanisms (such as fire line, controlled burning, etc.) including management | All open areas | Municipality, Rural municipality, DFO, SCWMO, AKC, NGOs & local communities | Municipality, Rural municipality, local communities and DFO | No. of events | 1 | 1,800,000 | 1,800,000 | 5km fireline construction-500000 Procurement of fire fighting equipments-1000000 Control burning and mangement-300000 |
| 2.20. Pasture area re-seeding and protection | All open areas | Municipality, Rural municipality, DFO, SCWMO, AKC, NGOs & local communities | Municipality, Rural municipality | No. of events | 1 | 250,000 | 250,000 | |
| 2.21. Plantation of fodder on fallow land such as Bauhinia species (Tanki, Koiralo), Brassiopsis hainla (Chuletro), Garuga pinnata (Dabdabe), etc. and fruit species such as citrus, avocado, etc. | All open areas | Municipality, Rural municipality, DFO, SCWMO, AKC, NGOs & local communities | Municipality, Rural Municipality, DFO, SCWMO | No. of events | L/S | 200,000 | 200,000 | |
| **D. Institutional mechanisms and policies** | | | | | | | | |
| 2.22. Strengthening of integrated municipal landuse committee | Watershed area | Municipality, Rural municipality, SCWMO, DFO, NGOs & Dept. of Roads. | Municipality, Rural municipality, SCWMO & DFO | No. of events | 5 | 100,000 | 500,000 | Yearly 1 meeting |
| 2.23. Comprehensive landuse planning with participatory approach | Watershed area | Municipality, Rural municipality, SCWMO, DFO & Dept. of Roads | Municipality & Rural municipality | No. of events | 1 | 200,000 | 200,000 | |
| 2.24. Implementing rules to prevent felling around the water sources and sloping areas above 30 degrees | Watershed area | Municipality, Rural municipality, SCWMO, DFO, NGOs & Dept. of Roads. | Municipality, Rural Municipality | No. of events | 1 | 100,000 | 100,000 | |
| 2.25. Discouraging use of pesticides and insecticides and encouraging use of alternatives such as Jholmal | Watershed area | Municipality, Rural municipality, SCWMO, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 100,000 | 100,000 | |
| 2.26. Formulating rules to regulate/prevent stone mining as it is reducing aquifer area and increasing sedimentation | Watershed area | Municipality, Rural municipality, SCWMO, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 50,000 | 50,000 | |
| 2.27. Developing incentive mechanism for private land management (such as agroforestry, horticulture and multi-year cropping for areas above 30 degrees and marginal land) | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 800,000 | 800,000 | |

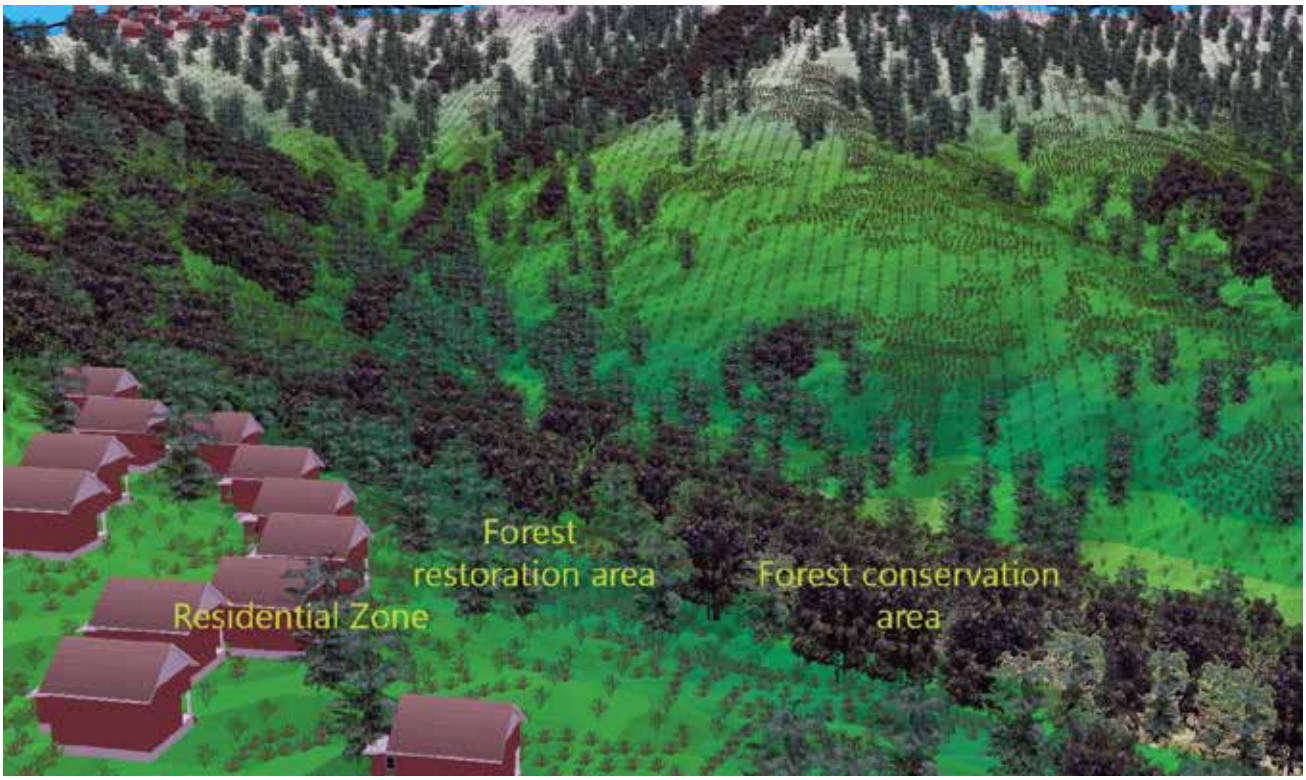
| Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 2.28. Designing and implementing subsidy for crop insurance | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 500,000 | 500,000 | |
| 2.29. Identifying subsidy for less water intensive crops and vegetables and promoting production | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 500,000 | 500,000 | |
| 2.30. Promoting cooperative and community farming among women's groups | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 300,000 | 300,000 | |
| 2.31. Developing mechanism for production-based incentives and monitoring (innovative agri-land management) | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 250,000 | 250,000 | |
| 2.32. Integrating employment generation activities in forest management, starting with community forest and private forest (such NTFP cultivation, agroforestry, beekeeping, ecotourism, etc.) | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO & NGOs | Municipality, Rural Municipality | No. of events | 1 | 500,000 | 500,000 | |
| 2.33. Engaging private sector in developing NTFP related value chain and entrepreneurship development | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO, Cottage industries, DCC & NGOs | Municipality, Rural municipality & DCC | No. of events | 1 | 100,000 | 100,000 | |
| 2.34. Equal representation of men, women and marginalised groups in decision-making body of CFUGs and watershed management committee plus capacity development | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO, DCC & NGOs | Municipality, Rural municipality & DCC | No. of events | 1 | 250,000 | 250,000 | |
| 2.35. Planting of trees that provide food to wildlife, especially wild food and fruits, and traditional wild crops such as Chutro, Satibaier, etc., inside community forests and national forests. Development of a buffer strip around agricultural land by planting fruit trees | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO, DCC & NGOs | Municipality, Rural municipality, SCWMO & DFO | No. of events | 1 | 500,000 | 500,000 | |
| 2.36. Planting crops that are not attractive to wild animal such as wheat, barley, NTFPs, etc. | Watershed area | Municipality, Rural municipality, SCWMO, AKC, DFO, DCC & NGOs | Municipality, Rural municipality, SCWMO & DFO | No. of events | 1 | 500,000 | 500,000 | |
| 2.37. Reproductive control measures to manage monkey population | Watershed area | Municipality, Rural municipality, SCWMO, DFO, DCC & NGOs | Municipality, Rural municipality, SCWMO & DFO | No. of events | 1 | 500,000 | 500,000 | |
| 2.36. Awareness programmes to communities about compensation due to wildlife damage | Watershed area | Municipality, Rural municipality, SCWMO, DFO, DCC & NGOs | Municipality, Rural municipality, SCWMO, DFO & DCC | No. of events | 1 | 200,000 | 200,000 | |
| **Total** | | | | | | | **15,250,000** | |
| **OUTCOME**<br>Improved ecosystem services through sustainable land use management with equal access and benefits to men, women and marginalized groups. | | | | | | | | |

The proposed land use plan (Figures 30 and 31) mostly followed the Nepal Land Use Policy (2015) regarding limits and protection of Land and Land Resources (LLRs) and optimum use and effective management thereto (MoLRM 2015). The major objective to prepare this proposed land use map is to define the best use of land without creating environmental issues and what is economically viable for dweller living in the watershed area. The proposed land use plan has been divided into following zones:

**Agriculture Zone:** "Agriculture Zone" shall denote the zone where agricultural production (corn crops, cash crops, horticulture, etc.), animal husbandry, fisheries, agricultural forest products and plants planted on private land, exist or may exist. This term also denotes any specific zone which is declared as agricultural zone by the Government of Nepal (GoN), among others. Agriculture Zone in the proposed land use map is prepared where there is already an existing agricultural area. For better utilization, in the proposed land use plan, agriculture zone is divided into two types: One in the area with low soil erosion rate, where farmers are allowed to continue regular cropland practices depending on the market demand; the other in the area where the soil erosion rate is high, where a radical terraced agricultural land use can be proposed for selective crops that can reduce soil erosion in the watershed. Radical terracing is a technique of landscaping a pierce of sloped land into a series of successively receding flat surfaces or platforms, which resemble steps, for the purposes of more effective farming. Graduated terrace steps are commonly used to farm on hilly or mountainous terrain where the terraced fields decrease the erosion and surface runoff retaining soil nutrients.[21]

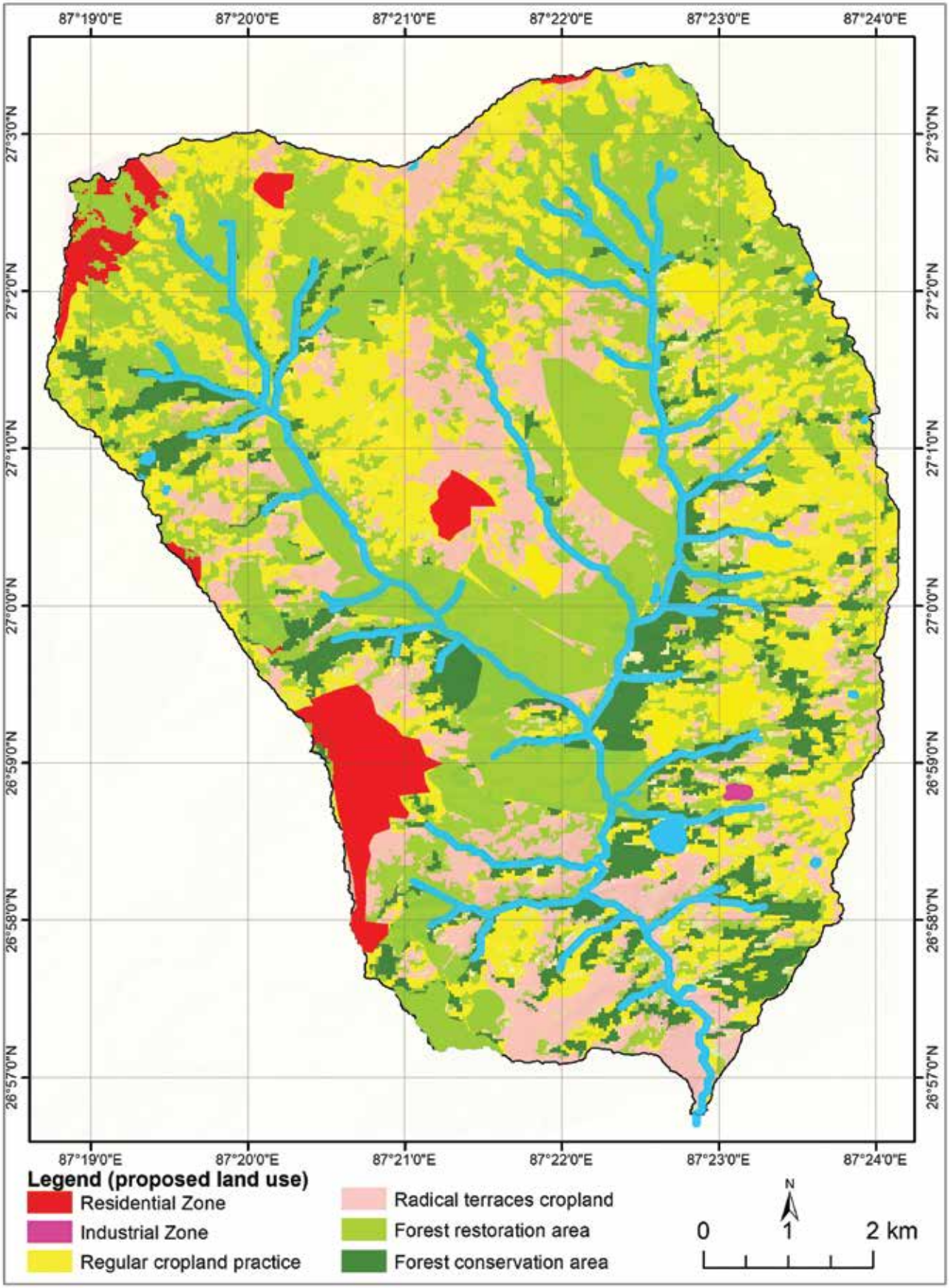
**Forest Zone:** "Forest Zone" means government, community, leasehold forest covered fully or partially by tree and vegetation including wildlife conservation, preserved area, bushes, nursery plant and the place which is declared as forest area by Government even in nonexistence of tree including lands with all types of forest. This term also denotes any specific geographical area which government declared as forest area for expansion of forest area or green area. The forest area in the watershed has been divided into two partitions i.e. Forest restoration area and Forest conservation area. Exiting forest land with the dense crown cover area will serve as a forest conservation area. And the areas where there is newly grown species (saplings) or bushes, the area could be offered as forest restoration area to have more green space in the watershed in future.

**FIGURE 30: 3D MAP OF THE NTW**




[21] https://qcat.wocat.net/en/wocat/technologies/view/technologies_2284/

**FIGURE 31: PROPOSED LAND USE MAP OF NTW**



**Industrial Zone:** "Industrial zone" mostly encompassed by the hut, wearhouse constructed for the establishment of an industry that produces goods or is operating thereof including the land having separated for the purpose. The industrial area can be known as a specific geographical zone declared by the Government of Nepal (GoN) as an industrial corridor, industrial village, industrial cluster, special export zone or special economic zone for promotion of industry.

**Mixed forest:** The mixed-type of cropland is also a type of agroforestry. Mixed forestry is basically a practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, village commons etc. Agroforestry is a collective name for land-use systems involving trees combined with crops and/or animals on the same unit of land. The mixed forest will focus on the production of multiple outputs with protection of the resource base emphasizing on the use of multiple indigenous trees and shrubs, low-input conditions and fragile environments, potential to provide most or all the ecosystem service and has the multiple environmental, economic as well as social benefits for the watershed. Few of the benefits of mixed forest can be: helpful in the reduction of surface run-off, nutrient leaching and soil erosion through impending effect of tree roots and stems of these processes; increment in a maintenance of outputs of food, fuelwood, fodder, fertilizer and timber; improving life standard of people etc.

**Residential Zone:** "Residential Zone" shall denote the land used by human beings for habitat purposes. This term also denotes shed, bhakari (large bamboo bin used to store crops), garage, stable, well, water tap, orchard, vegetable garden, yard or the land used for other such purposes whether the land is adjoined to a house or not. This term also indicates a colony home, apartment constructed by a business company or institution in a residential zone, and any specific zone declared as residential area by Government of Nepal (GoN), among others. The existing human settlement areas are proposed for the residential zone in the proposed land use map. In future, a detail assessment of the population growth trend should be done in order to separate a residential area. Construction of houses in those residential areas should maintain the setback rules to allocate space for utility services such as water, drainage, wastewater treatment etc.

**River and Lake-Reservoir Zone:** A water enriching zone such as existing rivers will serve as a river and lake-reservoir zone. During the field visit, it was observed that more springs were located in the upstream region whereas the downstream region was a dry and water scarce region. The upstream being rich in water sources supplies water to the downstream region. Springs are a very important component for the fulfilment of water demands while also contributing towards the flow of the river. Nibuwa and Tankhuwa rivers are the major source of water for Dhankuta and Chhathar Jorpati, which also contributed to the springs of the watershed. The water from the river is lifted up and collected by using different treatment methods and it is distributed to different wards in midstream and downstream. Spring revival activities can be done in the dried up springs and the uplifted water can be more efficiently treated and can be distributed to the community to meet the water demand of the watershed

*Component 3: Diversification and improvement of livelihood options*

An improved livelihood for all including men, women and marginalized groups through off-farm and non-farm activities is envisioned. This will be achieved through sustainable ecotourism; value chain of agriculture and local produce; and capacity building trainings trainings based on water availability and promoting soil and water conservation.

**COMPONENT 3: DIVERSIFICATION AND IMPROVEMENT OF LIVELIHOOD OPTIONS**

**OUTPUTS**

1. Promotion of sustainable tourism
2. Assessing of value chain of agriculture products
3. Promotion of high value agriculture products and native crops

| Details | Location /Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events/LS | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **A. Capacity development and awareness** | | | | | | | | |
| 3.1. Skill development trainings and awareness programmes | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, FNCCI & HAN | Municipality, Rural Municipality & DCC | No. of events | 10 | 50,000 | 500,000 | 4 events each for first 2 years |
| 3.2. Awareness campaigns for improved sanitation in upstream areas | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 12 | 20,000 | 240,000 | 4 events each for first 3 years |
| 3.3. Proper waste management training | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 8 | 20,000 | 160,000 | 4 events each for first 2 years |
| 3.4. Trainings on effective operation and promotion of homestays and eco-tourism including exposure visits | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, Finance Ministry & HAN | Municipality, Rural Municipality, DCC & HAN | No. of events | 5 | 100,000 | 500,000 | 4 training program and 1 exposure visit |
| 3.5. Training on financial literacy and management | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 8 | 20,000 | 160,000 | 2 events each for 4 years |
| 3.6. Trainings for tour operators and guides | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 1 | 50,000 | 50,000 | 1 event |
| 3.7. Training on alternative/off-farm livelihoods such as bee keeping, dairy farming and goat farming | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 10 | 25,000 | 250,000 | |

| Details | Location /Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events/LS | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 3.8. Trainings/capacity building programmes for income generation activities (nonfarm activities) and development social entrepreneurships | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 10 | 100,000 | 1,000,000 | Yearly two events |
| 3.9. Poverty reduction programmes through skill-based trainings such as weaving, organic farming and others for women's focus groups and marginalized groups | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs & DCC | Municipality, Rural Municipality & DCC | No. of events | 10 | 50,000 | 500,000 | 2 events each for 5 years |
| 3.10. Promotion of festivals and exchange visits | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | No. of events | 5 | 150,000 | 750,000 | Yearly one event |
| **B. Sustainable ecotourism** | | | | | | | | |
| 3.11. Demostaration and promotion of agro-ecotourism/ traditional agriculture including zoning and financial support | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, Cottage & Small industries, Krishi Paramarsha Sewa form & NTB | Municipality, Rural Municipality & DCC | L/S | 2 | 1,500,000 | 3,000,000 | Zonation 1 time event<br>Financial support for 50 HHs for demo and promotion |
| 3.12. Organic farming/smart agriculture farming | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, Cottage & Small industries & NTB | Municipality, Rural Municipality & DCC | L/S | 2 | 250,000 | 500,000 | 1 event in rural and 1 in municipality |
| 3.13. Exploring and promoting nature-based and adventure tourism activities (inside as well as outside of the watershed area) | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | 1 | 500,000 | 500,000 | Exploring 1 time event-50000<br>Field visits-40000<br>Promotion-1000000 |
| 3.14. Exploring and promoting cultural heritage and nature trails | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, Cottage & Small industries & NTB | Municipality, Rural Municipality & DCC | No. of events | 1 | 1,500,000 | 1,500,000 | |

| Details | Location /Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events/LS | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 3.15. Promotion and better management of homestays, especially in rural areas | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC, Cottage & Small industries & NTB | Municipality, Rural Municipality & DCC | No. of events | L/S | 1,090,000 | 1,090,000 | |
| 3.16. Documentation and dissemination of ethnic cultural activities | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | 1 | 500,000 | 500,000 | |
| **C. Value addition and marketing of agriculture products** | | | | | | | | |
| 3.17. Establishment/strengthening of agriculture cooperatives | All wards | Municipality, Rural Municipality, DFO, AKC, FECOFUN, DCC, Cottage & Small industries, Dept. of livestock's and vet office | Municipality, Rural Municipality & DCC | No. of events | 5 | 250,000 | 1,250,000 | 5 business plans |
| 3.18. Establishment of agricultural processing and storage | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | 1,000,000 | 1,000,000 | Processing unit plus est. of storage fascilities |
| 3.19. Exploring and strengthening the market linkages | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.20. Exploring and strengthening women's entrepreneurship | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.21. Promoting incubation centres for social entrepreneurship development and income generating activities in rural sites within the watershed | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.22. Ensuring that fair prices are obtained by farmers for their agricultural produce | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |

| Details | Location /Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events/LS | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 3.23. Establishing/supporting effective management of weekly markets by the Haatbazar management committees | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.24. Promotion of native agricultural crops such as finger millet, wheat, barley, maize, rice, dairy products, poultry and meat products and ensuring the market | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries, Dept. of livestocks and vet office | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.25. Diversification of agriculture towards high-value and native crops where possible | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| 3.26. Promotion of cardamom, avocado, ginger, broom, tea, milk, fresh vegetables, chilies, kiwi, etc. | All wards | Municipality, Rural Municipality, DFO, AKC, NGOs, DCC & Cottage & Small industries | Municipality, Rural Municipality & DCC | L/S | | | | |
| **TOTAL (Nrs)** | | | | | | | 13,450,000 | |
| **OUTCOME**<br>Improved livelihood for men, women and marginalized groups through off-farm and non-farm activities | | | | | | | | |

*Component 4: Climate change, disaster risk management and sustainable infrastructures*

A resilient socio-ecological system with reduced risks and disasters is the ultimate outcome of this component. The component focuses on efforts to minimize risks to ecosystems and society, and integrate climate change and risk management strategies in development plans of the watershed. The key activities are data generation on pertinent issues, capacity building of stakeholders across scales, and field interventions to manage erosion and mass wasting phenomenon.

**COMPONENT 4: CLIMATE CHANGE, DISASTER RISK MANAGEMENT AND SUSTAINABLE INFRASTRUCTURE**

**OUTPUTS**

1. Integration of climate change and disaster risk management in developing plans
2. Minimizing risks to ecosystems and community from water-induced disasters

| Details | Location/Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **A. Data generation and management** | | | | | | | | |
| 4.1. Identifying vulnerable areas and communities (with gender and social disaggregated data) to disaster and climate risks | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality, Rural Municipality, SCWMO & Ward offices | No. of events | 1 | 500,000 | 500,000 | |
| 4.2. Creating and maintaining data on erosion and landslide prone areas | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality, Rural Municipality & SCWMO | | | | | |
| 4.3. Analysing infrastructure development plans in vulnerable areas and potential impacts | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality, Rural Municipality & SCWMO | | | | | |
| 4.4. Hazard and Risk assessment should be done prior to the development to minimize the issues of landslide and erosion in the area. | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality, Rural Municipality & SCWMO | | | | | |
| 4.5. Preparing risk sensitive Land-use Plan (RSLUP) and implementation | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality/Rural Municipality/SCWMO/ PARDEP | | | | | |

| Details | Location/Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 4.6. Mainstreaming CCDRM in physical development plans, social and cultural development plans and economic development plans among others | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | Municipality/Rural Municipality/SCWMO | | 4 | 10,000 | 40,000 | |
| **B. Awareness and capacity building** | | | | | | | | |
| 4.7. Awareness campaign on climate smart villages | Watershed area | Municipality, Rural municipality, Wards, DoUDBC, SCWMO, Disaster Management Committee, Red cross and NGOs | DCC/ Municipality/Rural Municipality | No. of events | 2 | 50,000 | 100,000 | One event in Municipality and one in Rural municipality |
| 4.8. Awareness campaign and demonstration on low cost soil erosion control technologies such as terrace improvement, vegetative measures, and locations of erosion prone area to community members and extension workers. | Watershed area | Municipality, Rural municipality, DoUDBC, SCWMO, Disaster Management Committee, Red cross & NGOs | DCC/ Municipality/Rural Municipality | No. of events | 2 | 300,000 | 600,000 | 4 times (2 times each in municipality and rural municipality |
| 4.9. Awareness campaign on disaster risk reduction | Watershed area | Municipality, Rural municipality, DoUDBC, SCWMO, Disaster Management Committee, Red cross & NGOs | DCC/ Municipality/Rural Municipality | No. of events | | | | |
| 4.10. Exposure visit on environment friendly housing development in existing as well as emerging city area through demonstration | Watershed area | Municipality, Rural municipality, DoUDBC, SCWMO, Disaster Management Committee, Red cross & NGOs | DCC/ Municipality/Rural Municipality | No. of events | 1 | 300,000 | 300,000 | |
| **C. Field activities on managing erosion and mass wasting phenomenon** | | | | | | | | |
| 4.11. Green road: bioengineering and greenery Promotion on rural road. | Upper stream | Municipality, Rural municipality, Dept. of Roads, SCWMO, DFO & DoUBC | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 500,000 | 500,000 | 200m demo road |
| 4.12. Treatment of landslide and erosion prone area | 1 selected landslide | Municipality, Rural municipality, Dept. of Roads, SCWMO, DFO & DoUBC | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 1,000,000 | 1,000,000 | 1 landslide |
| 4.13. Nature based solution:- Afforestation, reforestation, plantation | All wards | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | L/S | 1 | 250,000 | 250,000 | |

| Details | Location/Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 4.14. Structural (bioengineering, retaining walls) and Non-structural measures (Hazard/susceptibility, Vulnerability, Risk Maps, Early warning systems) for landslide mitigation and preparedness. | 1 selected site | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 2,000,000 | 2,000,000 | 1800000 for structure and 200000 for landslide treatment |
| 4.15. Revitalization of erosion affected area, including stream banks | 1 affected site | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 1,000,000 | 1,000,000 | |
| 4.16. Gully stabilization for erosion prone areas in the upstream micro-catchment | Selected site | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 1,000,000 | 1,000,000 | 1 check dam plus plantation as demo |
| 4.17 Landslide slumping area treatment and Drainage Management | Bhirgaun | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 1 | 1,500,000 | 1,500,000 | Bhirgaun above the road from Nibuwa khola |
| 4.18. Drought risk reduction through water storage and recharge structures, soil moisture retention (mulching, cover crop), low water demanding crops, conservation of wetland and forests, agromet advisory for preparedness | all wards | Municipality, Rural municipality, SCWMO & DoF | Disaster Management Committee/Municipality / Rural Municipality | No. of events | 2 | 200,000 | 400,000 | 1 recharge pit and 1 storage |
| **D. Institutional mechanism and policies** | | | | | | | | |
| 4.19 Regulation of road construction so that all roads are green roads | all wards | Municipality, Rural Municipality, DCC, MoFE | MoFE/Municipality | No. of events | 1 | 500,000 | 500,000 | |
| 4.20. Implementing and following the indicators of SMART city | all wards | Municipality, Rural Municipality, DCC, MoFE | MoFE/Municipality | | | | | |
| 4.21. Conducting IEE/EIA and monitoring the Environmental Management Plan for major infrastructure development projects | all wards | Municipality, Rural Municipality, DCC, MoFE | MoFE/Municipality | | | | | |
| 4.22. Ensuring equal participation of women and men in considering demand, expectations, experiences and knowledge in utilization and management of resources through community representations | all wards | Municipality, Rural Municipality, DCC, MoFE | MoFE/Municipality | | | | | |

| Details | Location/Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| 4.23. Ensuring that the issues and problems of women and children are addressed in standard operating procedures which include evacuation, mitigation and financial allocation | all wards | Municipality, Rural Municipality, DCC, MoFE | MoFE/Municipality | | | | | |
| **TOTAL (Nrs)** | | | | | | | **9,690,000** | |
| **OUTCOME**<br>Resilient socio-ecological system with reduced risks and disasters | | | | | | | | |

### *Component 5: Integrated Social Development*

An equitable distribution of resources to all including men, women and marginalized sections of the society is the core pillar of the component. To do so, GESI is envisioned to be integrated in planning, implementation, monitoring and evaluation phases of the plan. The key actions are awareness at different levels, capacity building of marginalized groups, and a gender audit.

**COMPONENT 5: INTEGRATED SOCIAL DEVELOPMENT**

**OUTPUTS**

1. Integration of GESI into planning, monitoring and evaluation of the plan
2. Reduction of gender and social inequalities in access, use and control of resources

| Details | Location/ Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs | Amount in NRs | Remarks |
|---|---|---|---|---|---|---|---|---|
| **A. Data information and assessment** | | | | | | | | |
| 5.1. Gender audit of the municipality and ward annual budget | Municipality & Rural Municipality | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | No. of event | 5 | 100,000 | 500,000 | Yearly gender audit in Municipality |
| 5.2. Awareness and capacity building on social entrepreneurship schemes for women empowerment on financial management and strategies plus online marketing. | All wards | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | L/S | 5 | 150,000 | 750,000 | 7 days training program (500 beneficiaries over 5 years) |
| 5.3. Awareness programmes related to gender audit | Municipality & Rural Municipality | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | | | | | |
| 5.4. Women-focused leadership development trainings | All wards | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | | | | | |
| 5.5. Promoting women and marginalized groups to leadership positions through participatory approaches | All wards | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | | | | | |
| 5.6. Regular gender sensitivity training programmes, programmatic assessments from a gender lens and strengthening capacities of women and men within the government institutions | Municipality & Rural Municipality | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | | | | | |
| 5.7. Awareness-raising on strategies to reduce gender-based violence | All wards | Municipality, Rural municipality, All wards & NGOs | Municipality, Rural municipality, Wards, Tole representatives & NGOs | | | | | |

| Details | Location/ Area | Implementing partners | Monitoring partners | Unit<br>Ha/No. of events | Quantity | Unit cost in NRs *000 | Amount in NRs *000 | Remarks |
|---|---|---|---|---|---|---|---|---|
| **B. Institutional mechanism and policies** | | | | | | | | |
| 5.8. Strengthening the watershed management committee | Municipality & Rural Municipality | Municipality, Rural muncipality & All wards | Municipality, Rural muncipality, Wards | No. of event | 5 | 50,000 | 250,000 | |
| 5.9. Incorporating GESI in planning, implementation, monitoring, and evaluation of any programmes/plans. | Municipality & Rural Municipality | Municipality, Rural muncipality & All wards | Municipality, Rural muncipality, Wards | L/S | 1 | 150,000 | 150,000 | |
| 5.10. Establishing Counselling Centre with authority that can handle grievances, domestic violence, psychosocial services and support for well-being (economic, social & psychological) of women, men and the marginalized. Focusing on issues such as coping with/ adaption to difficulties due to long separation of partners due to migration; increased burden of financial repayments caused by micro-finance institutions and their high interest rates; appropriate utilization of remittances; grievance redressal system and liaison services | All wards | Municipality, Rural muncipality & All wards | Municipality, Rural muncipality, Wards | No. of event | 10 | 250,000 | 2,500,000 | 1 desk in each ward with a full time staff for 5 years |
| **TOTAL** | | | | | | | 4,150,000 | |
| **OUTCOME**<br>Equitable distribution of resources among women, men and marginalized groups | | | | | | | | |

*Component 6: Interdisciplinary action research and extension*

Evidence-based planning and decision making through action research and monitoring of pertinent and emerging cross-cutting issues related to different sectors including gender, agriculture, forestry and water is the major focus of the component. As such, the watershed plan and strategy are updated to be based on evidence.

| COMPONENT 6: INTERDISCIPLINARY ACTION RESEARCH AND EXTENSION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **OUTPUTS**<br>1. Exploration of emerging and pertinent issues<br>2. Evidence-based planning and decision-making | | | | | | | | |
| **Details** | **Location/Area** | **Implementing partners** | **Monitoring partners** | **Unit**<br>**Ha/No. of events** | **Quantity** | **Unit cost in NRs *000** | **Amount in NRs *000** | **Remarks** |
| **A. Action research and monitoring** | | | | | | | | |
| 6.1. Documentation of indigenous knowledge and practices at the watershed level | Watershed area | Universities, Researchers, SCWMO, DFO, Municipality and local government | Municipality, SCWMO, DFO and Universities | No of events | 1 | 400,000 | 400,000 | |
| 6.2. Assessment of effectiveness of conservation measures on soil properties, supply of water quantity and quality, soil erosion and sediment yield, biodiversity, social and economic outcomes, off-site impacts, etc. in collaboration with universities, research institutions and government organizations | Watershed area | Universities, Researchers, SCWMO, DFO, Municipality and local government | Municipality, SCWMO, DFO and Universities | No of events | 2 | 500,000 | 1,000,000 | Before and after (Ist assessment immediately after the endorsement and second assessment at the last of 5year) |
| 6.3. Assessment of watershed services for long-term strategic planning to adopt an integrated watershed management approach | Watershed area | Universities, Researchers, SCWMO, DFO, Municipality and local government | Municipality, SCWMO, DFO and Universities | No of events | | | | |
| 6.4. A sediment yield study before and after implementation of conservation measures. Study on climate change impacts on biodiversity and hydrological regimes in the watershed considering current trends and future scenarios | At local level | Rural municipality, municipality, Universities | Rural municipality, Municipality | No of events | 2 | 500,000 | 1,000,000 | |
| 6.5. Valuation of watershed services (both direct and indirect) | Watershed area | Rural municipality, municipality, Universities | Rural municipality, Municipality | No of events | 1 | 250,000 | 500,000 | |
| 6.6. Assessment of vegetation shift of species in the area | Watershed area | Rural municipality, municipality, Universities | Rural municipality, Municipality | No of events | 5 | 100,000 | b500,000 | Every year one event of Nrs 100000 |

| Details | Location/Area | Implementing partners | Monitoring partners | Unit Ha/No. of events | Quantity | Unit cost in NRs *000 | Amount in NRs *000 | Remarks |
|---|---|---|---|---|---|---|---|---|
| 6.7. Detailed assessment on pests in orchard and community's shift to avocado plantations from lemon | Watershed area | Rural municipality, municipality, Universities, NGOs, National Citrus Research Programme | Rural municipality, Municipality, NGOs | No of events | 1 | 200,000 | b200,000 | |
| 6.8. Understanding the gender dimension of micro-finance institutions and its implications on entrepreneurship development. | Watershed area | Rural municipality, municipality, Universities, NGOs | Rural municipality, Municipality, NGOs | No of events | 2 | 250,000 | 500,000 | |
| **TOTAL** | | | | | | | 4,100,000 | |
| **OUTCOME**<br>Evidence-based watershed plan and a regularly updated strategies taking into consideration the needs and priorities of men, women and the marginalized... | | | | | | | | |

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# Annexes

### Annex 1: Stakeholder consultation meeting for developing Nibuwa Takhuwa Watershed management plan

मिति : २०७५ । ११ । १३ गते

समय : विहान ८.०० वजे

स्थान : धनकुटा नगर कार्यपालिकाको वैठक हल

अध्यक्षता : का.बा. प्रमुख श्री शकुन्तला वस्नेत

कार्यक्रमको विवरण : निबुवा ताँखुवा खोला उपजलाधार क्षेत्र योजना तर्जुमा पुर्वतयारी छलफल ।

उपस्थिति विवरण :

| क्र.स | नाम थर | पद | कार्यालय/सस्था | मोबायल नं. | सहि |
|---|---|---|---|---|---|
| १ | श्री भिमकला श्रेष्ठ | उपाध्यक्ष | छथर जोरपाटी | ९८५२०५०५७५ | हस्ताक्षर |
| २ | श्री टीकादत राई | प्र.प्र.अ | धनकुटा न.का.पा. | ९८५२०३९१११ | हस्ताक्षर |
| ३ | श्री डम्वरु दाहाल | प्र.प्र.अ. | छथर जोरपाटी | ९८५२०३०९५५ | हस्ताक्षर |
| ४ | श्री शेखर श्रेष्ठ | व.ज.व्य.अ | जलाधार .व.का | ९८४५७८३७२१ | हस्ताक्षर |
| ५ | श्री निरेन तामाङ्ग | वडाध्यक्ष | धनकुटा न.पा. १ | ९८४२०७१३५७ | हस्ताक्षर |
| ६ | श्री चन्द्रलाल तामाङ्ग | वडाध्यक्ष | धनकुटा न.पा. २ | ९८४२०३७४२४ | हस्ताक्षर |
| ७ | श्री विकास घिमिरे | वडाध्यक्ष | धनकुटा न.पा. ३ | | अनुपस्थित |
| ८ | श्री जम्सेर राई | वडाध्यक्ष | धनकुटा न.पा. ४ | ९८४२१०९३६१ | हस्ताक्षर |
| ९ | श्री अम्विका परियार | का.व वडाध्यक्ष | धनकुटा न.पा. ५ | ९८४२०९३८७४ | हस्ताक्षर |
| १० | श्री मिलन. कु. खड्गी | का.व वडाध्यक्ष | धनकुटा न.पा.६ | ९८५२०४०५२१ | हस्ताक्षर |
| ११ | श्री कृष्ण मगर | वडाध्यक्ष | छयर जोरपाटी २ | ९८६९३२१२२८ | हस्ताक्षर |
| १२ | श्री ज्ञान व. लिम्बु | वडाध्यक्ष | छथर जोरपाटी ३ | ९८४२३२९०९३ | हस्ताक्षर |
| १३ | श्री धन ब. खड्का | उपाध्यक्ष | धनकुटा खानेपानी उपभोक्ता समिति | ९८४२०६१९९७ | हस्ताक्षर |
| १४ | श्री गुणनिधि पोखेल | भुगर्भशास्त्री | इसिमोड काठमाडौँ | ९८४३०४७०७३ | हस्ताक्षर |
| १५ | कृपा श्रेष्ठ | नक्साङकन | इसिमोड काठमाडौँ | ९८१०१८५३७७ | हस्ताक्षर |
| १६ | Saskia Kolstee | intern | ICIMOD | | हस्ताक्षर |
| १७ | श्री सिजल पोखेल | intern | इसिमोड काठमाडौँ | ९८५१२३३५६२ | हस्ताक्षर |
| १८ | श्री भगवती कार्की | सदस्य | धनकुटा न.खा.पा.उ. | ९८४२३२९०७० | हस्ताक्षर |
| १९ | श्री विवश राई | स.ले.प. | धनकुटा न.खा.पा.उ. | ९८४२१५८७७५ | हस्ताक्षर |
| २० | मिलन प्रधान | कालिगढ | खानेपानी उपभोक्ता समिति | ९८४२११३३६६ | हस्ताक्षर |

| | | | | | |
|---|---|---|---|---|---|
| २१ | निलहरी न्यौपाने | सामाजिक आथिक विश्लेषक | इसिमोड काठमाडौँ | ९८४४०३४२८७ | हस्ताक्षर |
| २२ | विश्वदिप चौधरी | भू.स.स. | भू तथा जलाधार व्यवस्थापन कार्यालय | ९८४२६७८९३३ | हस्ताक्षर |
| २३ | गगांराम शाह | भू.स.अ | भू-तथा जलाधार व्यवस्थापन का. | ९८४५२९५३५८ | हस्ताक्षर |
| २४ | लक्ष्मीदत्त भट्ट | विशेषज्ञ वरिष्ठ | इसिमोड काठमाडौँ | ९८४१२१६११० | हस्ताक्षर |
| २५ | डम्बर रोगु | प्रशासकिय अधिकृत | धनकुटा नगर कार्यपालिकाको कार्यालय | ९८४०३८०६३ | हस्ताक्षर |
| २६ | सुनिल कुमार राई | सब-इन्जिनियर | भू- तथा जलाधार व्यवस्थापन का. धनकुटा | ९८४२४३०५५३ | हस्ताक्षर |
| २७ | सुनिता रानाभाट | पारिस्थितिकी प्रणाली विश्लेषक | इसिमोड | ९८१८३२२४७४ | हस्ताक्षर |
| २८ | प्रतिभा कार्की | सब-इन्जिनियर | भू तथा जलाधार व्यबस्थापन का. | ९८६०८६५७३८ | हस्ताक्षर |

उल्लेखित उपस्थितमा निबुवा र ताँखुवा खोला जलाधार क्षेत्र व्यवस्थापन योजना तर्जुमाको उदेश्य माथि वरिष्ठ जलाधार व्यवस्थापन अधिकृत सेर बहादुर श्रेष्ठले प्रकाश पार्नु भयो।

त्यसै गरी जलाधार क्षेत्रको मुहान संरक्षण सम्बन्धि विगतमा इसिमोडको तर्फबाट भएको अध्ययन अनुसन्धान प्रतिवेदनको मूख्य बिषयवस्तु इसिमोडको विज्ञ लक्ष्मीदत्त भट्टवाट प्रस्तुतिकरण गरी छलफल भयो जलाधार क्षेत्रको विद्यमान भौगोलिक, भौर्गभिक अवस्थाको विषयमा इसिमोडको तर्फबाट विज्ञ टोलीले प्रस्तुतिकरण गरी छलफल गरीयो।

निर्णय १

निबुवा तथा ताँखुवा खोला जलाधार योजना तर्जुमाको लागि सरोकार क्षेत्रका स्थानीयहरुको सहभागीतामा तपसिल बमोजिमको जलाधार व्यवस्थापन समिति गठन गरियो।

तपसिल

१. संयोजक प्रमुख, धनकुटा नगरपालिका

२. सह-संयोजक अध्यक्ष, छथर जोरपाटी गाँउपालिका

३. सदस्यहरु : (क) धनकुटा नगरपालिका वडा नं. १ देखि ८ सम्मका वडाध्यक्षहरु।

(ख) छथर जोरपाटी गाँउपालिका वडा नं. २ र ३ का वडाध्यक्षहरु

(ग) धनकुटा खानेपानी तथा सरसफाई उपभोक्ता समितिको प्रमुख /अध्यक्ष

(४) सदस्य : धनकुटा नगर कार्यपालिकाले तोकेको ५ र छथर जोरपाटी गाउपालिकाले तोकेको २ जना प्रभावित क्षेत्रका महिला प्रतिनिधिहरु सदस्य।

(५) सदस्य : वरिष्ठ जलाधार व्यवस्थापन अधिकृत। (जलाधार व्यवस्थापन कार्यालय)

(६) सहयोगि : विज्ञ समूह इसिमोड

(७) सचिव : धनकुटा नगर कार्यपालिकाको प्रमुख प्रशासकिय अधिकृत।

उल्लेखित समितिको सहजिकरणमा जलाधार क्षेत्र व्यवस्थापन सम्वन्धि योजना तर्जुमा गर्ने निर्णय गरीयो।

## Annex 2: Prioritized activities

| Component | Prioritized Activities | Ranking |
|---|---|---|
| **Water source conservation and water supply management** | **A. Information, data management and assessment**<br>• Evaluation of water demand and supply<br>• Conducting detailed assessment of rainwater harvesting at household level (especially in dry area,)<br>• Collection and Maintenance of data from manual rain gauge | 2<br>2<br>2 |
| | **B. Awareness and Capacity building**<br>• Conducting awareness campaign on responsible use of pesticides, herbicides, & fertilizers and training on integrated pest management (IPM) at upstream and downstream area, Awareness campaign on wastewater use for irrigation of kitchen gardens<br>• Organizing exposure visit to women's and men's groups<br>• Promotion of awareness programmes on gender-based violence, gender- friendly technologies, and gender sensitivity through community out-reach programmes such as local media (newspapers/radio/FM stations) | 10<br>2<br>1 |
| | **C. Infrastructure development and maintenance**<br>• Construction of recharge ponds in strategic areas (community ponds/reviving traditional ponds in upstream water recharge area)<br>• Maintenance and construction of water tanks and pipelines<br>• Assessing the potential for construction of Wastewater Treatment Plant.<br>• Regulations on deep boring | 17<br>9<br>3<br>1 |
| | **D. Institutional mechanism and arrangements and policies**<br>• Developing and implementing springs and their recharge area management plan (particularly, in respect of private and public land)<br>• Developing mechanisms to ensure participation, representation and decision-making by women and marginalized communities in water resource management committees and subsidy plans<br>• Strengthening water users' committees at local level which would ensure participation of women, the poor and the marginalized, including the landless (needs assessment and identifying areas for capacity building)<br>• Institutional mechanism established for Social Audits (Social Audit Committee) both for the ward level and municipality for accountability and inclusive development | 12<br>7<br>1<br>1 |
| **Sustainable land use management** | **A. Data, information and assessment**<br>• Collecting and maintaining water demand for agriculture<br>• Assessment on bamboo cultivation and bamboo products market<br>• Management of invasive species | 3<br>2<br>2 |
| | **B. Awareness and capacity building**<br>• Promoting agriculture-related advance training: drip irrigation, sprinkler, herbicide, compost manure, water conservation pond, integrated pest management, beekeeping, mobile based agromet advisories to women and men and marginalized communities<br>• Awareness and training on farming of timur, chiraito, tejpatta, and other high value species<br>• Awareness campaign on Forest for Youth<br>• Awareness raising on water conserving trees species on private land and abandoned areas such as multipurpose broad leaf trees and others | 5<br>4<br>4<br>3 |
| | **C. Plantation and construction activities**<br>• Plantation of suitable species that control soil erosion and conserver soil moisture on public and abandoned land in areas above 30 degrees' slope (such as sisno, dhokre ful, aiselu, etc.)<br>• Establishing nurseries for management of quality seeds and seedling of species (broadleaf trees, native trees, etc.)<br>• Establishing seed bank, fertilizer bank, loan availability (including for planting of native species) and increasing coordination with micro-financial institutions<br>• Establishment of forest fire mitigation and control mechanisms | 2<br>3<br>1<br>2 |

| Component | Prioritized Activities | Ranking |
|---|---|---|
| | **D. Institutional mechanisms and policies**<br>• Comprehensive landuse planning with participatory approach<br>• Formulating rules to prevent tree felling around the water sources and sloppy areas<br>• Developing incentive mechanism for private land management (such as forestry, horticulture and multi-year cropping for areas above 30 degrees and marginal land); subsidy for crop insurance; and subsidy for less water-intensive identified crops and vegetable production<br>• Promoting cooperative and community farming among women's group<br>• Developing mechanism for production-based incentives and monitoring (innovative agri-land management)<br>• Integrating employment generation in forest management, starting with community forestry and attracting youth towards forestry<br>• Family planning for controlling monkeys | 5<br>2<br>7<br>6<br>6<br>1<br>2 |
| **Climate change, disaster risk management and sustainable infrastructures** | **A. Data, information and assessment**<br>• Creating and maintaining data on erosion and landslide prone areas<br>• Analysing infrastructure development plans with vulnerable areas and potential impacts. | 4<br>3 |
| | **B. Awareness and capacity building**<br>• Conducting awareness campaign and demonstration on soil erosion control technologies such as terrace improvement and location of erosion prone areas<br>• Conducting awareness campaign on disaster risk reduction<br>• Promoting environment friendly housing development in existing as well as emerging city area by demonstration | 2<br>2<br>1 |
| | **C. Field activities on mitigation of erosion and mass wasting phenomenon**<br>• Green road: bioengineering & greenery promotion on rural road<br>• Treatment of landslide and erosion prone area<br>• Revitalization of erosion affected area, including stream banks | 6<br>4<br>4 |
| | **D. Institutional mechanism and policies**<br>• Implementing and following the indicators of SMART city<br>• Conducting IEE/EIA and monitoring the Environmental Management Plan for major infrastructure development projects<br>• Ensuring equal participation of women and men in considering demands, expectations, experiences and knowledge in utilization and management of resources through community representation<br>• Ensuring that the issues and problems of women and the children are addressed in standard operating procedures that includes evacuation, mitigation and financial allocation | 6<br>7<br>2<br>2 |

| Component | Prioritized Activities | Ranking |
|---|---|---|
| **Integrated Social Development** | **A. Data, information and assessment**<br>• Gender audit of the municipality and ward annual budget | 4 |
| | **B. Awareness and capacity building**<br>• Conducting awareness programmes related to gender audit<br>• Organising women focused leadership development trainings<br>• Promoting women and marginalized men to leadership positions through participatory approaches<br>• Conducting regular gender sensitivity training programmes and programmatic assessments from a gender lens and strengthening capacities of women and men within the government institutions | 2<br>1<br>3<br>2 |
| | **C. Institutional mechanism and policies**<br>• Incorporating a gender lens in planning, implementation, monitoring, and evaluation of any programmes/ plans<br>• Establishing Counselling Centre with authority that can handle grievances, domestic violence, psychosocial services and support for well-being (economic, social & psychological) of women, men and the marginalized. Focusing on issues such as coping/adaption difficulties due to long separation of partners due to migration; increased burden of financial repayments caused by micro-finance institutions and their high interest rates; appropriate utilization of remittances; Grievance redressal system and liaison services | 1<br>4 |
| **Cross cutting: Research extension and tourism** | **A. Research and monitoring**<br>• Documentation of indigenous knowledge and practices at the watershed level<br>• Assessment of effectiveness of conservation measures on soil properties, supply of water quantity and quality, soil erosion and sediment yield, biodiversity, social and economic outcomes, off-site impacts, etc., in collaboration with universities, research institutions and government organizations<br>• Assessment of watershed services for long term strategic planning to adopt integrated watershed management approach<br>• Conducting sediment yield study<br>• Assessing climate change impacts on biodiversity and hydrological regimes in the watershed considering current trends and future scenarios<br>• Quantification and valuation of watershed services–both direct and indirect services. | 3<br>4<br>2<br>3<br>1<br>5 |
| | **B. Sustainable tourism**<br>• Raising awareness on improved sanitation<br>• Training on proper waste management training<br>• Promoting behavioural change for wise use of water<br>• Promotion of sustainable tourism approach such as eco-tourism and homestay<br>• Training on alternative/off-farm livelihoods, especially in water scarce areas | 6<br>3<br>3<br>2<br>3 |

## Annex 3: Methods for land cover, soil erosion and landslide susceptibility analysis

### Land cover

The assessment of Dhankuta watershed land cover of 1990, 2000, 2010 and 2018 was done using the Landsat Surface Reflectance Level-2 Landsat images. All the Landsat data were downloaded via the United States Geological Survey (USGS) data archived portal (https://earthexplorer.usgs.gov). For the estimation of land cover, we adopted an object-based image analysis (OBIA) method which is widely known as a Geographic Object-Based Image Analysis (GEOBIA). In recent years, the GEOBIA approach showed significant potential to efficiently extract land cover information with higher accuracy (Blaschke 2010; Radoux et al, 2011). During the object image analysis, the non-overlapping image segmentation technique was used to produce meaningful image objects based on the input satellite image information as well as thematic layers. In the region, GEOBIA has been used for the national land cover change assessment of Bhutan (Gilani et al. 2015). The land cover data of 1990, 2000, 2010 and 2018 was taken from Regional Database System of International Centre for Integrated Mountain Development (ICIMOD) (http://rds.icimod.org).

The downloaded Landsat image was first entered into the eCognition Developer 8.1 software for classification. For the classification of images, a "multiresolution segmentation" algorithm was used, which consecutively zoned image pixels into single image objects based on their neighbours and based on a relative homogeneity criteria (Hay et al. 2003; Hay & Castilla 2008). During the multiresolution image segmentation process, the image layer weights used were 1 for the Landsat band; 0 for band, 16 for scale parameter and 0.1 for shape. In the composition of homogeneity creation, "shape" used 0.1 and "compactness" used 0.5. The multiresolution segmentation object assumed that similar features would have similar kinds of spectral responses and that the spectral response of an element would be unique concerning all other aspects of interest. In the multiresolution segmentation process, the homogeneous areas were used to create larger image objects and the heterogeneous regions into the smaller object or segment (Baatz et al. 2006).

### Estimation of soil erosion areas

The models applied to estimate the soil erosion driven by water and associated sediment yield are categorized into empirical, regression and conceptual models. Empirical or regression models include the Universal Soil Loss Equation (USLE) (Wischmeier & Smith 1978) and the Revised Universal Soil Loss Equation (RUSLE) (Renard et al. 1991). RUSLE is useful to identify the spatial distribution of soil loss for a larger region (Ganasri & Ramesh 2016). Assessing soil erosion through the integration of soil erosion models, field data, and data obtained from remote sensing platforms using geographic information systems (GIS) methods have shown satisfactory results (Alkharabsheh et al. 2013; Ganasri & Ramesh 2016; Uddin et al. 2016). The well-known RUSLE equation is presented as follows (Wischmeier & Smith 1978):

$$A = R \times K \times L \times S \times C \times P$$

where, $A$ is soil loss in tons per hectare, $R$ is the rainfall-erosivity index, $K$ represents soil erodibility index, $L$ represents slope length, S is the slope steepness factor, $C$ represents land cover management factor, and $P$ represents supporting practices factor. The description of input data, data preprocessing and calculation of each factor are discussed in greater detail below. These factors (RKLSCP) were combined using the RUSLE framework in the ArcGIS model builder environment for the estimation of average soil loss.

### Development of specific RUSLE data layers

The equations used for the calculation of individual factors are given in Table -I. The rainfall erosibity factor, slope length factors and soil erodibility were estimated using several site-specific equations.

### Rainfall erosivity factor (R)

The rainfall erosivity factor (R) is used as an important layer for soil loss assessment under future land use and climate change (Meusburger et al. 2012; Uddin et al. 2016; Uddin et al. 2018). Rainfall erosivity factor shows the ability of rainfall to cause erosion on the earth. Normally, raindrops with higher intensity control the release amount of soil and runoff used to carry as sediment. But there are not enough records of rainfall intensity in Nepal, and the records of monthly rainfall

**TABLE I: INPUT DATA SOURCES, AND PUBLISHED EQUATIONS USED IN RUSLE**

| Soil erosion factor | Input data | Data source | Equation or published factor |
|---|---|---|---|
| Soil erodibility factor (K) | Soil maps from Nepal | | Literature review |
| | ALOS 5m | JAXA | |
| | ALOS 5m | JAXA | |
| | | | $C = 0.1 * (-NDVI + 1)/2$ (Almagro et al. 2019) |
| | | SERVIR | |

data are therefore used for the determination of the R-factor using the average annual value. The R-factor was evaluated from world climate precipitation data (Fick & Hijmans 2017) using the following equation (McGarigal 2002):

$$R = 0.0483 * P^{1.610}$$

where $P$ = annual precipitation (mm)

## Soil erodibility factor (K)

One of the mandatory layers for a soil erosion study is the soil erodibility factor (K), which is associated with soil types that provide information on or soil loss in different environmental situations, topography and geographic locations. K factor also measures the susceptibility of soil surface to erosion due to precipitation and runoff. The K factor is related to crucial soil factors such as soil texture, structure, organic matter and permeability which trigger soil loss (Panagos et al. 2012). The soil erodibility factor (K) is a lumped parameter and quantitative description that represents an integrated annual value of a particular soil. For a particular soil association, the soil erodibility factor is the rate of erosion per unit of the erosion index from a standard plot. In this study, K values are brought out from published work conducted in and around Nepal (Franklin 2001; Gardner & Gerrard 2003; Khosrowpanah et al. 2007; Jain et al. 2001; Mandal & Sharda 2011). If two researchers produced two different K values for the same soil type, we used the mean value of those two researches.

## Slope-length factor (L)

The slope-length factor (L) is defined as the distance from the point of origin of overland flow to another point on the site erosion potential. The slope-length factor is the ratio of field soil loss to the corresponding soil loss of 22.13 m slope length and is estimated as

$$L = (\lambda/22.13)^m$$

where λ is the slope length and m assumes the value of 0.2 to 0.5. (Wischmeier & Smith 1978) have come out with varying values of exponent m for different slopes and these are as follows (Singh et al. 1981; Jain et al. 2001). For this purpose, the m map was created using the slope map as the input.

The $L$ value was estimated by using the field slope length calculated from ALOS DEM and is given as follows:

$$L = [90/22.13]^m$$

## Slope-steepness factor (S)

Steep slopes and undulating topography provide a critical platform to springing precipitation water into a lower place rapidly (Figure 4). The slope-steepness factor (S) represents how fast water can flow on a particular surface interacting with the angle of ground and effecting the magnitude of soil erosion. The slope factors differ according to the shape and size of the ground; at the same time soil loss increases more with slope steepness than it does with slope length. It is the

**TABLE II: DATA SOURCE AND CALCULATION OF SLOPE ERODIBILITY FACTOR**

| | | | |
|---|---|---|---|
| Slope gradient Rainfall erosivity factor (R) | Value of mPrecipitation (ESRI grids, 10 arc-minutes) | World climate precipitation data (Reed et al. 2010) | R = 0.0483*P1.610 where P=annual precipitation (mm) |
| 1% slope length factor (L) | SRTM 30 m digital elevation data | (SRTM 2008) | 0.2L = (λ/22.13)m where λ is the field slope length (m) and m assumes a value from 0.2 to 0.5 (Singh et al. 1981) |
| 1–3% slope steepness factor (S) | SRTM 30m digital elevation data | (SRTM 2008) | 0.3S = (0.43 + 0.30 s + 0.043 s2)/6.613 (Wischmeier & Smith 1978) |
| 3–4.5% land cover management factor (C) | NDVI from Landsat | (GLOVIS 2008) | 0.4C = 0.431− 0.805*NDVI (Renard et al. 1997) |
| 4.5% or more | 0.5 land cover map | ICIMOD (Uddin et al. 2015) | |

ratio of soil loss from the field gradient to that from a 9 percent slope under otherwise identical conditions. The relation of soil loss to the gradient is influenced by the health and density of vegetative cover and soil particle size. For estimating the S factor, the following equation was used (Wischmeier & Smith, 1978):

$$S = (0.43 + 0.30_s + 0.043_s2)/6.613$$

where *s* is the slope in percentage

## Cover management factor (C)

The vegetation cover is the second most crucial factor and similar to topography in controlling the soil erosion risk and impact of erosion (Van der Knijff et al. 1999). When rainfall drops on vegetated areas, the vegetation canopy intercepts the rainfall, increases the infiltration and reduces the rainfall energy. The C factor is usually assigned based on the type and density of vegetation cover. Such an approach results in transforming land cover into discrete weighted data.

Alternatively, De Jong (1994) developed the following relationship between field calibrated C factor values and Landsat satellite-based Normalized Difference Vegetation Index (NDVI) to produce a continuous *C* factor surface

$$C = 0.1 * (- \text{NDVI}+1)/2$$

where $NDVI = \frac{NIR - Red}{NIR + Red}$

The annual composite *NDVI* of 2018 were created from Landsat data.

## Support practice factor (P)

The erosion control practice factor (P) reflects the impact of support practices on average annual erosion rate, and it also mostly accounts for control practices that reduce the soil loss area of runoff by their influence on runoff concentration, runoff swiftness, drainage systems, and hydraulic forces exercised by the runoff on the earth surface.. It is measured as the ratio of soil erosion with a specific support practice to the corresponding loss with ploughing up and downslope (Renard et al. 1997; Prasannakumar et al. 2012). Briefly, the P factor map was prepared utilizing the 2018 land cover map where the erodibility factor of the support practice factor was assigned based on the mean value of secondary published data for a particular land cover class in the region (Franklin 2001; Renard et al. 1997; McGarigal 2002; Sonneveld & Nearing 2003; Renard et al. 1991; Wang et al. 2000; Dissmeyer & Foster 1981).

## Landslide Susceptibility Analysis

The susceptibility analysis was done by using the Frequency Ratio Model (Ehret et al. 2010). The frequency ratio (FR) is a bivariate statistical method that is simple to implement with accurate results. This model is basically used to calculate the ratio of the cell with landslide occurrence in each class for a reclassified factor or possible conditioning factor.

$$\text{Frequency Ratio Model (FRi)} = (Mi/M) / (Ni/N)$$

where

$M_i$ = Number of pixels with landslides for each subclass conditioning factor,

$M$ = Total number of landslides in the study area,

$N_i$ = Number of pixels in the subclass area of each factor

$N$ = Number of total pixels in the study area

Landslide Susceptibility Index (LSI) = $Fr_1 + Fr_2 + Fr_3 + Fr_4 \ldots\ldots\ldots\ldots Fr_n$

where, Fr is the frequency ratio and n is the number of selected causative factors.

**TABLE III: DATA COLLECTED AND ITS SOURCE**

| S.N. | Data | Source |
|---|---|---|
| 1 | DEM | ALOS DEM of 5m resolution was used for the analysis ("The AW3D DEM is licensed via Durham University (UK), with funding from DFID-UKRI SHEAR (project number: 201844). © NTT DATA, RESTEC/ Included©JAXA"). |
| 2 | LULC | Regional database, ICIMOD (1990, 2000, 2010, 2018) |
| 3 | Rainfall | CRU-TS 4.03 (Harris et al. 2014) downscaled with WorldClim 2.1 (Fick & Hijmans 2017). |
| 4 | Road | Open Street Map |
| 5 | Geology | Modified from Dhital M. R. (1992) & Timsina, C. (2011) |

## Annex 4: Geological survey

Geological survey is the basic work and systematic investigation of the geology of an area, which reflects the geology and structure beneath a given piece of land. Geological surveys are conducted for the purpose of preparing a geological map using an inventory form (Table III). Any geological surveying method employs several techniques and instruments including traverses, walk-over surveys, studying the exposures, outcrops and the landforms. A geological survey can be undertaken using a number of methods depending upon the size of the region and the amount of information required. In geological surveys, geological structures such as folding, faulting and including all the discontinuities present in litho-units are of great importance. Geological methods rely on the identification of rocks and minerals. They are done in order to get an understanding of the environment in which they are formed. Such surveys aim to find out what rock types occur at or close to the surface and how these rock types are related to each other.

Geological mapping is usually the first task in any reconnaissance survey. Structural features or conditions favour the accumulation and retention of groundwater in aquifers.

**TABLE III: GEOLOGICAL INVENTORY FORM**

| **Geological inventory form** | | | | |
|---|---|---|---|---|
| Location: | | | | |
| GPS | | | | |
| Latitude | | | | |
| Longitude | | | | |
| Elevation | | | | |
| Accuracy | | | | |
| Outcrop description | | Sketch of view | | |
| Rock description | | | | |
| Type | Foliation/ bedding | Joint (J1) | Joint (J2) | Joint (J3) |
| Strike | | | | |
| Dip direction | | | | |
| Dip amount | | | | |
| Persistence | | | | |
| Spacing | | | | |
| Roughness | | | | |
| Aperture | | | | |
| | | | | |
| Persistence | Continuous/discontinuous | | | |
| Spacing | Perpendicular length of joint space | | | |
| Roughness | Polished/rough/smooth/slick sided/very rough | | | |
| Aperture | Tight/ open | | | |
| Degree of weathering | Fresh/slightly/moderately/highly/extremely/residual | | | |
| Stratification | | | | |
| Thinly laminated | <6mm | Medium bedded | | 0.2-0.6m |
| Laminated | 6-20mm | Thickly bedded | | 0.6-2.0m |
| Very thinly laminated | 20-60mm | Very thickly bedded | | >2m |
| Thinly bedded | 60mm-0.2mm | | | |
| Photograph no: | | | | |

## Annex 5: Hydrogeological survey

In this survey, groundwater sources and water bodies were studied in and around the study area since groundwater movement is different from surface water movement. During the inventory, springs, ponds, wells, seepage, etc., were explored, identified and located. The data were collected in depth as far as possible. The first task was to locate the sources in the map which has now been mostly replaced by GPS devices using spring inventory form (Table IV). The spring observation, identification, water discharge measurement, water quality assessment, landuse and land cover around the spring and socio-economic factors play vital roles in understanding the behaviour of a spring. Socio-economic information includes water demand and supply, dependency, perception on water quality, managerial aspects and influences on springs by natural and man-made hazards Discharge is an important variable which governs many aspects of streams and springs functions such as water availability, habitat and diversity. Various methods can be applied for the measurement of discharge of springs as well as streams.

### Spring discharge measurement

In the mid hill region, there are various springs, seepage zones and ponds which have different characteristics and they have non-uniform discharge rates from place to place. Discharge measurement is very crucial to know how the springs is behaving throughout time. Due to diverse topography and communities near springs, springs are managed differently. In such cases, discharge measurement techniques too must be adopted accordingly.

### Most used spring discharge measurement techniques

Bucket-stopwatch method: The simplest method is to hold a bucket or jug of known volume below spring so that all the water from the outlet accumulates into the bucket or jug and to measure the time taken to fill it. This method can be used when the spring is free flowing with no infrastructure like tanks, the spring discharge is significant, and the entire flow can be channelled into the container

Water level drop method: Some springs seep into the surface that is not clearly defined and do not have an outflow. Water is stored in a small ditch and is drawn using a bucket or jug. The discharge of these springs can be measured by removing a known volume of water and measuring the recovery time.

Water level change method: Some springs occur in the form of seepage and a storage tank is constructed to collect the water. It is not possible to measure the discharge of these springs directly. The method of choice is water level change with volume estimation. The discharge is calculated from the observed rise in water level in the tank over a set time. The dimensions of the tank are used to calculate the water volume.

### Stream discharge measurement

The most common approach to measuring stream discharge is the area-velocity method which involves measuring area and velocity. The flow can be calculated using the float method with a measuring tape, floating object and timer. Flow is the best measure in running water. Two observers are required to take measurements. Firstly, you determine the float distance by measuring and marking two points along the stream channel and is calculated as

$$\text{Discharge (Q)} = \text{Area (A)} \times \text{Velocity (V)}$$

where, Area = Width of channel X average depth, Velocity = Distance of two points X Average time X Correction factor

According to NARMSAP (2004), correction factors are defined as: 0.65 for the depth of a river less than 30cm, 0.70 for the depth of a river between 30cm to 1.2m and 0.75 for the depth of a river greater than 1.2m.

Sometimes, it is difficult to use the area-velocity method for slow and steep streams. The salt dilution method (Photo 3) is the alternative method of stream gaging which involves injecting *Sodium Chloride* (common table salt) and determining its dilution in stream flow. Common table salt is popular for dilution because it is cheap, readily available, portable, and gives accurate measurements by conductivity meter and is also non-toxic. Instruments required in this method are bucket, stirring stick and conductivity meter. The first step is to measure natural conductivity downstream. Collect a bucket of water from the stream and then dissolve a known quantity of salt into the

**TABLE IV: SPRING INVENTORY FORM**

| **Spring inventory form** | | | | |
|---|---|---|---|---|
| Date: | | | | |
| Time: | | | | |
| Spring name / ID: | | | | |
| GPS location | Latitude: | Longitude: | Elevation: | Accuracy: |
| | | | | |
| **Nature of discharge:** | | **Nature of spring:** | | |
| Land use surrounding at<br>Upslope:<br>Downslope:<br>Sidewise: | | | Sketch of spring area | |
| Types of springs: Hard-rock/sediment/rock- sediment interface<br>If spring is on hard rock:<br>Rock types:<br>Strike/dip direction/dip amount:<br>Joints measurements:<br>If spring is on sediment:<br>Type of deposits:<br>Type of soil/sediments:<br>Thickness of sediments: | | | | |
| Physical parameter of spring: | | | | |
| Temperature (°C): | | | | |
| Hydrogen ion concentration (pH): | | | | |
| Electrical conductance (µS): | | | | |
| Total dissolved solids (ppm): | | | | |
| Discharge | | | | |
| Measurement 1 | | Measurement 2 | Measurement 3 | |
| Water use: | | | | |
| Dependency: | | | | |
| Photograph no.: | | | | |
| Remarks (if any): | | | | |

bucket of water. Again, measure the conductivity of the solution in bucket. Then inject the bucket of salt water upstream into the stream channel. Record the result with the conductivity meter every 5 seconds until the conductivity stabilizes.

When the injection of the trace into the stream is sudden, the discharge is given by,

$$Q = \frac{C_1 V}{\int_{t_1}^{t_2} (C_2 - C_0)\,dt}$$

where, V = volume of injected solution, $(t_2-t_1)$ is the time in which all the tracer passes the sampling section, $C_1$ is the concentration of tracer injected into the stream and $C_2$ is the concentration of the tracer at sampling section monitored continuously with time.

## Annex 6: Seasonal and annual trends with significance for precipitation and temperature

| Variable | Season | Significance (α) | Trend |
|---|---|---|---|
| Precipitation | Winter | 0 | -0.09 |
| | Pre-monsoon | 0 | 0.024 |
| | Monsoon | 0 | -1.91 |
| | Post-monsoon | 0 | -0.53 |
| | Annual | 0 | -2.76 |
| Maximum temperature | Winter | *** | 0.063 |
| | Pre-monsoon | *** | 0.055 |
| | Monsoon | *** | 0.056 |
| | Post-monsoon | *** | 0.065 |
| | Annual | *** | 0.059 |
| Minimum temperature | Winter | * | 0.018 |
| | Pre-monsoon | 0 | 0.011 |
| | Monsoon | ** | 0.014 |
| | Post-monsoon | 0 | 0.006 |
| | Annual | * | 0.014 |

## Annex 7: Selected springs for seasonal variability of discharge and seasonality

| S.N. | Name | Sp ID | Post monsoon discharge Q (lpm) | Pre monsoon discharge Q (lpm) | Seasonality |
|---|---|---|---|---|---|
| 1 | Dhoje Mul | Sp 47 | 9.85 | 3 | Perennial |
| 2 | Jorpati Sano Pokhariko Mul (Green tank) | Sp 113 | 15.62 | 9.24 | Perennial |
| 3 | Dhare Kuwa | Sp 114 | 2.73 | - | Perennial |
| 4 | Dhare Mul-2 | Sp 115 | - | - | Perennial |
| 5 | Pani Tanki | Sp 116 | - | - | Perennial |
| 6 | Biyeshi Dhara | Sp 51 | 1.02 | 1.02 | Perennial |
| 7 | Sathdeu Mul | Sp 32 | 19.04 | 13.5 | Perennial |
| 8 | Thafre Khola | Sp 33 a | 300.00 | 195 | Perennial |
| 9 | Thafre khola 1 (Siran mul) | Sp 33 b | 139.53 | 90.68 | Perennial |
| 10 | Saape Aahal | Sp 34 | 61.22 | 36.8 | Perennial |
| 11 | Sano Padhero | Sp 65 | - | - | Perennial |
| 12 | Dharabari Rupitar Mul | Sp 66 | 8.00 | 3.6 | Perennial |
| 13 | Jordhara | Sp 46 a | | - | Perennial |
| 14 | Jordhara Tankey | Sp 46 b | 10.00 | 7.8 | Perennial |
| 15 | Raniban Mul (Aahaldada Mul) | Sp 23 | 22.39 | 12.5 | Perennial |
| 16 | Suman Mul | Sp 52 | 3.49 | 1.8 | Perennial |
| 17 | Lama Chowk Mul (Sano Aahal) Tankhuwa Mul | Sp 49 | 6.91 | 3 | Perennial |
| 18 | Hemante Mul | Sp 53 | 28.21 | 17.04 | Perennial |
| 19 | Byapari Mul | Sp 57 | 4.36 | 4.02 | Perennial |
| 20 | Madhukhola Mul | Sp 58 | 11.43 | 7.5 | Perennial |
| 21 | Taraji Mul | Sp 56 | 2.77 | 2.4 | Perennial |
| 22 | Bohara Gaun Mul | Sp 55 | 12.07 | 6 | Perennial |
| 23 | Chapleti Bhirgaun Mul | Sp 71 | 26.32 | 18 | Perennial |
| 24 | Lungdang Khola Mul | Sp 24 | - | - | Perennial |
| 25 | Jalkanya Mul | Sp 68 | 1.49 | 2.25 | Perennial |
| 26 | Ritumardan Mul | Sp 69 | 9.27 | 8.45 | Perennial |
| 27 | Dhunge Mul | Sp 50 | 7.30 | 4.2 | Perennial |
| 28 | Debendra Pithakothe Mul | Sp70 | 3.6 | 1.5 | Perennial |
| 29 | Syalebari Mul | Sp 64 | 7.32 | 4.2 | Perennial |

*(-) cell defines no data available.

## Annex 8 : Selected springs for seasonal variability of in situ water quality

| Sp ID | pH_2020 | pH_2019 | TDS_2020 (ppm) | TDS_2019 (ppm) | Temp_2020 (°C) | Temp_2019 (°C) | EC_2020 (µS/cm) | EC_2019 (µS/cm) |
|---|---|---|---|---|---|---|---|---|
| Sp 47 | 7.51 | 7.85 | 25.1 | 21.2 | 14.7 | 15.6 | 46.3 | 29.9 |
| Sp 113 | 7.34 | 8.3 | 11.28 | 17 | 15.9 | 14.9 | 23.4 | 25 |
| Sp 114 | 5.93 | - | 49 | - | 17.5 | - | 97.3 | - |
| Sp 115 | 8.12 | - | 68.5 | - | 16.5 | - | 137.3 | - |
| Sp 116 | 7.6 | - | 48.8 | - | 13.2 | - | 98 | - |
| Sp 51 | 6.38 | 6.45 | 149.3 | 211 | 16.3 | 17.2 | 292 | 299 |
| Sp 33 a | 6.65 | - | 34.5 | - | 13 | - | 67.9 | - |
| Sp 33 b | 7.5 | - | 37.4 | - | 12.8 | - | 74.3 | - |
| Sp 34 | 7.67 | - | 23 | - | 16.3 | - | 47.2 | - |
| Sp 65 | 5.77 | - | 56.8 | - | 12.5 | - | 114.1 | - |
| Sp 66 | 6.63 | 6.95 | 50.7 | 71 | 16.6 | 16.9 | 100.3 | 100 |
| Sp 46 a | 7.44 | 7.61 | 20.4 | 28.6 | 16.6 | 16.3 | 41.8 | 40.3 |
| Sp 46 b | 7.44 | - | 20.4 | - | 16.6 | - | 41.8 | - |
| Sp 23 | 6.53 | - | 57.5 | - | 16.3 | - | 112.9 | - |
| Sp 52 | 7.56 | 7.18 | 34.7 | 47.2 | 16.5 | 17.5 | 69.8 | 66.4 |
| Sp 49 | 7.14 | 6.92 | 45.2 | 73.1 | 16 | 16.7 | 90.6 | 104 |
| Sp 53 | 6.96 | 7.6 | 39.3 | 53.8 | 15.6 | 19.7 | 78.8 | 75.7 |
| Sp 57 | 6.97 | 7.02 | 43.2 | 57.2 | 19.7 | 20.4 | 85 | 80.5 |
| Sp 58 | 7.08 | 6.81 | 39.2 | 49.6 | 9.1 | 19.3 | 70.2 | 69.3 |
| Sp 56 | 5.98 | 6.65 | 77.5 | 100 | 18.9 | 20 | 155.2 | 140.9 |
| Sp 55 | 7.56 | - | 27.6 | - | 13.2 | - | 55.2 | - |
| Sp 71 | 7.42 | 7.89 | 23.7 | 31 | 16.7 | 17 | 47.7 | 43.6 |
| Sp 24 | 7.42 | - | 36.2 | - | 14 | - | 72.6 | - |
| Sp 68 | 6.88 | 6.64 | 26.8 | 28 | 14.2 | 17.2 | 54.5 | 39.3 |
| Sp 69 | 6.07 | 6.75 | 39.3 | 49.1 | 17 | 17.1 | 78.6 | 69.2 |
| Sp 50 | 7.300 | - | 32.8 | - | 16.7 | - | 49.6 | - |
| Sp70 | 6.92 | 7.1 | 24.8 | 31.7 | 16.3 | 15.7 | 47.2 | 44.8 |
| Sp 64 | 7.100 | 6.87 | 39 | 48.1 | 15.8 | 17.5 | 76.8 | 68 |

*(-) cell defines no data available.

## Annex 9: Laboratory report of water quality: samples from various sources in Nibuwa –Tankhuwa Watershed

| S.N | Parameters | Unit | Fafre | Tankuwa Tank | PST2 | Marga Mul | SW3 | SW2 | SW1 | PST3 | PST1 | Salleri system |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Appearance | - | Clear | Clear | Clear | Clear | Clear | Clear | Clear | Clear | Clear | Clear |
| 2 | Turbidity | NTU | 5 | 1 | 1 | 1 | 0.9 | 1 | 1 | 0.8 | 2 | 1 |
| 3 | pH | - | 6.22 | 6.71 | 6.91 | 6.42 | 6.81 | 6.74 | 6.34 | 6.83 | 7.22 | 7.24 |
| 4 | Electrical conductivity | µS/cm | 51 | 58 | 92 | 232 | 53 | 52 | 76 | 93 | 85 | 68 |
| 5 | Total alkalinity as CaCO3 | mg/l | 16 | 20 | 36 | 30 | 16 | 16 | 20 | 40 | 36 | 24 |
| 6 | Total hardness as CaCO3 | mg/l | 12 | 20 | 24 | 72 | 16 | 12 | 24 | 24 | 28 | 20 |
| 7 | Calcium as Ca+2 | mg/l | 2.4 | 4 | 6.4 | 16 | 2.4 | 2.4 | 6.4 | 6.4 | 5.6 | 4.8 |
| 8 | Magnesium as Mg+2 | mg/l | 1.5 | 2.4 | 2 | 7.8 | 2.4 | 1.5 | 2 | 2 | 3.4 | 2 |
| 9 | Total Iron as Fe+2 | mg/l | 0.06 | 0.03 | 0.2 | 0.03 | 0.03 | 0.03 | 0.02 | 0.08 | 0.4 | 0.03 |
| 10 | Total Ammonia as N | mg/l | 0.02 | 0.03 | 0.03 | 0.02 | 0.05 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 |
| 11 | Nitrate as NO3- | mg/l | 18.9 | 3 | 1.48 | 11.3 | 4.7 | 5.35 | 16.7 | 1.25 | 3.57 | 1.8 |
| 12 | Chloride asCl- | mg/l | 8.52 | 8.52 | 11.4 | 39.8 | 8.52 | 8.52 | 12.8 | 8.52 | 8.52 | 10 |
| 13 | Manganese as Mn | mg/l | 0.1 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| 14 | Chromium as Cr | mg/l | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| 15 | Fluoride as F | mg/l | 0.55 | 0.6 | 0.34 | 0.49 | 0.45 | 0.38 | 0.55 | 0.39 | 0.34 | 0.54 |
| 16 | Residual Chlorine | mg/l | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

## Annex 10: Ponds profile of Nibuwa-Tankhuwa Watershed

| ID | Pond | Photograph |
|---|---|---|
| Sp92 | Sukeko Pokhari<br>Lat:27.013376 Long: 87.321805<br>Elevation: 1736 m<br>Ancient pond<br>As artificial plastic pond at present<br>Either side of highway |  |
| Sp106 | Jorpati Pokhari<br>Lat: 27.058181 Long: 87.378931<br>Elevation: 2266 m<br>Ancient pond at the top of ridge<br>Abandoned<br>In private land<br>Currently cabbage farm |  |
| Sp96 | Army Camp Pokhari<br>Lat: 27.048493 Long: 87.315739<br>Elevation: 2086 m<br>Rehabilitated a few years ago to store water<br>Not maintained now due to unavailability of water<br>Almost dried now |  |
| Sp60 | Army Camp Mul<br>Lat: 27.046626 Long: 87.316827<br>Elevation: 2118 m<br>Perennial spring<br>Used for domestic purposes<br>1 household<br>Favouring groundwater recharge |  |

| | | |
|---|---|---|
| Sp73 | Januka Pokhari<br>Lat: 27.04188 Long: 87.324607<br>Elevation: 1916 m<br>Spring water collection pond<br>Small but well maintained by land owner<br>Favouring groundwater recharge |  |
| | Soti Aahal<br>Lat: 27.0198 Long: 87.4000<br>Elevation: 1704m location: Chhathar Jorpati 3<br>Ancient pond<br>Dried now<br>Biggest pond in the watershed | |
| | Artificial ponds<br>Constructed in water scarce places<br>Used as animal husbandry<br>Sometimes used as vegetable farming as well as domestic |  |

## Annex 11: Deep borings in study area (data source: social mobilizer)

| S.N | Deep boring | Latitude | Longitude | Elevation (m) | Installed Date | Initial Discharge | Present discharge | Well depth |
|---|---|---|---|---|---|---|---|---|
| 1 | Bakratunda deep boring | 27.02383 | 87.3107 | 1920 | 2074 Falgun | 7 l/s | 7 l/s | 108m |
| 2 | Army Camp deep boring | 27.04106 | 87.3182 | 2036 | 2074 Chaitra | 4 l/s | 2.5 l/s | 130m |
| 3 | Jorpati deep boring* | 27.05715 | 87.37087 | 2159 | 2074 Jestha | 1 l/s | Dried | 140m |
| 4 | New road deep boring | 27.0359 | 87.3126 | 1947 | 2072 Falgun | 6 l/s | 4 l/s | 120m |

*Not functioning

## Annex 12: Month-wise sufficiency of income for livelihood in Dhankuta Municipality

| | 1-3 months | 4-6 months | 7-9 months | 9-12 months | More than 12 months | Not mentioned |
|---|---|---|---|---|---|---|
| Ward no. 1 | 103 | 182 | 16 | 13 | 1.324 | 1 |
| Ward no. 2 | 50 | 207 | 125 | 137 | 443 | |
| Ward no. 3 | 163 | 77 | 27 | 2 | 237 | |
| Ward no. 4 | 3 | 10 | 32 | 22 | 589 | 1 |
| Ward no. 5 | 1 | 27 | 30 | 7 | 647 | 7 |
| Ward no. 6 | 44 | 106 | 34 | 10 | 794 | 1 |
| Ward no. 7 | 160 | 53 | 38 | 46 | 864 | 1 |
| Ward no. 8 | 126 | 169 | 67 | 12 | 85 | |
| **Total** | **650** | **831** | **369** | **249** | **3660** | **11** |
| **Percentage** | **11.2645** | **14.4013** | **6.39479** | **4.31518** | **63.4336** | **0.19063** |

## Annex 13: List of participants

| S.No. | Name | Organisation | Address | Mobile No. |
|---|---|---|---|---|
| 1 | Ambika Ghimire | Nibuwa Tankhuwa Watershed | Dhankuta | 9842110627 |
| 2 | Arjun Chhurahang | Dhankuta Nagarpalika Khanepane Samiti | Dhankuta | 9862033071 |
| 3 | Babu Ram Karki | Chathar Jorpati | Dhankuta | 9842256103 |
| 4 | Ballabha Pangmi Magar | Chathar Jorp. Ward NO. 2 | Dhankuta | 9846671821 |
| 5 | Bhakta Man Rai | Dhankuta Municipality | Dhankuta | 9842116254 |
| 6 | Bhim Kala Shrestha | Chhathar Jorpati | Dhankuta | 9852050575 |
| 7 | Bijay Santoshi Rai | FNCCI Dhankuta | Dhankuta | 9842024971 |
| 8 | Bika Ram Rai | Dhankuta Municipality | Dhankuta - 5 | 9842096642 |
| 9 | Bikas Adhikari | Dhankuta Municipality | Dhankuta | 9852059952 |
| 10 | Bishnu Poddar | Dhankuta Municipality -5 | Dhankuta | 9852050987 |
| 11 | Chautislal Rai | Dhankuta M. Ward 8, Water User Group | Dhankuta | 9812318691 |
| 12 | Chintan Tamang | Mayor, Dhankuta Municipality | Dhankuta | |
| 13 | Durga Dhakal Basnet | Member, Samudayak Samaj | Dhankuta | 9842385741 |
| 14 | Gira Adhikari | HUSADEC-Nepal | Dhankuta | 9852070266 |
| 15 | Gyan Bahadur Limbu | Chathar Jorp. Ward NO. 3 | Dhankuta | 9842329093 |
| 16 | Hari Kumar Rai | Nepal Red Cross Society | Dhankuta 5 | 9842117503 |
| 17 | Harkha Prasad Limbu | Hile Khanepani UG | Hile, Dhankuta | 9862037764 |
| 18 | Jam Sher Rai | Dhankuta Municipality - 4 | Dhankuta | 9852070745 |
| 19 | Janga Bdr. Rai | Dhankuta Municipality -7 | Dhankuta | 9842255677 |
| 20 | Jeewan Prasad Rai | Tekhime Krishi Paramarsha Sewa | Dhankuta Hile - 1 | 9852053879 |
| 21 | Jyoti Pradhan | Solve-Nepal | Dhankuta | 9842103902 |
| 22 | Kabita Rai | Chhathar Jorpati | Dhankuta | 9842497300 |
| 23 | Kopila Shankar | Member, Nibuwa Tankhwa Watershed | Dhankuta | 9842070821 |
| 24 | Krishna Prasad Paudel | Cottage and Small Industry | Dhankuta Municipality | 985206128 |
| 25 | Lok Nath Dhungana | Vet. Hospital | Dhankuta | 9852022283 |
| 26 | Min Prasad Subedi | Pardep Nepal | Dhankuta - 7 | 9842062029 |
| 27 | Nil Bahadur Thap | FECOFUN, Dhankuta | Dhankuta | 9852050293 |
| 28 | Niren Tamang | Dhankuta Municipality - 2 | Dhankuta | 9842071357 |
| 29 | Patak Bahadur Thapa | Divisional Forest Office | Dhankuta | 9845604428 |
| 30 | Prakash Limbu | Soil Cons. Mgnt. Office | Dhankuta Municipality | 9855052639 |
| 31 | Puranshwori Rai | Dhankuta M. Ward 8 | Dhankuta | 9844757376 |
| 32 | Purna Maya Gurung | Krishi Gyan Kendra, Dhankuta | Dhankuta | 9852050424 |
| 33 | Radha Rai | Dhankuta Mun. Ward 8 | Dhankuta | 9825351492 |
| 34 | San Bdr. Rai | Dhankuta Municipality | Dhankuta | 9842026733 |
| 35 | Shakuntala Basnet | Deputy Mayor, Dhankuta Municipality | Dhankuta | 9852070888 |
| 36 | Sher Bahadur Bhujel | Shreedhoj Dharapani Tole, Chathar Jorpati 2 | Shreedhoj, Dhankuta | 9842062657 |
| 37 | Sumanta Yangbung | Vet. Office, Dhankuta | Dhankuta | 9842107080 |
| 38 | Narendra Rai | Patrakar Mahsangh | Dhankuta | 9852050100 |

| S.No. | Name | Organisation | Address | Mobile No. |
|---|---|---|---|---|
| 39 | Chuda Bohara | Chhatar Jorpati, Account Officer | Dhankuta | 9840721708 |
| 40 | Ram Bahadur Thapa | Chief Admin. Officer, Dhankuta Municipality | Dhankuta | 9852039111 |
| 41 | Damber Rogu | Admin. Officer, Dhankuta Municipality | Dhankuta | 9842038063 |
| 42 | Kabita Rai | Assistant Staff, Dhankuta Municipality | Dhankuta | 9842109722 |
| 43 | Narayan Thapa | Hotel Association | Dhankuta | 9852050717 |
| | | | | |
| **ICIMOD** | | | | |
| 1 | Kanchan Shrestha | Progrmme Coordinator | | |
| 2 | Nabin Bhattarai | Forest Land Restoration and REDD+ Research Associate | | |
| 3 | Gunanidhi Pokharel | Hydrology Research Associate | | |
| 4 | Pradhumna SJB Rana | Research Associate | | |
| 5 | Kabir Uddin | Geo-Infor. & Remote Sensing Specialist | | |
| 6 | Kripa Shrestha | Research Associate | | |
| 7 | Govinda Shrestha | Senior Programme Associate | | |
| 8 | Madhav Dhakal | Hydrological Analyst | | |

## Annex 14: Household activity distribution among male and female

| Household activities | Women | Men |
|---|---|---|
| Herding livestock | + | + |
| Carrying water | ++ | |
| Collecting forage | + | + |
| Transporting manure and application | + | + |
| Planting | ++ | |
| Feeding livestock | ++ | |
| Cooking | ++ | |
| Labour exchange (Parma) | + | + |
| Harrowing | ++ | |
| Weeding | ++ | |
| Planting | ++ | |
| Transplanting | + | + |
| Threshing | ++ | |
| Screening seeds | ++ | |
| Leaf litter collection | ++ | |
| Transporting, preparing feeding and livestock management | + | + |
| Seed selection | ++ | |
| Corn shelling | ++ | |
| Herding livestock | + | + |
| Ploughing | | ++ |
| Pesticide and fertilizer application | | ++ |
| Fuel wood collection | + | + |
| Marketing | + | + |

Based on the interviews with women's groups in Wards 8 and 4

++work solely done by either men or women, + work done by mutual participation

## Annex 15: Potential site for the construction of recharge structures

Various potential areas in Chhathar Jorpati Rural Municipality and Dhankuta Municipality were identified for the interventions in consultation with municipality, representative wards, Soil Conservation and Watershed Management Office.

| S.N. | Potential sites | Photo |
|---|---|---|
| **Dhankuta Municipality** | | |
| 1 | Suke Pokhari<br>Ancient dried pond (ward 1), Plastic lined where the rainwater is collected<br><br>Pond has the probability to collect rainwater and road runoff after renovation. The plastic is to be removed to allow infiltration and ground water recharge |  |
| 2 | Shivalaya Temple<br>There was a flowing spring a few years back<br>Seepage area was cemented by local people, after which discharge from the spring was reduced<br>Proposed plan is to revert it to what it was earlier and to construct a pond to collect seepage water |  |
| 3 | Dharabari Rupitar<br>Seepage area<br>Private land<br>Proposed activity: construct pond in the seepage area |  |

| | | |
|---|---|---|
| **Chhathar Jorpati Rural Municipality** | | |
| 1 | Four ponds in a Dhoje Dada area (27.05516˚ N, 87.38024˚) to be made<br>Estimated size of the pond will be about 5m x 5m with depth about 1m<br>The area lies in the Community Forest |  |
| 2 | Two ponds in a Dhoje Dada to be constructed (27.057302° N, 87.377432° E), which is the highest elevation in the NT Watershed |  |
| 3 | Chuldhunga Pond (27.04924° N, 87.38368° E)<br>Large pond can be renovated to increase capacity in this area<br>Community Forest |  |

## Annex 16: List of Community Forests in Nibuwa-Tankhuwa Watershed

| S.N. | Name of CF | Ward No. | Area (Ha) |
|---|---|---|---|
| **Dhankuta Municipality** | | | |
| 1 | Samsaari sukehphokari CF | 1 | 36.55 |
| 2 | Lungdaang aaitabaare CF | 1 | 24.67 |
| 3 | Lungdadevi CF | 1 | 18.23 |
| 4 | Bayerbote CF | 1 | 9.62 |
| 5 | Herchane CF | 1 | 112.5 |
| 6 | Dhadkharka CF | 2 | 41.41 |
| 7 | Chapehit CF | 2 | 10.36 |
| 8 | Syaule CF | 2 | NA |
| 9 | Dhasebaire CF | 2 | 102 |
| 10 | Madhuganga Salleri CF | 2 | 76.73 |
| 11 | Simle CF | 2 | 14 |
| 12 | Patle Pangsing CF | 3 | 34.32 |
| 13 | Sil Dhunga CF | 3 | 26.5 |
| 14 | Aitabare Raniban CF | 3 | 8.7 |
| 15 | Hadikharka CF | 3 | 201.07 |
| 16 | Kaagiyoghari CF | 3 | 23 |
| 17 | Wagle Salleri CF | 4 | 17.49 |
| 18 | Chureghati CF | 4 | 3.66 |
| 19 | Chaaraagaun | 4 | 129.89 |
| 20 | Badahari CF | 5 | 36.42 |
| 21 | Khanyubaas CF | 5 | 120.36 |
| 22 | Simle CF | 5 | 14 |
| 23 | Ghelpe Pantaagawaa CF | 7 | 32.41 |
| 24 | Kattike khop CF | 7 | 44.25 |
| 25 | Chuliban CF | 7 | 3524.75 |
| 26 | Tiridang CF | 8 | 6.18 |
| 27 | Chuliban Deurali CF | 8 | 32.61 |
| 28 | Sikaawaa saakilaa CF | 8 | 63.55 |
| **Chhathar Jorpati Rural Municipality** | | | |
| 29 | Himali Salleri CF | 2 | 100 |
| 30 | Gurungkhop CF | 2 and 3 | 80 |
| 31 | Dhojedhaara CF | 2 | 60 |
| 32 | Panchami CF | 3 | 2 |
| 33 | Taaklakharka CF | 3 | 677 |
| 34 | Laaligurans CF | 3 | 13.88 |
| 35 | Karunje CF | 3 | 7.35 |
| 36 | Singhadevi Patle CF | 3 | 5 |

## Annex 17: Floral and faunal species of Nibuwa-Tankhuwa Watershed area

### *Floral species of the watershed*

| S.N. | Species | | | Protection status | |
|---|---|---|---|---|---|
| | English name | Botanical name | Local name | National | IUCN |
| | GYMNOSPERMAE | | | | |
| 1 | Pine | *Pinus roxburghii* | Khote Salla | | LC |
| 2 | Sal | *Shorea robusta* | Sal | Protected | LC |
| 3 | Rosewood | *Dalbergia latifolia* | Satisal | Protected | VU |
| 4 | Sandalwood | *Santalum album* | Srikhanda | | VU |
| 5 | Ultrasum bead tree | *Elaeocarpus ganitrus* | Rudrakshaksya | Threatened | VU |
| 6 | Indian laurel, black murdah | *Terminalia elliptica* | Asna | | |
| 7 | Black plum | *Syzygium cumini* | Jamun | | LC |
| 8 | Indian butter tree | *Diploknema butyracea* | Chiuri | | |
| 9 | Silk cotton tree | *Bombax ceiba* | Simal | Protected | |
| 10 | Magnolia | *Magnolia champaca* | Champ | Protected | EN |
| 11 | Teak | *Tectona grandis* | Tuni | | |
| 12 | Cutch tree | *Acacia catechu* | Khayer | Protected | EN |
| 13 | Walnut | *Juglans regia* | Okhar | Protected | |
| 14 | Pink silk tree | *Albizia julibrissin* | Rato Siris | | |
| 15 | Air potato | *Dioscorea bulbifera* | Gittha | | |
| 16 | Rhododendron | *Rhododendron arboreum* | Laligurans | | LC |
| 17 | | *Machilus odoratissima* | Kaulo | | |
| 18 | Fragrant bay tree | *Phyllanthus emblica* | Amala | | |
| 19 | Shikakai | *Acacia concinna* | Sikakai | | |
| 20 | Malabar nut | *Adhatoda vasica* | Asuro | | |
| 21 | Holy basil | *Ocimum sanctum* | Tulasi | | |
| 22 | Asparagus | *Asparagus racemosus* | Kureelo | | |
| 23 | Chebulic myrobalan | *Terminalia chebula* | Harro | | |
| 24 | Belliric myrobalan | *Terminalia bellerica* | Barro | | |
| 25 | Soap nut | *Sapindus mukorossi* | Rittha | | |
| 26 | Bay leaf | *Cinnamomum tamala* | Tej Paat/Dalchini | | LC |
| 27 | Nepali pepper | *Zanthoxylum armatum* | Timur | | `LC |
| 28 | Broom grass | *Thysanolaea maxima* | Amriso | | |
| 29 | Mauwa | *Engelhardtia spicata* | Mauwa | | LC |
| 30 | Mug wort | *Artemisia dubia* | Tetipati | | |
| 31 | Tiger's milk spruce | *Falconeria insignis* | Khirro | | |
| 32 | Chinese tallow | *Rubus ellipticus* | Ainselu | | |
| 33 | Marking nut tree | *Semecarpus anacardium* | Bhalayo | | |
| 34 | Club moss | *Lycopodium clavatum* | Nagebeli | | |
| 35 | Needlewood tree | *Schima wallichii* | Chilaune | | LC |
| 36 | Chest-nut | *Castanopsis indica* | Katus | | LC |
| 37 | Nepal alder | *Alnus nepalensis* | Uttis | | LC |
| 38 | | *Symplocos ramosissima* | Kharane/ dabdabe | | |
| 39 | Himalayan tree hydrangea | *Hydrangea robusta* | Phirphere | | |
| 40 | Wolly dyeing rosebay | *Wrightia arborea* | Khiro | | |
| 41 | Barberry | *Berberis arista* | Chutro | | LC |
| 42 | Wood apple | *Aegle marmelos* | Bel | | |
| 43 | Stinging nettle | *Utrica dioica* | Sisnu | | |
| 44 | | | Dhokre ful | | |

## *Faunal species with their protection status of Nibuwa-Takhuwa Watershed*

| S.N | Species | | | Protection status | |
|---|---|---|---|---|---|
| | **English name** | **Scientific name** | **Local name** | **National** | **IUCN** |
| | **MAMMALS** | | | | |
| 1 | Golden jackal | *Canis aureus* | Syal | Common | LC |
| 2 | Macaques | *Rhesus macaque*<br>*Bonnet macaque* | Badar | Common | LC |
| 3 | Indian crested porcupine | *Hystrix indica* | Dumsi | Common | LC |
| 4 | Hare | *Lepus nigricollis* | Karayo | Common | EN |
| 5 | Jungle cat | *Felis chaus* | Ban biralo | Common | LC |
| 6 | Indian pangolin | *Manis crassicaudata* | Salak | Protected | EN |
| 7 | Wild boar | *Sus scrofa* | Badel | Common | LC |
| 8 | Spotted deer | *Axis axis* | Mirga | Common | LC |
| 9 | Yellow-throated marten | *Martes fluvigula* | Maalsaapro | Common | LC |
| | **BIRDS** | | | | |
| 10 | Egyptian vulture | *Neophron percnopterus* | Seto giddha | Protected | EN |
| 11 | Barn swallow | *Hirundo rustica* | Gauthali | Common | LC |
| 12 | Himalayan vulture/ Himalayan griffon vulture | *Gyps himalayensis* | Himali Giddha | Protected | NT |
| 13 | Common nightingale | *Luscinia megarhynchos* | Jureli/bulbul | Common | LC |
| 14 | Red jungle fowl | *Gallus gallus* | Lueche | Common | LC |
| 15 | Spotted dove | *Streptopelia chinensis* | Dhukkur | Common | LC |
| 16 | Sparrow | *Passer domesticus* | Bhangera | Common | LC |
| 17 | Indian/common peafowl | *Pavo cristatus* | Mujur | Common | LC |
| 18 | Common crow | | Kag | Common | |
| 19 | Common myna | *Corvus splendens* | Rupi | Common | LC |
| 20 | Black francolin | *Francolinus francolinus* | Kalo titra | Common | LC |
| 21 | Indian grey hornbill | *Ocyceros birostris* | Khairo Dhanesh | Common | LC |
| 22 | Asian pied starling | *Sturnus contra* | This is spotted owlet | Common | |
| 22 | Little egret | *Egretta garzetta* | Bakulla | Common | LC |
| 24 | Greenish warbler | *Phylloscopus trochiloides* | Fistechara | Common | LC |
| 25 | Kalij pheasant | *Lophura leucomelanos* | Kalij | Common | LC |
| 26 | Common cuckoo | *Cuculus canorus* | Cuckoo | Common | LC |
| 27 | Himalayan monal | *Lophophorus impejanus* | Danphe | Protected | LC |
| | **REPTILES** | | | | |
| 28 | Snail | | Ghonga/ghongi | Common | LC |
| 29 | Millipede | | Arimatthe/khajuro | Common | |
| 30 | Common lizard | | Cheparo | Common | |
| 31 | Snakes | | Sarpa | Common | |
| 32 | Bengal monitor lizard | *Varanus bengalensis* | Kaalo gohoro | Common | LC |
| 33 | Golden monitor Lizard | *Varanus flavescenes* | Sun gohoro | | LC |

## Annex 18: Nepal's drinking water quality standards

### Water quality measurement

Water quality can be measured by an in-situ test or laboratory test. A hand-held tracer, vials, strips, etc., can be taken to the field for the in-situ measurement. In-situ testing kits are easy to use and cheap in comparison with laboratory tests. There are different varieties of water quality tracers available in the market as per study purpose. Such tracers can measure basic parameters, viz., electrical conductivity (EC), salinity, hydrogen ion concentration (pH), temperature, total dissolved solids (TDS) and dissolved oxygen (DO). Vials that indicate the presence or absence of coliform contamination can be used to test for coliform contamination. Instead of tracers, sometimes water quality test strips are also used to carry out in-situ tests.

For the detailed investigation, samples should be collected systematically and taken to the laboratory. Laboratory tests, however, are expensive and more delicate. Hence, a lot of precautions should be taken when doing these kinds of tests.

| Group | Parameter | Unit | Maximum concentration limits |
|---|---|---|---|
| Physical and chemicals | Turbidity | NTU | 5 (10)** |
| | pH | | 6.5-8.5* |
| | Colour | TCU | 5 (15)** |
| | Taste and odour | | Would not be objectionable |
| | Total dissolved solids | mg/l | 1000 |
| | Electrical conductivity | µc/cm | 1500 |
| | Iron | mg/l | 0.3 (3)** |
| | Manganese | mg/l | 0.2 |
| | Arsenic | mg/l | 0.05 |
| | Cadmium | mg/l | 0.003 |
| | Chromium | mg/l | 0.05 |
| | Cyanide | mg/l | 0.07 |
| | Fluoride | mg/l | 0.5-1.5* |
| | Lead | mg/l | 0.01 |
| | Ammonia | mg/l | 1.5 |
| | Chloride | mg/l | 250 |
| | Sulphate | mg/l | 250 |
| | Nitrate | mg/l | 50 |
| | Copper | mg/l | 1 |
| | Total hardness | mg/l | 500 |
| | Calcium | mg/l | 200 |
| | Zinc | mg/l | 3 |
| | Mercury | mg/l | 0.001 |
| | Aluminium | mg/l | 0.2 |
| | Residual Chlorine | mg/l | 0.1-0.2* |
| Micro germs | E-Coli | MPN/100ml | 0 |
| | Total Coli form | MPN/100ml | 95 % in sample |

Note : * These standards indicate the maximum and minimum limits.

** Figures in parentheses are the upper range of the standards recommended.

Sources: Environment Statistics of Nepal 2008, Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Kathmandu, Nepal

ICIMOD

Australian Aid

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Government of Nepal

**Dhankuta Municipality**

Office of Municipality

Dhankuta, Province #1, Nepal

www.dhankuta.gov.np