Sub watershed delineation, prioritization and preparation of Seti Nadi 1 sub watershed management plan of Tanahun District of Gandaki Province, Nepal

Submitted To

Soil and Watershed Management Office

Damauli, Tanahun, Gandaki Province

Submitted By

SMART Private Limited
Anamnagar- 29, Kathmandu
☎ 01-4254409/9851202141
Email: smartpvt@outlook.com
Web site: www.smart.info.np

July 2020

Table of Contents

FOREWORD

Soil, water and forests are principal natural resources of Nepal. Appropriate management of these resources can contribute in the overall development of the nation. Despite the paramount importance of such resources in the socio-economic development of the country, deterioration of the resources is omnipresent. Hence, management of these resources has been a major challenge in our Nepalese context.

Soil conservation and watershed management is one of the major program components of the Ministry of Forest and Environment (former Ministry of Forests and Soil Conservation). Before federal system, the Department of Soil Conservation and Watershed Management (DSCWM) was the mandated government agency under the ministry to carry out Soil Conservation and Watershed Management (SCWM) program and district level Soil Conservation Office was the implementing agency of SCWM activities in the district level. Now in the changing federal system of Nepal, the DSCWM and Department of Forests combined together and the named as Department of Forests and Soil Conservation. In provincial level, the implementing agency of SCWM program is Soil and Watershed Management Office (SWMO).

In order to meet the objectives of the SCWM program, the government has adopted policies and strategies in different periods. For the purpose, sub watershed area has been considered as planning and management unit for implementing integrated watershed management package programs that include vegetative, agronomic and water management measures.

Working areas of SWMO Tanahun are 6 districts {(Kaski, Tanahun, Lamjung, Manang, Gorkha and Nawalpur} of Gandaki Province. The working districts fall mainly in High Himalayas to middle mountain areas and vulnerable Terai physiographic zone of the country where watershed condition is at marginal condition. Soil erosion and landslides are common problems in up-stream areas and floods with riverside cutting problems in down-stream area. Loss of human lives and properties has been very serious problem and big challenges. To address such problems, SWMO Tanahun has planned to focus its program at vulnerable sub watershed areas of the working districts. To implement the approved SCWM programs, the prioritization of sub watersheds of each individual district is must in this context. Sub watershed management planning is another very important part for effective implementation of approved SCWM program.

With the advent of modern technologies such as Geographic Information System and Remote Sensing, the prioritization of sub watersheds of Tanahun District has been carried out and management plan of the prioritized sub watershed areas have been prepared by using these tools. I

would like to express my thanks to the consulting team of SMART Pvt. Ltd. I also express my thanks to office staff particularly Soil Conservation Officer Bidurnath Sapkota, Chandra Prakash Sedai, Watershed Management Officer Shyamsundar Adhikari, Soil Conservation Assistant Umanga Baral, Administration Officer Shreekant Neupane, Accountant Kamal Bhattarai and all other staff of SWMO Tanahun for their help in the course of prioritization of sub watersheds and preparing the management plan.

My sincere thanks goes to Honorable Minister Bikas Lamsal and Secretary Dr. Deepak Kumar Kharal for encouraging us to conduct this study with budgetary support. I would like to thank to Officer Tenth Narayan Acharya, Officer Eighth Shiva Pariyar and Officer Seventh Saroj Panthi of Planning Division of Ministry of Industry, Tourism, Forest and Environment (MOITFE) for planning and budgeting to conduct this study. Last but not the least, I would like to thank Province Forest Director Kedarnath Paudel and undersecretary Indra Prasad Adhikari for their generous support in preparing this plan.

Diwakar Paudel

Senior Watershed Management Officer

Date: 2077/3/25 **Soil and Watershed Management Office, Tanahun**

Abstract

Sub watershed prioritization is the ranking of different sub watersheds of a watershed according to the order in which they have to be taken up for development. The watersheds need to be prioritized for taking up the developmental activity, based on the severity of the problems in the watershed. The study is conducted to prioritize the sub watersheds of Tanahun District of Gandaki Province, Nepal, to map the hazards of the district and to prepare the sub watershed management plan of most vulnerable sub watershed. The criteria for prioritizing the sub watershed are based on its bio-physical and anthropogenic value. Bio-physical value provides 60% weight and anthropogenic value provides 40% weight for the study. Household survey, PRA, RRA, field observation, local body profile survey, operational plan of community forest user group, annual reports of SWMO, both published and unpublished literatures, reports and other related documents are the major tools for data collection. Data were analyzed using ArcGIS, Maximun Entropy (MaxEnt), Geofabrik, WorldClim database, USGS and Exel software. A total of 17 sub watershed are delineated in this district. Finally, sub watershed management plan of Seti Nadi 1 sub watershed was prepared. This sub watershed covers the 141 km^2 area of Suklagandaki Municipailty, Bhimad Municipality and Myagde Rural Municipality of Tanhun District. Total NRs 148050000 is proposed for proper management of Seti Nadi 1 Sub Watershed for five years. This sub watershed may be taken up with development and management plans to conserve natural resources on a sustainable basis with immediate effect, which will ultimately lead to soil and water conservation for benefit of people.

Keywords: *Anthropogenic value, ArcGIS, bio-physical value, prioritization, management plan, sub watershed*

1. INTRODUCTION

1.1 Background

A watershed is an area with a fixed drainage (water) divide as a boundary and drained through a common outlet of river/ creek or stream drained to a common place, such as lake or outlet. The term 'drainage basin' is commonly used in American literature to mean the watershed, but its British equivalent is 'catchment'. Watershed, catchment area, drainage area, river basin and drainage basin are terms that are generally used interchangeably and are defined as above. Although the difference between these words is probably not defined the first three terms – watershed, catchment area and drainage area - should be used comparatively for the small streams and rivers, whereas river basin or drainage basin is the aggregation of several watersheds, catchment area or drainage area (Sthapit, 1998). Watershed of small streams or small segment of the river is sub watershed. The area of sub watershed is varied according to the area of management units (countries, districts and so on).

Land, water and forest make major natural resources within a watershed. There are strong linkages between these natural resources. The use of one resource will have effects on another. Also, the peoples and their socio-economic and cultural behavior, external interests on the watershed resources, and policies on the use of these resources will have effects on these resources. Therefore, interactions among different factors such as population dynamics, livelihood systems, external interests, policies, norms and laws have to be considered in watershed management (FAO, 2006).

Soil conservation and watershed management activities have been widely acknowledged at field level but necessary data, technology, planning, and budget are felt insufficient. Moreover, the implementation part has been a challenge for the different political units in different aspects like lack of coordination, consideration of upstream-downstream linkages, partial and incomplete solutions of problems on the same river system and other socio-cultural issues at the field level. As water runs across different political boundaries, the best way to manage is to address the natural and hydrological units of the river basin by bringing together all the interests of upstream and downstream. However, previously implementation of soil and watershed conservation programs had been implemented within the political units (districts) as working boundaries. That approach makes life difficult for the natural resource manager to bring coordination, cooperation and synergy of the conservation efforts among the upstream and downstream stakeholders.

Nepal is situated in the central part of the Himalaya (26022' - 30027' N, 80004' - 88012' E), covering an area of 1,47,181 km^2 and an elevation ranges from 67 m to 8848 m. Nepal has diverse climates due to the large variation in elevation. The climate varies from a humid tropical type in the tropical lowlands in the south to alpine cold semi-desert type in the trans-Himalayan zone (Ohsawa et al., 1986). Nepal's forest ecosystems can be categorized into 10 major groups based on climatic conditions: (1) tropical, (2) subtropical broad-leaved, (3) subtropical conifer, (4) lower temperate broad-leaved, (5) lower temperate mixed broad-leaved, (6) upper temperate broadleaved, (7) upper temperate mixed broadleaved, (8) temperate coniferous, (9) subalpine, and (10) alpine scrub (Stainton, 1972). The average annual rainfall is around 1000 – 2000 mm, but sometimes it exceeds 3000 mm in some lower parts of the country (Ichiyanagi et al., 2007). Nepal has a diverse geography that ranges from permanent snow and ice-covered very rugged Himalayan Mountains in the north to the tropical alluvial plains in the south. Due to variations in climate and topography, Nepal is classified into five physiographic zones (i.e., Terai, Siwalik, Middle Mountain, High Mountain and Himalaya) (Barnekow Lillesø et al., 2005; Shrestha et al., 2010).

Gandaki is one province out of seven provinces of Nepal. This province is situated in the center part of Nepal by covering the 11 districts: Nawalpur, Tanahun, Gorkha, Lamjung, Kaski, Syanjya, Parbat, Baglung, Myagdi, Manang and Mustang. Similarly, there are 85 local administrative bodies, Nepal's biggest Pokhara Metropolitan City, 26 Municipalities and 58 Rural Municipalities. There is a constitutional provision of 60 members including proportional to the state assembly (MoITFE, 2018). In the north-central part of Nepal, the Gandaki Province is spreading from Himal to Terai from north to south. Near the border of India, the lowest part near the Gandak canal of Narayani River is at the height of 93 meters above sea level. This height went up gradually to Dhaulagiri is a huge iceberg with 8,167 meters, Manasalu 8,163 meters, and Annapurna first 8,091 meters. In this state, only the high Himalayan mountain range has fallen to the middle of the country. The valley is situated in the upper part of Manang, Mustang, and Gorkha. Apart from this, the vast majority of natural areas like mountainous, wind, soil, environment, biological diversity, is in this province (MoITFE, 2018). This province consists of five distinct geographical regions: Himalaya, High Mountains, Middle Mountains, Shiwaliks and Terai or Inner Madhes.

Around 37.1% area of the province is covered by forest. Major trees species of the province are *Shorea robusta, Dalbergia sissoo, Acacia catechu, Pinus roxburghii, Schima wallichii,* and *Castenopsis indica.* The major forest management models exercised in the province are community forest management, collaborative forest management, and block forest management. The scientific forest management program was launched in all these forests throughout the province. Guchchi Chyau (*Morchella esculenta*), Kurilo (*Asparagus officinalis*), Lauth Salla (*Taxus baccta*), Nirmasi (*Delphinium denudatum*), Okhar (*Juglans regia*), Paakhanved (*Bergenia ciliate*), Panchaule (*Dactylorhiza hatageria*), Satuwa (*Paris polyphylla*), Sungadhwal (*Valeriana jatamansi*), and Timur (*Zanthoxylum piperitum*) are major NTFPs of the province (MoITFE, 2018).

Gandaki Province is rich in protected areas. Around 45.68 % area of the Gandaki Province is covered by protected areas. Annapurna Conservation Area, Manaslu Conservation Area, some parts of Dhorpatan Hunting Reserve and Chitwan National Park are situated in this province. Annapurna Conservation area is famous for mountain trekking and unique landscape, Dhorpatan Hunting Reserve is popular for trophy hunting of blue sheep and Himalayan tahr. Similarly, Chitwan National Park is famous for rhino and tiger, and the Manaslu Conservation Area is famous for trekking, unique landscape, and mountain biodiversity (DNPWC, 2017; MoITFE, 2018).

Tanahun District, a part of Gandaki provenance, is one of the seventy-seven districts of Nepal. The district, with Damauli as its district headquarters, lies in between 27° 36' to 28° 5' N latitude and 83° 57' to 84° 34' E longitudes with an area of 1,546 km^2. Its elevation ranges from 187 m above sea level to 2,323 m above sea level and its topography is characterized by northwest to southeast running hill chains with moderate to very steep slope, deeply cut river valleys and gentle to moderate sloped plains. The neighboring districts of Tanahun are Gorkha and Chitwan in east, Chitwan and Nawalpur in south, Kaski and Syanja in west and Kaski and Lamjung in north. The district is full of rivers such as Marsyangdi, Madi, Trishuli, Seti along with other rivulets. Tanahun consists of 3 climatic zone; low tropical, upper tropical and subtropical with an elevation range of below 300m, 300m to 1000m and 1000m to 2000m respectively.Forests covers an area of 78,111.22 ha, agro based area covers an area of 64,061 ha, and pasture land covers an area of 4,306 ha.

At the time of the 2011 Nepal census, Tanahun District had a population of 323,288. Of these, 61.9% spoke Nepali, 20.8% Magar, 8.3% Gurung, 4.1% Newari, 1.1% Darai, 0.8% Urdu and 0.7% Tamang as their first language. The district is politically divided into 10 Municipalities, out of which four are urban municipality and six are rural municipalities.

Nepal is soil erosion vulnerable country due to its fragile topography and irregular rainfall pattern. The surface erosion rate on laterite slopes varied from 0.03 to 1.53 cm y−1 depending on land cover and slope gradient in the Mid Hill region of Nepal (Higaki et al., 2005). A recent study shows that soil erosion rates ranging from 0.03 to 100.33 t/ha/year in the hilly watershed of western Nepal. Abandoned terraces and degraded forests are major consequences of landslides (Gerrard and Gardner, 2002). In Nepal, intense rainfall and conventional tillage practices coupled with poor soil structure and steep slopes are the main drivers of soil erosion (Chalise et al., 2019). After the enforcement of the new constitution of Nepal in 2072, the responsibility for watershed management has been shared among local government, the provincial government and federal government and four basin management centers have been established by the federal government. Basin Management Centre, Gandaki is one among them; Then the Department of Soil Conservation and Watershed Management (now merged as Department of Forests and Soil Conservation) implemented various projects, programs and regular programs on watershed approach. The climate is dominated by the Indian summer monsoon system; about 80% of the precipitation falls between June and September (Panthi et al. 2015). During this season, heavy rainfall commonly leads to water-related disasters such as landslides in the hills, flash floods in the Siwaliks, and riverine floods in the plains. The spatial distribution of precipitation varies across the zones creating microclimates that affect annual water availability. In the hills, springs are a major source of water and depend on annual rainfall to recharge the aquifers that feed them. The river discharge varies throughout the year influenced by both snowmelt and precipitation. The hydrograph of the Devghat stations in Chitwan District (below the confluence of the Kali Gandaki and Trishuli Rivers) showed a seasonal variation in average monthly discharge in the period 1963–2010 ranging from 277 m^3/sec in March to 4,634 m^3/sec in August. The maximum daily discharge recorded was 14,100 m^3/sec on 05 August 1974. The daily values show a rise in discharge from May contributed by snow and glacier melt, followed by a further increase resulting from rainfall run-off from June onwards. Manandhar et al. (2012) observed a (statistically insignificant) increasing trend in the pre-monsoon and post-monsoon discharges and a decreasing trend in annual minimum discharge at Kotagaon station over the period 1964–2006.

Gandaki Province is vulnerable to soil erosion due to its sloppy topography and high rainfall around Pokhara Valley. Landslides, flash floods, river cuttings and gully erosion are major causes of human casualties and properties loss in this province. Due to the presence of bare and no vegetation land Mustang and Manang Districts are vulnerable to wind erosion. Apart from this haphazard rural road

construction practices in rural and local areas increase soil and landslide in upstream areas and flash floods at downstream areas. It has been very big challenges and issues in natural disasters in these days in Nepal. To address these issues and challenges of soil erosion, landslides and floods, the sub watershed prioritization is a scientific way of selecting the most vulnerable among all watersheds of the district. Due to limited resources for conservation and management, prioritization should be conducted to identify the most vulnerable sub watershed. The managers should allocate more resources for these prioritized subs watersheds.

Delineation of sub watersheds within a large drainage basin and their prioritization is required for proper planning and management of available resources for sustainable development. Delineation of potential zones for implementation of conservation measures above the entire watershed at similar occurrence is inaccessible as well as uneconomical; therefore it is a prerequisite to apply the appropriate technique for prioritization of sub watersheds. Watershed prioritization has gained importance in natural resources management, especially in the context of watershed management when managers have limited resources. Quantifying soil erosion hazard and spatial prioritization of sub watersheds would aid in better watershed management planning and implementation of soil conservation and watershed management activity in the prioritized sub watershed.

1.2 Rational of Study site

For Watershed management activities a Watershed management plan is essential to know the overall situation of the Watershed including natural resources and socio-economic assessment of the area and also the possible intervention and implementation strategy for the better outcome of the different intended watershed management activities. Out of 17 sub watershed in Tanahun District, Seti Nadi 1 sub watershed (141 sq km) is the first priority watershed with respect of biophysical and demographic analysis.

Increasing population has created intense pressure on agriculture and in turn our subsistence agriculture system is widely claiming the forest land. Quantitative and qualitative degradation of resources is due to our primitive farming system which practices unscientific land use and over exploitation. Here is an immediate need to plan an integrated approach so as to manage natural resources more scientific in a sustainable way. Scientific management tools with respect to certain bio-physical and socio-economic condition of any area is most needed to have an effective outcome of the applied economic and human resources.

Bottom up approach in the development planning is adopted to make this sub watershed management plan. The available natural resources, socio-economic condition of the local people residing within the sub watershed area and other bio-physical condition has been assessed by the study team. Suklagandaki Municipailty, Bhimad Municipality and Myagde Rural Municipality also demands the similar type of work in this site as this is very important to conserve this area. The sub watershed area is exploiting in the name of development. After effective implementation of the plan, there will be easy supply of water and other natural resources to the surrounding area. Hence the Watershed management plan is hoped to be a key for the proper planning, management and utilization of the available natural resources towards a prosperous socio-economic as well as ecological condition of the selected urban watershed area.

1.3 Objectives

The general objective of the study is to prioritize the sub watershed for management and conservation purpose. Specific objectives are as follows

- To identify the all sub watershed within the study area
- To find out the most vulnerable sub watershed and prioritize for the conservation and intensive management
- To map the water induced hazards in the Tanahun district
- To prepare the management plan of top vulnerable sub watershed

The plan envisages sound ecological balance for enhancement of socio-economic situation of people in the watersheds.

1.4 Scope and Limitation

This study is conducted by the by SWMO, Tanahun (by the help of SMART Pvt. Ltd.) more focused on the problems related to water source degradation and their possible treatments within the Seti Nadi 1 Sub Watershed area. Scope of this plan includes a clearly defined geographic area within which the integrated sub-watershed management plan will be implemented and clearly identified environmental and social issues that need to be addressed so that management efforts can be effectively targeted to achieve the objectives. The main scope of the plan is to prepare a strategic

document for increasing productivity and utility of land and water resources for biodiversity conservation as well as local communities' livelihood.

Current situation of natural resources over exploitation, the scope of watershed management plan is wide which emphasized measures related with:

- The proper / rationale utilization of different land uses (agriculture, forest, range and pasture) according to its capability or suitability,
- Improvement of the productivity of the land in perpetuity through appropriate bio-conservation measures while fulfilling the basic needs of the population such as food, fodder, fuel-wood, timber and water,
- Efficient harvesting, conservation and utilization of water resources for drinking, irrigation and other uses,
- Management of the water addressing climate change and the water induced disaster (drought, flood, and slope failure) related problems by applying proper soil and water conservation measures,
- Mitigation measures to reverse the erosion processes.

Watershed management plan gives detail about the bio physical and socio-economic information of sub watershed area and recommends the scientific land use and watershed management activities according to its situation analysis. Intended output at the end year of the program implementation will be the sufficient and sustainable drinking water supply and the socio-economic condition of the local people will be uplifted and also their knowledge and attachment with natural resources conservation and management issues. Biophysical and socioeconomic analysis of this study were based on secondary data generated by different organizations thus results may vary from the current situation as coverage of different land use has changed in recent time. Due to the limited financial resources, detail field verification was not possible which may have overshadowed few critical issues. However field issues and problems had been tried to address properly so that they can be incorporated in activities. More importantly this study has sufficient room to incorporate any advices and suggestions in coming days to make it more practical and creditable.

2 MATERIALS AND MATHODOLOGY

2.1 Study area

Tanahaun district is one of the district of Gandaki Province, Nepal. This district covers an area of 1,546 km^2 and geographically located at 27° 55' 0 N latitude and 84° 15' 0 E longitude. Its neighbouring district is Gorkha and Chitwan in east, Chitwan and Nawalpur in south, Kaski and Syanja in west and Kaski and Lamjung in north. The district consists of 10 Municipalities, out of

which four are urban municipality and six are rural municipalities. The district is full of rivers such as Marsyangdi, Madi, Trishuli, Seti along with other rivulets. Tanahun consists of 3 climatic zone; low tropical, upper tropical and subtropical with an elevation range of below 300m, 300m to 1000m and 1000m to 2000m respectively. The average climate figure for Tanahun is a 6.5. This is based on various factors, such as average temperatures, the chance of precipitation and weather experiences of others. Tanahun has the moderate climate prevailing. Forests covers an area of 78,111.22 ha, agro based area covers an area of 64,061 ha, and pasture land covers an area of 4,306 ha.

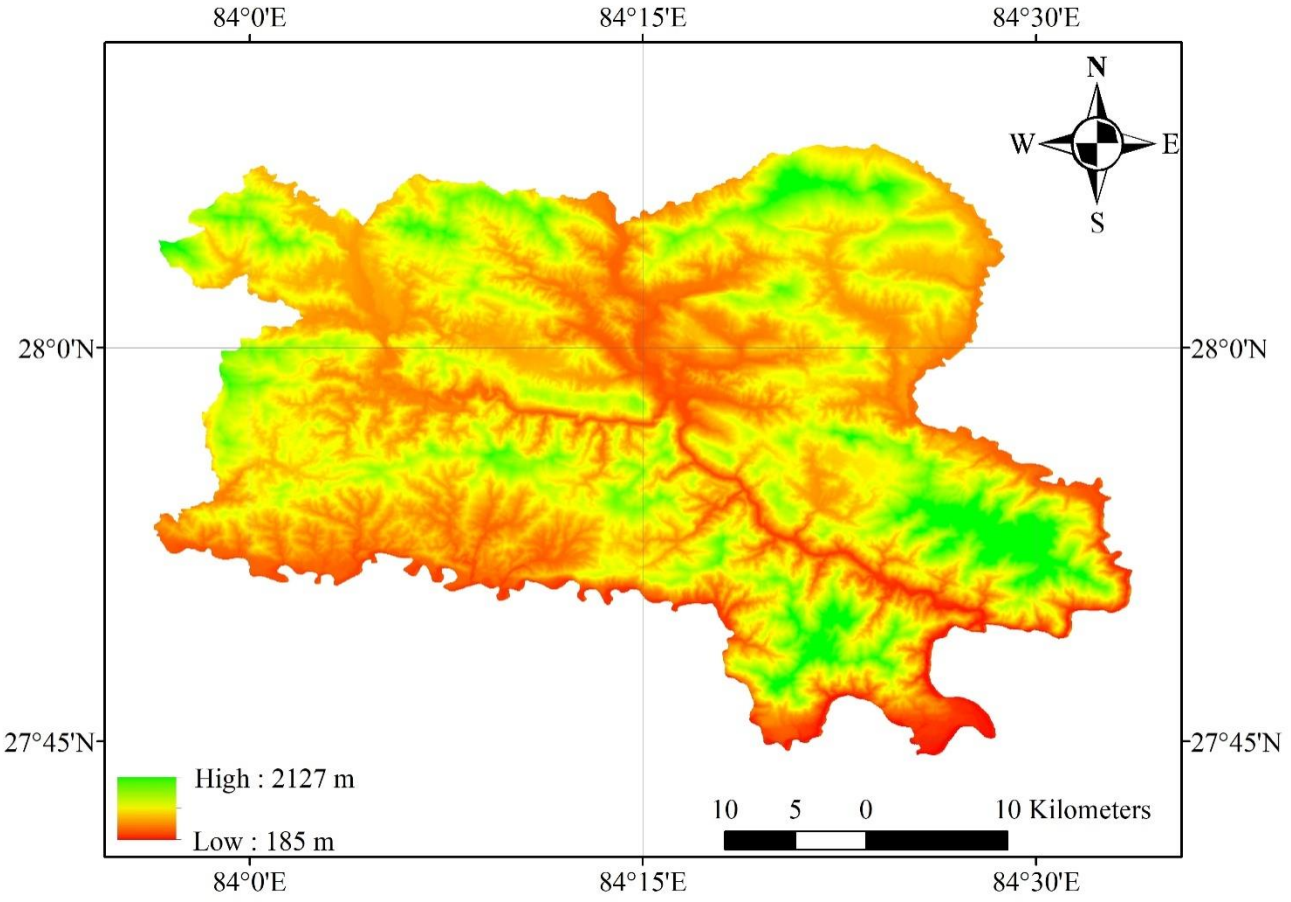


Figure 1: Study area with digital elevation model

2.2 Sub basin and Sub watershed delineation

Sub-basins were delineated by the help of ArcGIS (ESRI, 2017). First of all, Digital Elevation Model (DEM) having 30 m spatial resolution was downloaded from USGS website (https://earthexplorer.usgs.gov/) (USGS/EarthExplorer, 2017). Sub-basins were calculated by using basin tool of ArcGIS (ESRI, 2017). Sub-basin raster file was converted to the polygons and final sub-basins were mapped. Sub watershed delineation

Similar to the basin and sub basin delineation, sub watersheds were delineated using ArcGIS (ESRI, 2017). DEM file of district was refined by fill tool; then flow direction tool was used to prepare flow direction raster; flow accumulation tool was used to prepare the flow accumulation raster; raster calculator was used ("flow_accumulation_raster>5000") and give name "flow_accumulation_raster 5000".tif to extract the streams where water come from more than 5000 pixels. After that, point shape files of pour point were created at outlet of the watershed; watershed tool of ArcGIS was used (use flow direction raster as input raster) to prepare the raster file of sub watershed. Finally, raster files were converted to polygons using raster to polygon tool. For large streams, segments of stream were delineated as sub watersheds. At the time of segmentation, areas of sub watersheds were balanced (try to make equal sizes of watershed within the district) and considered the local level (try to segment based on the boundary of the local level). Delineation process tried to inbound the watershed in a single local level (Metropolitan City, Municipality and Rural Municipality).

2.3 Sub watershed prioritization

Sub watersheds are prioritizing based on the morphometric characteristics of the sub watersheds (Abdul Rahaman et al., 2015; Arulbalaji and Padmalal, 2020), sediment yield (Adhami and Sadeghi, 2016), climatic, vegetation related, topographical and socio-economic data (Vittala et al., 2008). This study has followed the methodology suggested by Sthapit (1998) for sub-watershed prioritization which includes the biophysical and anthropogenic characteristics. The study provided 60 % weight for the biophysical and 40 % weight for the anthropogenic characteristics. These two important characteristics are combined into comprehensive sub watershed priority values. Spatial analysis of prioritization was conducted in ArcGIS (ESRI, 2017). The steps involved are described below.

2.3.1 Bio-physical characteristics

Biophysical characteristics are the major characteristics that play a major role in soil erosion. The slope is a major factor to determine the severity of soil erosion. In high slope, the velocity of runoff and erosivity of water is also high. Similarly, the vegetation cover is also a key factor to determine the erosion potentiality of the area. High vegetation cover can reduce soil erosion than low vegetation cover.

Step I Preparation of land use erosion potential (LUEP) map

As suggested by Sthapit (1998), land use erosion potential (LUEP) map is prepared by marking high, moderate, and low erosion potential areas. The alphabetic symbols H or M or L are given to indicate

high, moderate and low erosion potentials. Slope more than 30° is considered as high, slope between 5° to 30° is considered as medium and slope less than 5° is conserved as low erosion potentials. Slope map of Tanahun district is shown in **Figure 2**.

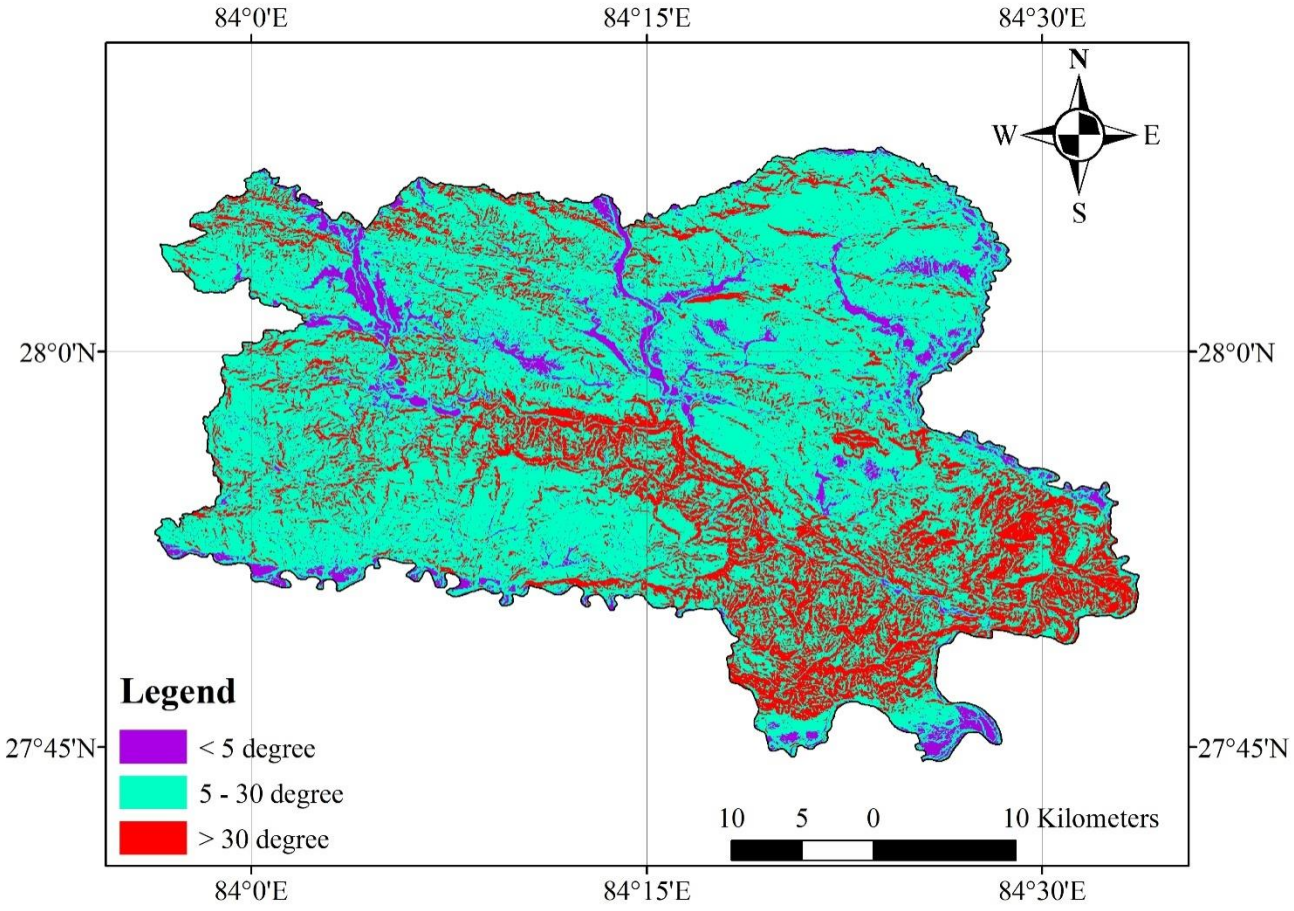


Figure 2: Slope of the Tanahun District

Step II. Preparation of land system erosion potential (LSEP)

As suggested by Sthapit (1998), land system erosion potential (LSEP) map is prepared by marking high, moderate and low erosion potential areas. The alphabetic symbol h or m or l, are given to indicate high, moderate and low erosion potentials. Agricultural land, bare land and riverside were considered as high; open forest, shrub land, grassland and lake were considered as medium and close forest, built-up area, snow and glacier were conserved as low erosion potentials. Land use / land cove maps of this district is shown in **Figure 3**.

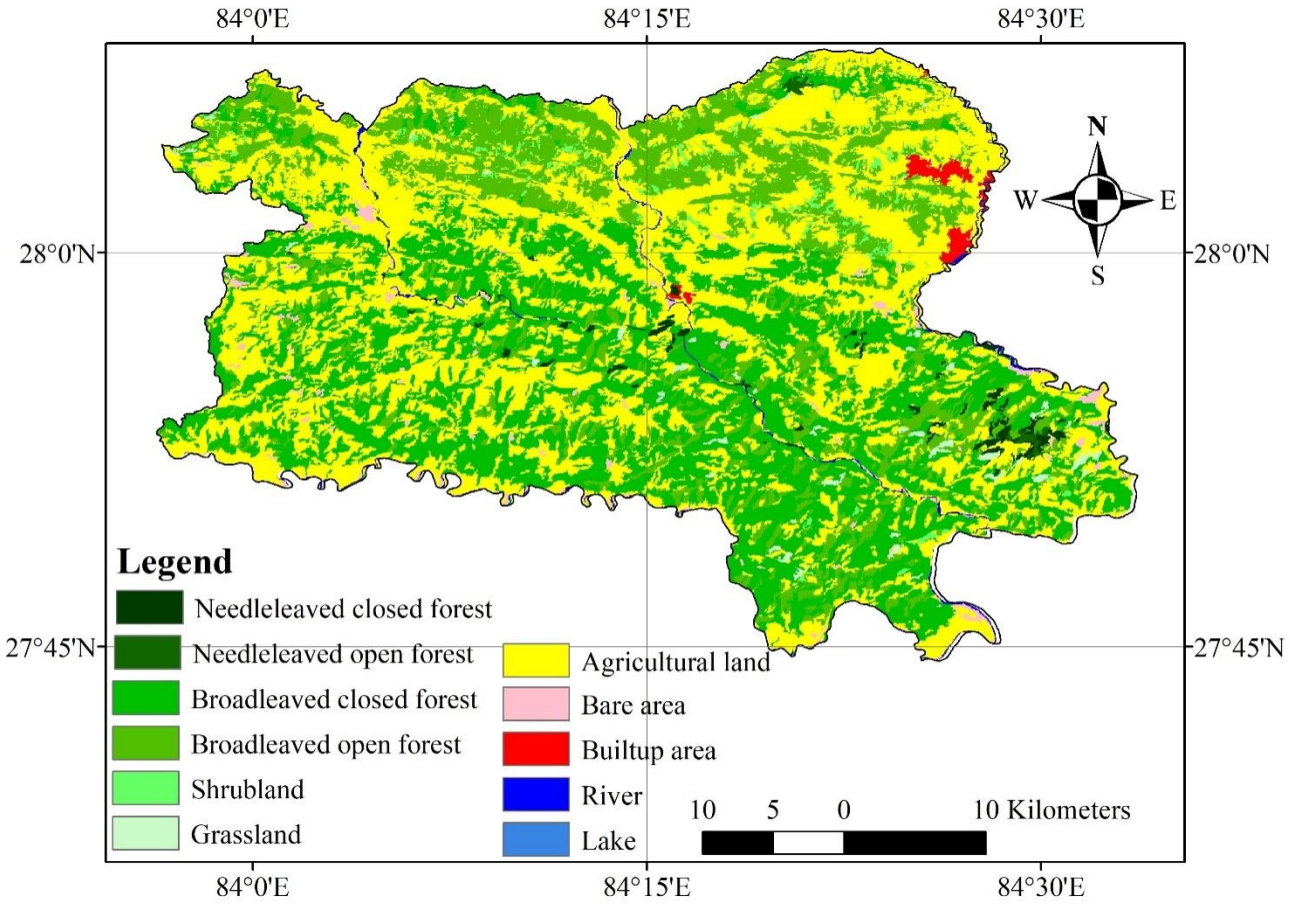


Figure 3: Land use/land cover of Tanahun District

Step III Preparation of erosion potential composite (EPC) map

An erosion potential composite (EPC) map is prepared by overlaying the land use erosion potential (LUEP) map on the land system erosion potential (LSEP) map. The common areas are overlapped by LUEP and LSEP was marked. These overlapped areas are given double letter symbols taken from LUEP and LSEP. The symbols always start from the LUEP map. For example, when LUEP is M and LSEP is l, the symbol given on the EPC map is Ml.

The double letter symbols of the composite map are converted into single letters to indicate very high, high, moderate, low and very low land use land system erosion potentials (LULSEP). The final indication of very high, high, moderate, low and very low erosion potentials are made using the following conversion table.

Single letter symbol of LULSEP	Double letter symbol of LULSEP
Very high (H)	Hh
High (h)	Hm, Mh
Moderate (M)	Hl, Mm, Lh
Low (L)	Lm, Ml
Very low (l)	Ll

Step V Calculation of very high, high, moderate, low, very low erosion potential areas

The composite map (explained in Step IV) and the sub watershed map (explained in Step I) are overlaid. The very high, high, moderate, low and very low LULSEP areas for each sub watershed were calculated by the help of ArcGIS (ESRI, 2017).

Step IV Estimation of land use land system erosion potential value (LULSEPV)

Very high, high, moderate, low and very low LULSEP areas are given 8,6,4,2 and 1 numerical values to enable quantitative comparison of sub watersheds. The erosion severity for each sub watershed called the land use land system erosion potential value (LULSEPV) based on biophysical parameters is calculated in numerical terms using the following equation.

LULSEPV = {(Very high area* 8) + (high area*6) + (moderate area*4) + (low area*2) + (very low area*1)}/Total area of the sub watershed

Step V Estimation of sub watershed biophysical value (SWSBPV)

Biophysical and population parameters are combined in finalizing the sub watershed prioritization. Biophysical and population parameters are given 60% and 40% weight in the prioritization. 1 is the least possible LULSEPV reflecting null priority in adopting soil conservation and watershed management measures. Similarly, sub watershed with highest LULSEPV carries the greatest weight, i.e. 60. For prioritization of the sub watershed, the estimated LULSEPV is calibrated in a 0 to 60

scale starting from 1 as the highest value using the following equation where LULSEPV is the land use land system erosion potential value of the sub watershed derived in Step IV.

SWSBPV = (LULSEPV – 1) / (Highest LULSEPV -1)*60

2.3.2 Anthropogenic characteristics

Resource degradation caused by ecological phenomena in the Nepalese hills is thought to be beyond the control of soil conservation and watershed management measures on financial an economical grounds. Therefore, resource degradation triggered by human activities is the main concern of watershed management professionals. In the rural context, with very little off-farm economic activity, most people depend for their livelihood on existing watershed resources such as land, water, vegetation and livestock. The increasing population exerts pressure on these resources and accelerates watershed degradation. In similar watersheds, the needs of the people and their practices play a significant role in the magnitude of the degradation. Practices are governed by complicated multiple socio-economic factors that require specific study.

A simplified version of existing practices is reflected in the land utilization map that is incorporated in the LULSEPV. The population pressure, which not only plays a dominant role in human-induced watershed degradation but also causes changes in practices, requires attention in sub watershed prioritization. Two similar watersheds with different populations will naturally have different degradation rates. A heavily populated watershed will have more pressure on resources as compared to a lightly populated one. Nepalese soil conservation professionals accept this fact but so far it has not been included in the prioritization process. The method below incorporates population density as an indication of pressure on resources into sub watershed prioritization.

Sthapit (1998) considered only population characteristics during the prioritization. Recently, rural roads are identified as major drivers of soil erosion. Similarly, livestock density is also identified as a major cause of soil erosion. Therefore, this study allocates 20 points for population density, 10 points for road density and 10 points for the livestock density during the sub watershed prioritization.

Step I Estimation of population density (PD), road network density (RD) and livestock density (LD) for each sub watershed

The population densities (latest CBS data) of the local level are used for evaluating sub watershed wise population densities. To transfer these population densities of local level on to the sub watersheds, the boundaries of the local level district sub watershed were intersected. Then the average population density of the watershed is estimated using a weighted average method.

Road networks were downloaded from the website of Geofabrik website (https://www.geofabrik.de/data/shapefiles.html). This shapefile and sub watersheds were intersected and the total length of the road was calculated. Finally, road network densities (m/km^2) of all watersheds were calculated with the help of ArcGIS (ESRI, 2017).

Raster file of livestock (cattle, goat, and sheep) density was obtained from the Center for Earth Observation and Citizen Science (see https://www.geo-wiki.org) (Robinson et al., 2014). That raster file was converted into a polygon using "rater to polygon" tool of ArcGIS (ESRI, 2017). Boundaries of sub watersheds and shapefile of livestock density were intersected. Then the average livestock density of the watershed is estimated using a weighted average method.

Step II Estimation of average population density (APD), average road network density (ARD) and average livestock density (ALD) of the district

The average population density (APD) of the district is estimated by dividing the total population by the total area of the district.

APD = Total population of the district/ Area

The average road network density (ARD) of the district is estimated by dividing the total length of road by the total area of the district.

ARD = Total length of the road of the district/ Area

The average livestock density (LPD) of the district is estimated by the help of a weighted average of livestock density of the district.

ALD = Total sum of (Livestock density X Area of that patch/Total population of the district)

Step III Estimation of sub watershed population density numerical value (SWSPDNV), sub watershed road density numerical value (SWSRDNV), and sub watershed livestock density numerical value (SWSLDNV)

In cases where the highest population density differs too much from the densities of the rest of the sub watersheds, the highest density of a more representative watershed is considered as the highest population density (HPD). The population density is very highly influenced by market places or municipal areas. This population is often not entirely dependent on the watershed resources for its livelihood.

Anthropogenic characteristics carry a 40% weight in the sub watershed prioritization. In order to simplify the calculation, the following equations are used in estimating the sub watershed population density numerical value (SWSPDNV), sub watershed road network density numerical value (SWSRDNV), sub watershed livestock density numerical value (SWSLDNV),

When the population density of the sub watershed is less than the average population density of the district,

SWSPDNV = PD/APD*10

Where PD = Population density of the sub watershed and APD = Average Population density of the district.

When the population density of the sub watershed is higher than the average population density of the district,

SWSPDNV = (PD-APD)/ (HPD-APD)*10+10

Where PD = Population density of the sub watershed, HPD = Highest population density of the sub watershed in the district and APD = Average population density of the district.

Step IV Estimation sub watershed road network density numerical value (SWSRDNV)

When the road network density of the sub watershed is less than the average road network density of the district,

SWSRDNV = RD/ARD*5

Where RD = Road network density of the sub watershed and ARD = Average road network density of the district.

When the road network density of the sub watershed is higher than the average road network density of the district,

SWSRDNV = (RD-ARD)/ (HRD-ARD)*5+5

Where RD = Road network density of the sub watershed, HRD = Highest road network density of the sub watershed in the district and ARD = Average road network density of the district.

Step V Estimation sub watershed livestock density numerical value (SWSLDNV)

When the livestock density of the sub watershed is less than the average livestock density of the district,

SWSLDNV = LD/ALD*5

Where LD = Livestock density of the sub watershed and ALD = Average livestock density of the district.

When the livestock density of the sub watershed is higher than the average livestock density of the district,

SWSLDNV = (LD-ALD)/ (HLD-ALD)*5+5

Where LD = Livestock density of the sub watershed, HLD = Highest livestock density of the sub watershed in the district and ALD = Average livestock density of the district.

Combining biophysical and anthropogenic characteristics

The biophysical and population characteristics are combined together on the same numerical scale for finalizing the priority ranking.

Step I Estimation of sub watershed priority cumulative value (SWSPCV)

The SWSBPV, SWSPDNV, SWSRDNV, SWSLDNV are added together to estimate sub watershed priority cumulative value (SWSPCV).

SWSPCV = SWSBPV + SWSPDNV + SWSRDNV + SWSLDNV

Step II Priority ranking

The sub watershed priority ranking is based on the SWSPCV. The values are arranged in descending order for prioritization ranking. Priority is given to the sub watershed with the highest SWSPCV.

2.4 Hazard mapping

Most serious climate induces hazards are flood and landslide. This study identified the flood and landslide risk zone of the district. Identified risk zones are vulnerable to the hazards. These regions are recommended for the intensive management to save lives and environment.

2.4.1 Data collection

2.4.1.1Primary data collection

First of all, discussion with government officials and other stakeholders were conducted in all 6 districts of the study area identify the potential risk zone and locations of hazards. Then study team visited and identified locations for collection of GPS points for modeling and mapping. The team also recorded other information likes photos, type of hazards, condition of hazards, affected population, and impact of hazards, land use types and possible remedy measures.

2.4.1.2 Secondary data collection

GPS locations of floods and landslides were also collected from secondary sources such as pervious study reports, reports prepared by governments and academic institutions. Some points of floods and landslides were collected by the help of Google earth.

2.4.1.3 Environmental variables

The environmental variables were downloaded from freely available sources (**Table 1**) and pre-processed in ArcGIS (ESRI, 2017) to make appropriate format (ASCII) and same spatial resolution (30 m). Some variables with vector features (i.e. point and line) were also converted into raster format having the same resolution (30 m). The environmental variables were divided into four categories as follows.

Table 1: Environmental variables used for the study

Category	Variables	Source	Unit
Topographic	Aspect	USGS	degree
	Elevation		m
	Slope		degree
	Distance to water	Geofabrik	km
Climatic	Mean precipitation	WorldClim	cm
	Mean temperature		degree
	Mean solar radiation		
Vegetation Related	Mean EVI	MODIS	dimension less
	Forest	Global forest change	dimension less
Anthropogenic	Land use land cover	ICIMOD	type
	Distance to road	Geofabrik	km
	Distance to path		km
	Distance to settlement	Department of survey, Nepal	km

2.4.1.4 Topographical variables

Topographical variables have been widely used for species habitat modeling for 20 years (Osborne et al., 2001). These variables were also used for mapping of disasters because aspect, elevation and slope are directly related to types of disasters. For this study, Digital Elevation Model (DEM) of 30 m resolution was downloaded from the United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov/), and aspect and slope were computed from the DEM using ArcGIS software (ESRI, 2017).

2.4.1.5 Climatic variables

Driving force of the most of hazards are climatic variables. Temperature, precipitation and solar radiation are directly related to the disasters like fire, flood and landslide. Therefore, this study use climatic variable as input of the model. Climatic variables were downloaded from the WorldClim

database (http://worldclim.org/). The WorldClim database (version 2) is a set of global climate layers that derived from over 4000 weather stations between 1950 and 2000, including annual time series with annual means, seasonality, and extreme or limiting temperature and precipitation data (Hijmans et al., 2005). In this study, average of temperature, precipitation and solar radiation were used as input of the model (**Table 1**).

2.4.1.6 Vegetation-related variables

Vegetation-related variables are responsible for accelerate or mitigate the disaster. For example, vegetation may be favorable for the fire but unfavorable for the landslide. In this study, forest cover and mean of Enhanced Vegetation Index (EVI) were used as model input.

Forest cover data prepared by Hansen et al. (2013)was downloaded from the Global Forest Change (GFC) website was used as a variable. EVI time series data from 2015, 2016, and 2017 from USGS computed from images obtained by Moderate Resolution Imaging Spectroradiometer (MODIS) was smoothed by using an adaptive Savitzky-Golay filter in the TIMESAT program (Jönsson and Eklundh, 2004) to reduce the cloud effect. Finally mean EVI was calculated and used for the modeling.

2.4.1.7 Anthropogenic variables

The triggering factors of most of the natural hazards are human activities. Now a days, roads and paths are being major causes of landslide. Therefore anthropogenic variables were incorporated into the models. Anthropogenic variables included were distance to human paths and roads, distance to settlements, and land use land cover. Location of paths and roads was obtained from shapefile available on the Geofabrik website (https://www.geofabrik.de/data/shapefiles.html). Settlement locations were obtained from the Department of Survey, Nepal. Distance raster files of paths, roads and settlements were created by using ArcGIS (ESRI, 2017). Land use land cover data were downloaded from the International Centre for Integrated Mountain Development website (ICIMOD; http://www.icimod.org) (Uddin et al., 2015) and incorporated into the model.

2.4.2 Modeling

Maximum Entropy (MaxEnt) is a software program used to model species distributions by using geo-referenced occurrence data and environmental variables to predict suitable habitat for a species (Phillips et al., 2006). This model is successfully used for disaster risk modeling also. Variables listed in **Table 1** were incorporatedinto MaxEnt (version 3.4.1) along with occurrence data of hazards to determine potential disaster risk zone. We selected ten 1000 maximum iterations and 10 replicates during modeling (Barbet-Massin et al., 2012). We used 70 percent of data to train and rest to validate the model. The maximum sum of sensitivity and specificity (MaxSSS) threshold is appropriate to convert the continuous probability map to binary map when only presence data are available from the field (Liu et al., 2013). Therefore, this threshold was used to produce the risk flood and landslide risk of the study area.

For environmental modeling, wide range of models (e.g. BIOCLIM, BRT, DOMAIN, GARP, GLM, and MaxEnt) has been developed to cover aspects as diverse as climate change, biogeography, biology, spatial ecology and habitat management. These models have been used to predict the distribution of plants, and animals (Gillespie and Walter, 2001; Guisan et al., 1998; Pearce and Ferrier, 2000; Phillips et al., 2006). These species distribution models are also using to predict the risk of landslides (Goetz et al., 2011), fires (Renard et al., 2012), accidents (Maher and Summersgill, 1996) and diseases (Murray et al., 2011). Due to the chance of not occurring the hazards due other causes like human protection and other environmental causes like protection of forests to prevent the flood and landslides, researcher's field visit, the recording of the true absence data points is a challenging task during the study. Moreover, collection of large number of data for hazards is also another challenge in research. Therefore model which needs only presence data from the field is becoming more popular among the species distribution models. In this scenario MaxEnt needs only presence data for the modeling (Phillips et al., 2006). Therefore, this study used MaxEnt software to model the hazards of the district.

2.5 Preparation of management plan

2.5.1 Planning process

Then Department of Soil Conservation and Watershed Management prepared/endorsed a 'Guideline for sub-watershed management planning' in 2016. Principles, process and methodology described in the guideline were followed with scope for improvement and/or innovation where possible. The guideline describes procedures of data collection and analysis to come up with the recommended measures in the management of the sub-watershed resources mainly land, water and vegetation while fulfilling the basic needs of local communities and reducing the land degradation process essential for improving livelihood of the people. In addition, climate change impacts, vulnerability to various hazards and disaster risk related data/ information were collected using various tools like social vulnerability mapping, vulnerability matrix, risk mapping and historical records of disasters. Checklist, format, and questioners were prepared before collecting the information. Information was collected through participatory discussion, stakeholder consultation, focus group discussion, and key informant interviews, and field observation. Collected data were analyzed using the Google Erath Pro, Microsoft Office and format and tables recommended by the guideline for sub-watershed management planning. Land degradation mapping was carried out using open source latest Google Earth Image.

The framework for planning is presented in Figure 1 below.

Figure 1. Integrated sub-watershed planning framework

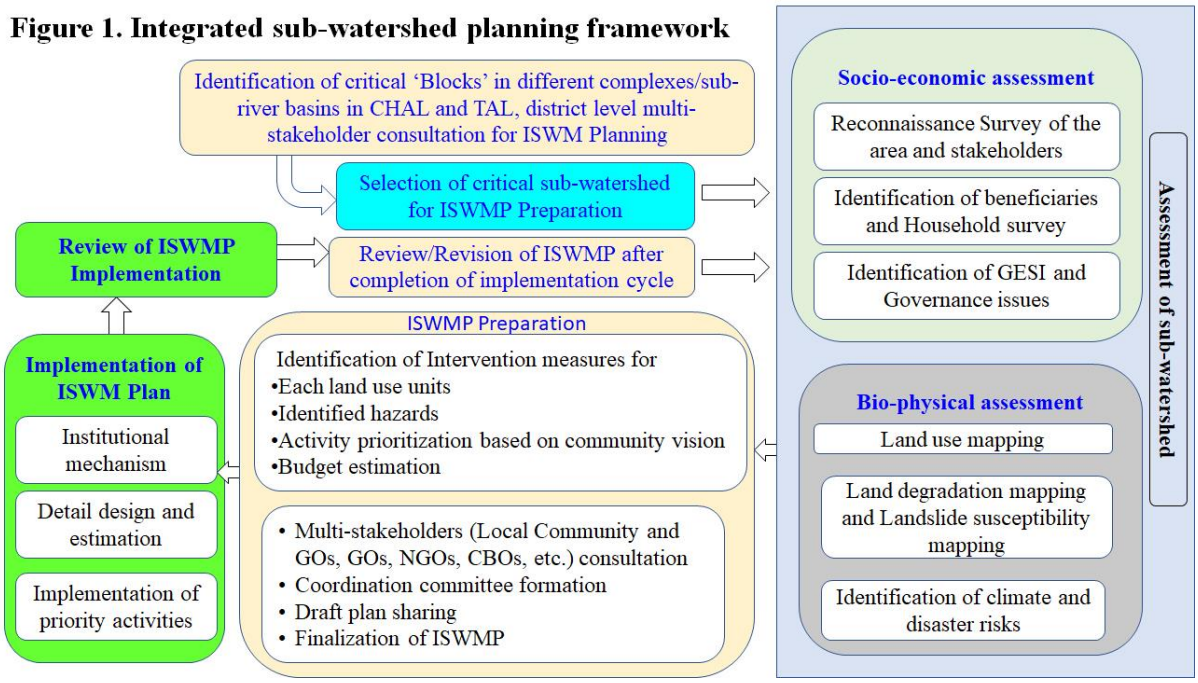


Figure 4: Integrated Sub watershed planning framework

2.5.2Data Collection

2.5.2.1 Primary Data sources

Household survey

Socio-economic, demographic and other necessary information were collected from the household survey. Randomly selected houses from the different Urban and Rural Municipalities and its wards within the Watershed area were used for the purpose of data collection.

PRA and RRA

Focused group discussion was conducted to obtain information about watershed. PRA and RRA were done to extract important information about watershed, its condition and issues with local community. In addition, key informants like local leaders, teachers and social workers were consulted for information, suggestions regarding the procedure and activity of planning and also for verification of data collected.

Field observation

During the visit to the Watershed areas different field observations were made by the office staffs to identify the type and severity of the problems. Problems related to the water sources like construction of road, haphazard cultivation, slash burn and other forest related issues were studied, and photographed.

Local Body Profile Survey

In order to generate information on local level institutions, status of development infrastructures and others, Municipality and Ward Profile survey were carried out.

2.5.2.2 Secondary Data Sources

District profiles of Tanahun district and the available village profiles of Suklagandaki Municipality, Bhimad Municipality and Myagde Rural Municipality, Population census reports, Operational plan of Community forest User group and Annual reports of SWMO were reviewed during the preparation of the plan. Both published and unpublished literatures, reports and other related documents were considered as the important tools of the information collection. The necessary digital data were used of planning. DEM was downloaded from website of USGS website

(https://earthexplorer.usgs.gov/) and slope and aspect were calculated by the help of ArcGIS (ESRI, 2017).

2.5.3 Data Analysis

GIS software followed by Google Earth were used to delineate a sub watershed area for conservation of water sources in the long run. Thematic layers were gathered from ICIMOD and DEM from USGS website for slope, aspect, altitude variation, LULC. Problems identified from field survey was analyzed and appropriate activities was recommended to overcome the issues. Excel was used to analyze the data during the study.

3. RESULTS AND DISSCUSSION

3.1 Sub basins of Gandaki Province

This study identified and delineated four sub basins in the Gandaki Province (**Figure 4**). Largest sub basin is the Kaligadaki Sub Basin whereas smallest sub basin is Budhi Gandaki Sub Basin. Some parts of the province are not covered by these four sub-basins. Area of Dhorpatan Hunting Reserve (Western part of the Province) is watershed of Karnali Basin and rest area is watershed of Gandaki Basin.

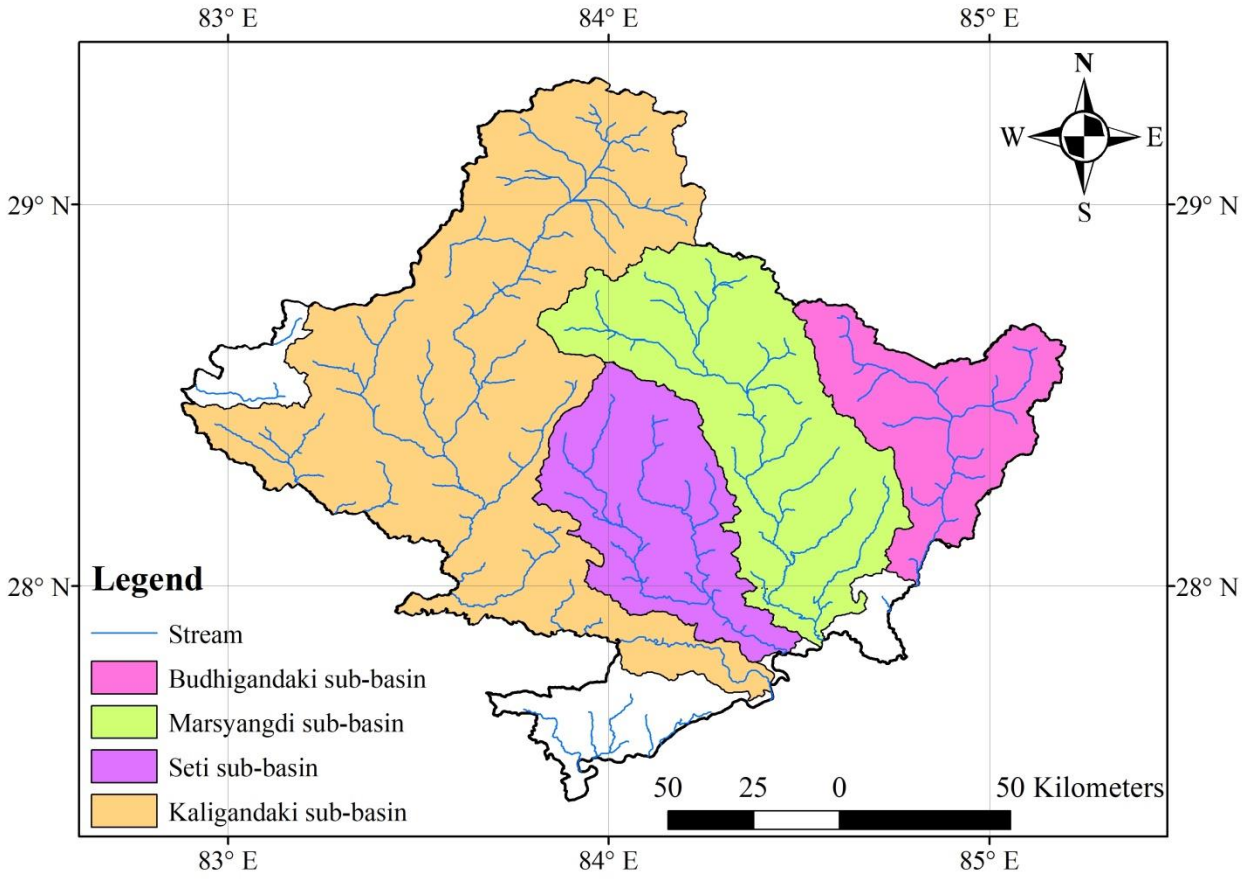


Figure 5: Sub basins of Gandaki Province

If only Tanahun district is considered as working unit, the study identified three sub basins: Seti, Kali Gandaki and Marsyangdi (**Figure 6**).

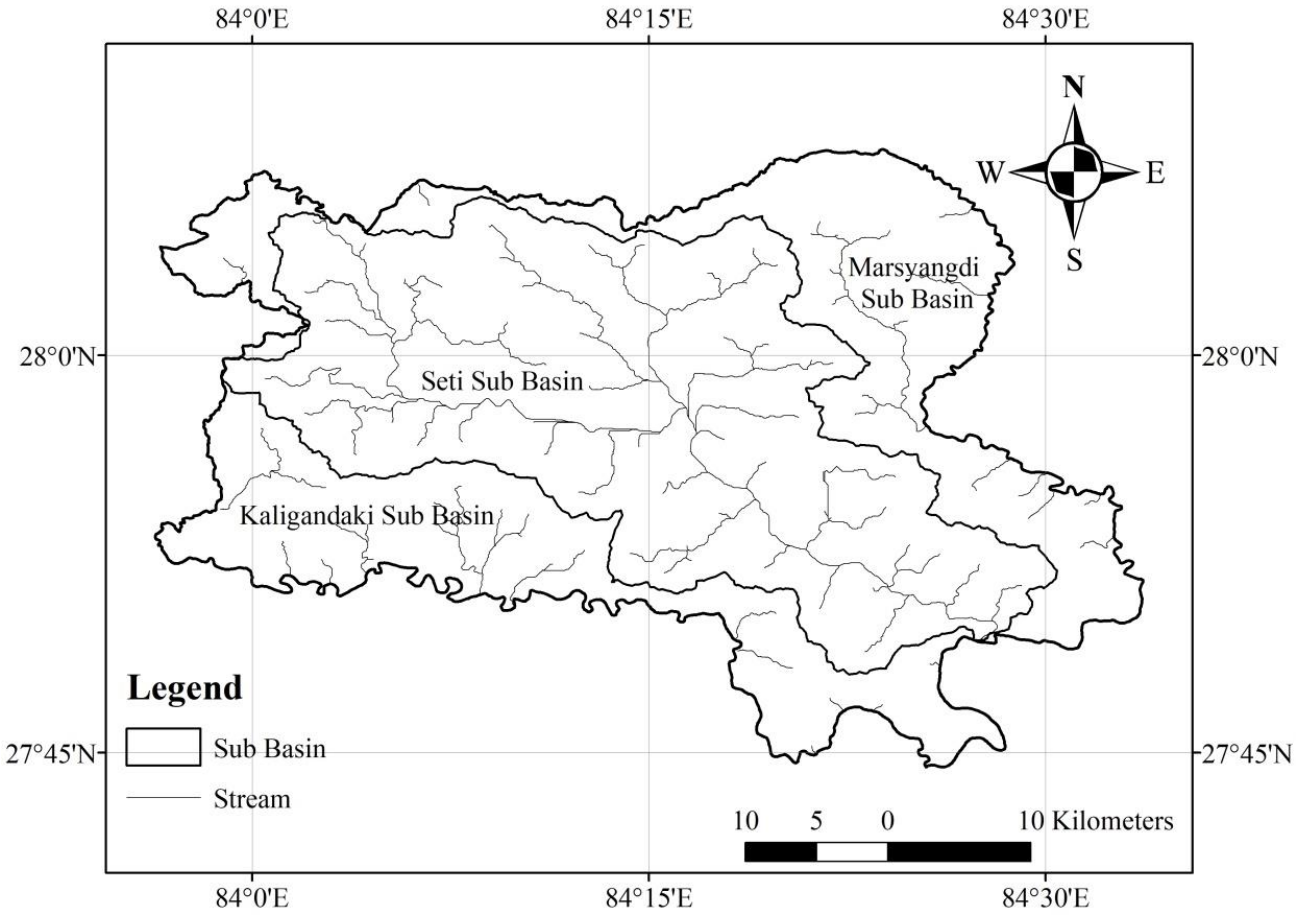


Figure 6: Sub basins of Tanahun District

3.2 Sub watersheds of districts

A total of 17 sub-watersheds are delineated in the Tanahun District (**Figure 7**). The range of the sub-watershed is 205 km^2 to 39 km^2. The largest sub-watershed is Madi Nadi and smallest is Trishuli Nadi 2 (**Table 2**).

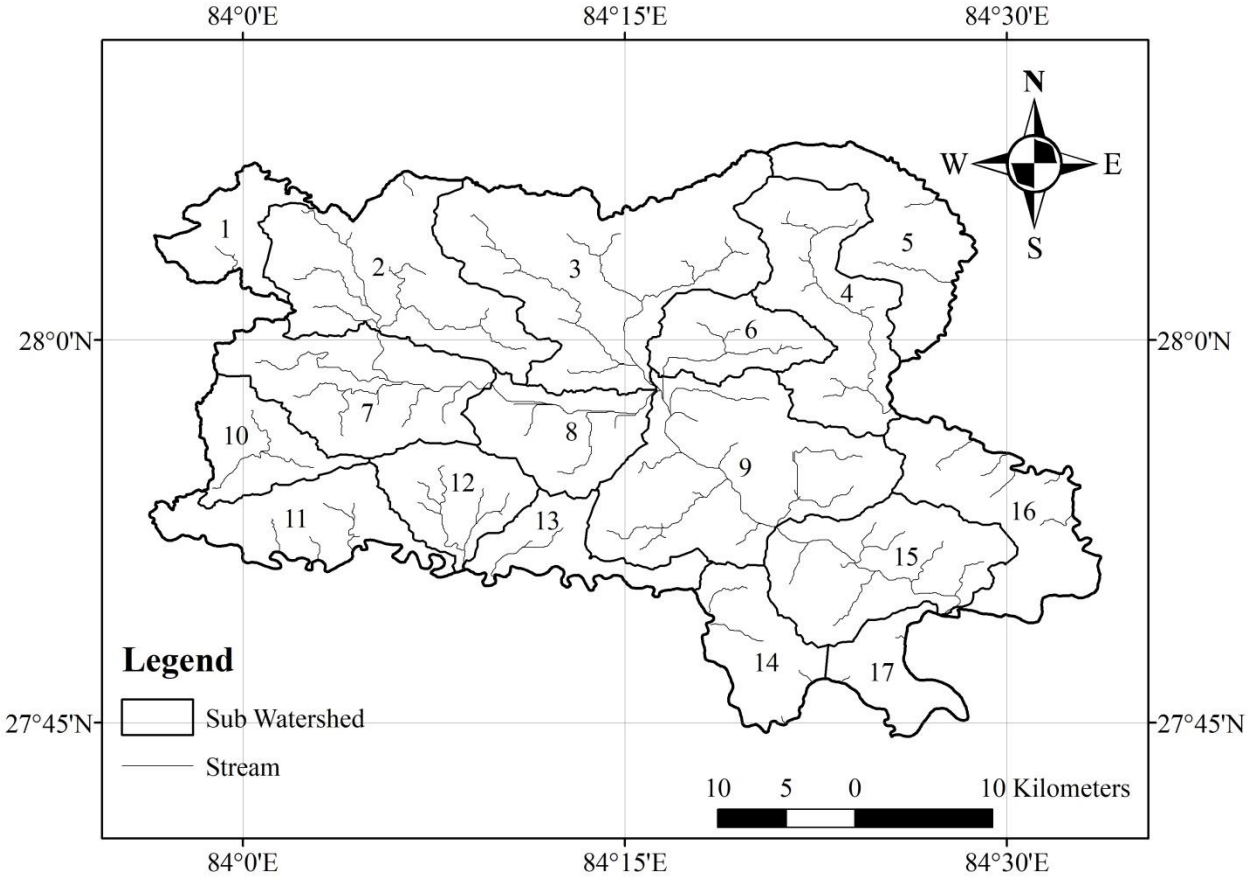


Figure 7: Sub-watersheds of Tanahun District

Table 2: Sub watersheds of Tanahun

S.N.	Name of Sub Watershed	Area (km^2)	Corresponding local level
1	Kyangdi Khola	44	Shukla Gandaki Municipality
2	Seti Nadi 1	141	Shukla Gandaki Municipality and Myagde Rural Municipality
3	Madi Nadi	205	Byas and Shukla Gandaki Municipality and Myagde Rural Municipality
4	Chudi Khola	112	Bhanu Municipality and Bandipur Rural

			Municipality
5	Marsyangdi Nadi	84	Bhanu Municipality
6	Buldi Khola	54	Byas and Bhanu Municipality
7	Seti Nadi 2	113	Bhimad Municipality and Myagde Rural Municipality
8	Seti Nadi 3	69	Rishing and Myadgde Rural Municipality
9	Seti Nadi 4	182	Byas Municipality and Bandipur and Rishing Rural Municipality
10	Maldi Khola	51	Bhimad Municipality and Ghiring Rural Municipality
11	Kali Gandaki Nadi 1	76	Ghiring Rural Municipality
12	Kutang Khola	59	Rishing and Ghiring Rural Municipality
13	Kali Gandaki Nadi 2	48	Rishing Rural Municipality
14	Kali Gandaki Nadi 3	60	Devghat Rural Municipality
15	Seti Nadi 4	112	Anbu Khaireni and Devghat Rural Municipality
16	Trisuli Nadi 1	96	Anbu Khaireni Rural Municipality
17	Trisuli Nadi 2	39	Devghat Rural Municipality

3.3 Prioritized sub-watersheds

Seti Nadi 1 sub-watershed is top prioritized sub-watershed of the Tanahun district with an area of 154 km^2. This sub-watershed located atShukla Gandaki and Bhimad Municipality and Myagde Rural Municipality. Similarly, Marsyangdi Nadi is the second prioritized sub-watershed of the district and located to Bhanu Municipality (**Table 3**).

Table 3: Sub watershed prioritization of Tanahun

S.N.	Name of sub watershed	Area (km^2)	Corresponding local level	Bio Physical value {SWSBPV (LULSEPV-1)/(HighestLULSEPV-1)*60}	Anthropogenic value (Population Density+ Livestock Density +Road Network Density)	Total value	Rank
2	Seti Nadi 1	141	Shukla Gandaki Municipality (ward: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12), Bhimad Municipality (ward: 8, 9) and Myagde Rural Municipality (ward: 2, 3, 4, 5, 6, 7)	55.18	35.72	90.90	1
5	Marsyangdi Nadi	84	Bhanu Municipality	58.19	31.16	89.35	2
4	Chudi Khola	112	Bhanu Municipality	60.00	28.44	88.44	3

			and Bandipur Rural Municipality				
6	Buldi Khola	54	Byas and Bhanu Municipality	53.40	34.74	88.14	4
3	Madi Nadi	205	Byas and Shukla Gandaki Municipality and Myagde Rural Municipality	55.54	28.52	84.06	5
1	Kyangdi Khola	44	Shukla Gandaki Municipality	57.91	24.42	82.34	6
10	Maldi Khola	51	Bhimad Municipality and Ghiring Rural Municipality	52.26	26.20	78.46	7
7	Seti Nadi 2	113	Bhimad Municipality and Myagde Rural Municipality	51.35	26.91	78.26	8
11	Kali Gandaki Nadi 1	76	Ghiring Rural Municipality	50.73	24.82	75.55	9
16	Trisuli Nadi 1	96	Anbu Khaireni Rural Municipality	56.48	15.73	72.21	10
9	Seti Nadi 4	182	Byas Municipality	46.19	25.81	72.00	11

			and Bandipur and Rishing Rural Municipality				
8	Seti Nadi 3	69	Rishing and Myadgde Rural Municipality	54.17	16.37	70.54	12
15	Seti Nadi 4	112	Anbu Khaireni and Devghat Rural Municipality	55.12	12.67	67.79	13
12	Kutang Khola	59	Rishing and Ghiring Rural Municipality	49.34	17.91	67.24	14
13	Kali Gandaki Nadi 2	48	Rishing Rural Municipality	47.41	19.13	66.54	15
17	Trisuli Nadi 2	39	Devghat Rural Municipality	50.47	13.91	64.37	16
14	Kali Gandaki Nadi 3	60	Devghat Rural Municipality	50.16	10.18	60.34	17

3.4 Hazards of district

3.4.1 Flood/ river cutting risk

The water is an only flood causing agent. The study found that flood risk is higher near to the water resources. In favorable condition, water automatically creates the flooding. Lands within one kilometer from water body are highly susceptible to flooding. Generally, area two kilometer far from the water body is safe from flooding in normal condition. Normally the flooding occurs in flat land. This study also identified that flat land has risk of flood. Area having slope less than 10 degree is

susceptible to high flood risk. In flat land water can't drain immediately so land can face the flooding. Lands more than 30 degree slope are safe from the flooding.

At the national level, the Department of Hydrology and Meteorology (DHM), under the Ministry of Science Technology and Environment (MoSTE), is mandated to monitor all hydrological and meteorological activities in Nepal. DHM collects hydrological, meteorological, and climate information and disseminates it to a variety of stakeholders for water resources, agriculture, energy, and other development activities (www.dhm.gov.np). In Gandaki Province, DHM has 15 existing river monitoring stations. The stations are regularly monitored and the information is collected centrally at the DHM office. Most of the hydro-meteorological stations are manually operated, while some have been upgraded to automatic stations, able to continuously monitor flood parameters such as rainfall and water level around the clock and to transmit the data in real time. A number of flood early warning systems have also been put in place to forewarn communities of approaching flood disasters. Flood risk area of district is shown in **Figure 8**.

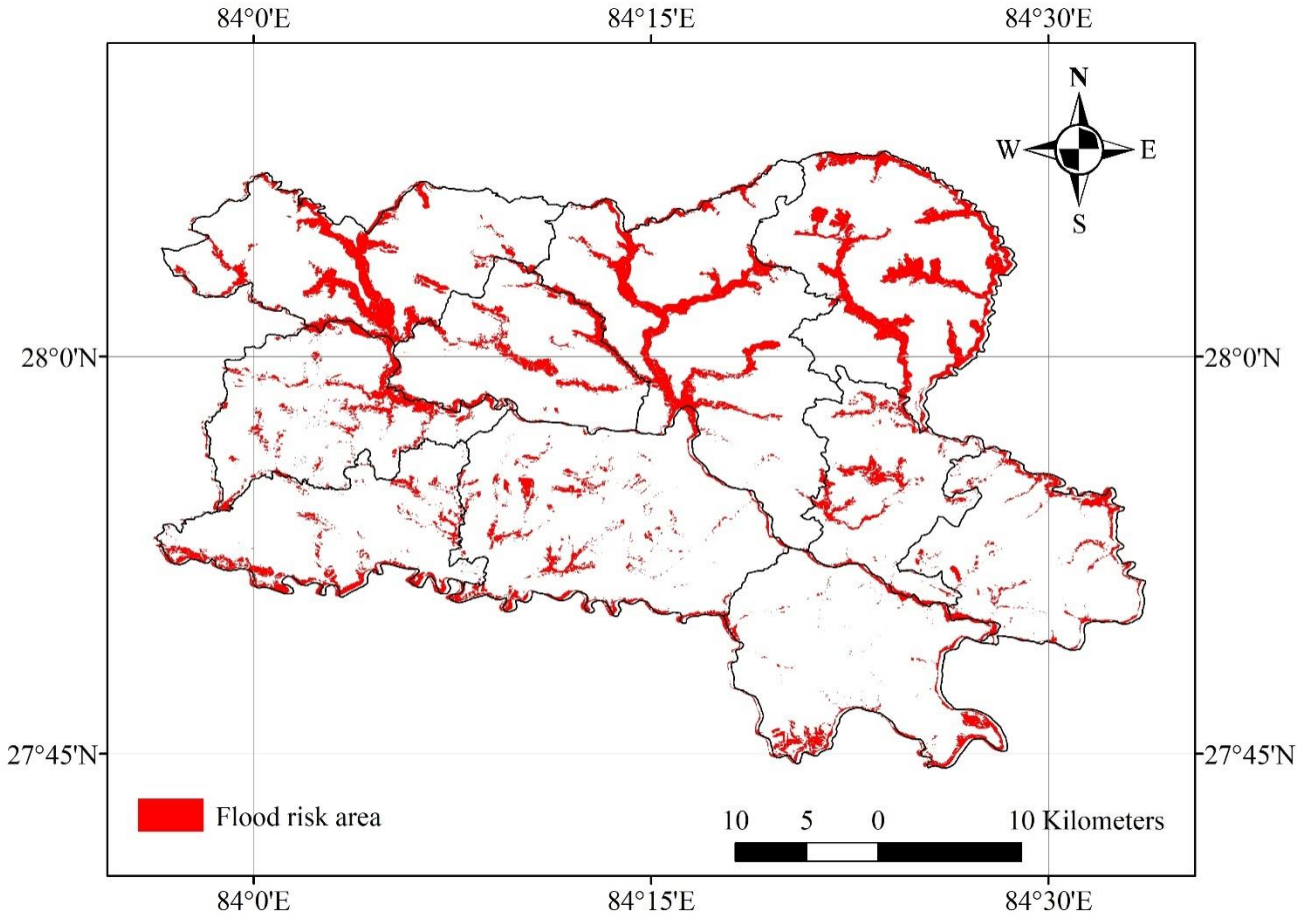


Figure 8: Flood risk in Tanahun District

Due to flat territory, the Tanahun is less flood prone district of the Gandaki Province. Tanahun and Palungtar Rural Municipality are more flood prone local levels of this district (**Figure 8**). Details of flood prone area of this district is shown in **Table 4**.

Table 4: Flood risk area of Tanahun

Rural Municipality (RM)/ Municipality	Ward	Location of flood	River/stream
Devghat RM	3,4	Lower part of Bargaun	Bar khola
Abukhaireni RM	6	Lower part of Piughare	Seti river
	1	Lower part of Baradiphat	Stream
Bandipur RM	1	Lower part of Nahola Upallophat	Nahola khola
	2	Sukaura	Godi khola
	3	Bartar,Tharubas	Stream
Rising RM	1	Lower part of Jhalputar	Seti River
	7	Lower part of Barhabise	Stream
	5	Edge of Kaligandaki	Kaligandaki River
	1	Lower part of Puttar, Gadhi	Kaligandaki River
	4	Dumriswanra	Kaligandaki River
Bhanu Municipality	1,2,4,5,6,7	Both sides settlement of Chudi khola (Bariphat, Sepa Bagaincha, Syauli, Chudi Ramghabesi, Pauwadihi, Padke Pasal, Tuhure Pasal)	Chudi khola
	4,7,8	Both edge of Dharampani khola	Dharampani khola
	4,7	Both edge of Phaudi khola	Phaudi khola
	9	Archaldhara, Karkigau	Chiti khola
	8	Near Jharuwaphat	Telkati khola
	11	Jyamire, Rupakot phedi, Masyantar, Thati	Sawdi khola
	11,10	Manechauka,Luitelphat	Naudi/Paudi khola
Byas Municipality	1,2,3,4,10,11	Both edge settlements of Buldi khola (Bisghare Damauli, Bigyanchaur, Malebagar,Judipari, Talghare, Atighat, Ghasikuwa, Jalbire,Beltan)	Buldi khola
	3,4,10,7	Shantinagar, Byas Cave, Damauli Bridge, Botegaun, Lower part of Kalesti Bazaar,Kumalgaun, Lower part of Jymirkholagau, Dulaipani, Parajulibesi, Patal	Madi River
	7,8	Near Soti Pasal, Sotibesi, Bhandarigau, Baguwa bazaar,	Risti khola
	7,10,9	Simaltat, Pokhralphat, Kumalgaun, Jhinuwatar, Lower part of Sunkholsigau, Bajaude, Ranipani	Kalesti khola
	6	Ratmate	Mand khola, Madi

			River
	6	Lower part of Lamichhanedihi, Kholibesi, Kaphalphat, Barhabise	Sage khola
	5	Nepaltar, Barbote, Sagephat, Thulotal, Patenitar, Chapaghat, Patan	Sage khola
	5	Patan	Madi /Seti River
Maygde RM	3,4,5,6,7	Tilahartar,Boltar, Thatitar, Chhabise, Rithepani,	Magde khola
	1,2	Tallo Gunadi,Pipaldihi, Samadi, Pipaldihi, Dabunphat	Gunadi khola
	5	Jhakkas, Tallotar, Lower part of Chhan Patan,	Seti River
Shuklagandaki Municipality	2	Pulchok	Seti River
	7	Simaltar	Kumle/ Mygde khola
	7	Eklethar,Syauli Bazaar,	Seti River
	7	Chyandada	Mygde khola
	9	Dhamar, Lower part of Syauli Bazaar, Male Bagar	Suraudi khola
	8	Mustan Basti, Lalimgau,Dhorphirdi, Male Bagar lower part	Bange khola/Kyangdi khola
	12	Lower part of Bhatdada, Lamakhet, Korlin, Puridobhan	Hadi khola/ Suraudi khola
	11	Sankhe	Dagdi khola
	10	Simle	Kyangdi khola
Bhimad Municipality	6,7	Bhimad Bazaar,	Seti River
	1	Dumribesi, Lower part of Pallabari	Maldi/Saldi/Kamangdi khola
	6,7	Male Bagar, Both side of Jyagdi khola	Jyagdi khola
	5,6	Both edge of Pirung khola	Pirung khola

3.4.2 Landslide risk

The major driving force of the landslide is gravity. In higher slope land mass should face the high gravity power. Therefore area having high slope is vulnerable to the landslide. The study identified that higher the slope higher is the risk of landslide. Lands having less than 10 degree slopes are nearly safe from the landslide.

Out of 11 land use land cover types, areas near to the rivers are more susceptible to the landslide. Similarly, agricultural lands and grasslands are also facing the landslide risk during the rainy season. Other land cover types such as forest and built-up area not facing landslide risk. Landslide risk area of district is shown in **Figure 9**.

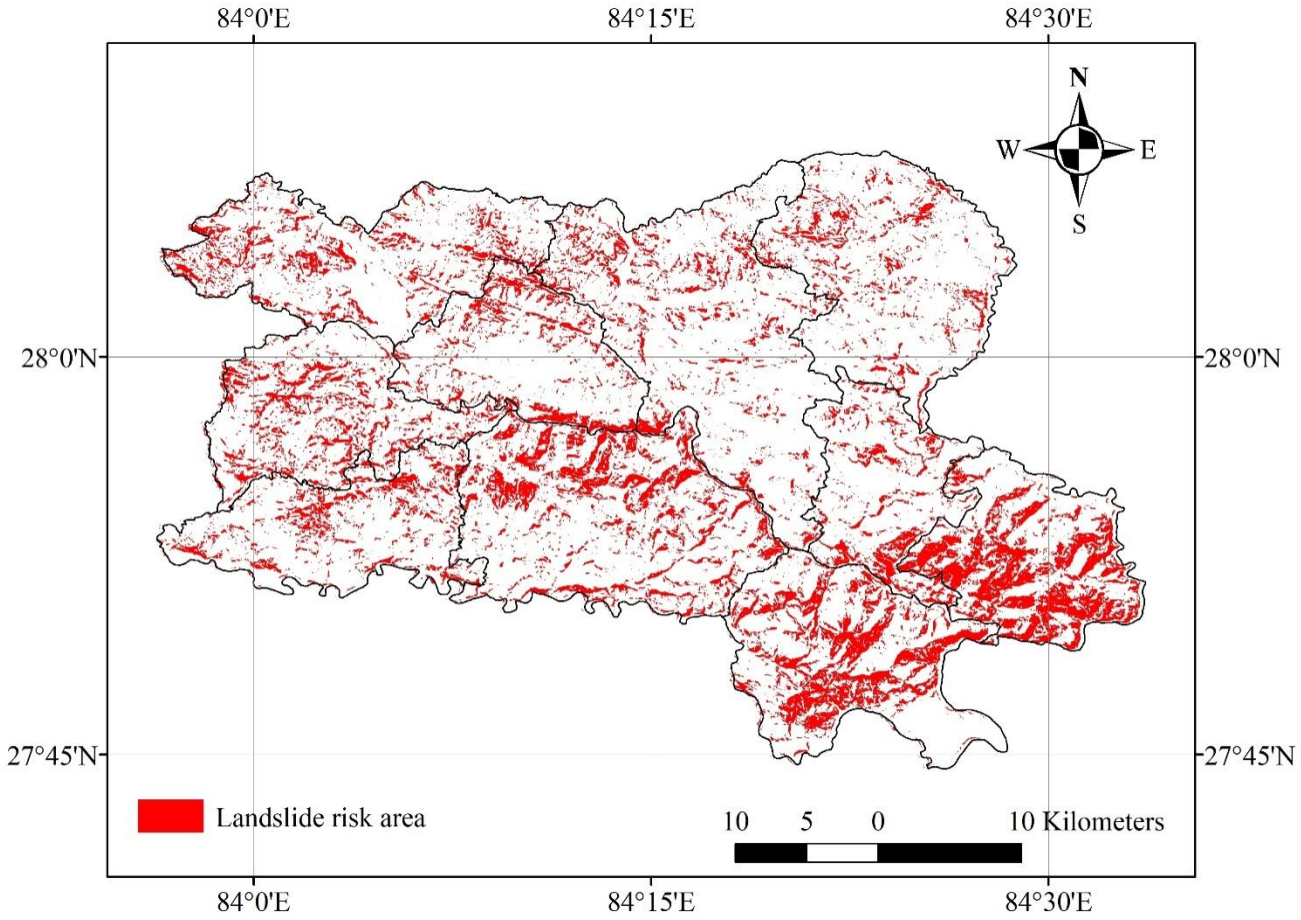


Figure 9: Landslide risk area of Tanahun District

Table 5: Landslide risk area of Tanahun District

Rural Municipality (RM)/ Municipality	Ward	Locations of Landslide	Potential Hazard
Devghat RM	1	Northern part of ward 1 (Damdame,Gharibas), Samthar, Ghatedada, Saldada,Mandhane	Landslide
	2	Southern part of Naram, northern part of Chherang khola, Northern part of Chundi khola	Landslide, edge fall
	3	Bhokteni area, western part of Ngaldi khola, eastern part of Gendran and northern part of Bar khola	Landslide
	4	Solighopte area,Saldada area, Kaphaldada area, Kartap,Sinchyang area, Amdada area	Landslide

	5	Southern part of Phoshrepani and Bagandi	Landslide
Abukhaireni RM	1	Bardada, Khanikhan, Bhangeri	Landslide
	2	Pauwa and western side of Raudi khola, Eastern part of Nayagaun and western side of Khani khola	Landslide
	3	Khanikholagau, Dharapani area, Lutpakha area	Landslide
	4	Marsyangdi Hydro area, Shankhargaun, Amdada area, Khashran area, Trishuli River edge fall	Landslide, edge fall
	5	Western part of Siudi khola, bagai area, Kheusni and Lakhupakha area, Dumsidhunga, San Bhanjyang, Bhoteswara, Domarbesi, Trishuli River edge fall,	Landslide, edge fall
	6	Ratnapur and Dadagaun area, Near Sihar khola, tallo Hilekharka area,Dharagaubesi, Jal Bhanjyang area,	Landslide
Bandipur RM	1	Southern upper part of Dumre bazaar	Landslide
	3	Bandipur Paragliding area, Muchuk area,	Landslide,
	4	Marsyangdi River edge cutting at Bimalnagar area	Edge cutting
	6	Dharampani area, Bhutkhola area, eastern part of Gajeswara	Landslide
Rising RM	1	Mathillo Setan, Ramche area, southern part of Dhobla, edge fall of Seti River and Dihul khola	Landslide, edge fall
	2	Apthok, Jhakridada, northern part of Charghare, edge fall of Dihul khola	Landslide, edge fall
	3	Dubun dada area, southern part of Archaldi, edge fall of Seti River and Kaligandaki River	Landslide, edge fall
	4	Singuwa, southern part of Bhirkot, edge fall of Kaligandaki River	Landslide, edge fall
	5	Jhatare area, Ratenidhara, Sapaudi, edge cutting of Jwala khola	Landslide, edge fall
	6	Kaphaldada, Dharampani,Madariswara,Syanlun, edge fall of Jyamire khola	Landslide, edge fall
	7	Bolswara, Pokhari bhanjyang area,Machadan, Kotlan	Landslide
	8	Chhatiwan,Gordi area	Landslide
Ghirin RM	1	Nayagaun, northern upper part of Puttar	Landslide
	3	Garhathok,Silimthok	Landslide
	4	Edge fall of Kaligandaki River	Edge fall
	5	Bhoteni area, Bel bhanjyang area	Landslide
Bhanu Municipality	1	Marsyangdi River edge fall	Edge fall
	3	Marsyangdi River and Paudi khola edge fall	Edge fall
	5	Thulodhunga area	Landslide
	6	Padke pasal area, Chudi khola edge cutting	Landslide, edge fall

	7	Upper part of Sagbari	Landslide
	8	Paudi khola edge fall	Edge fall
	10	Arukharka, Bandre	Landslide
	12	Eastern part of Ahale village, edge fall of Okhale khola and Karsyangdi khola	Landslide, edge fall
	13	Upper part of Bajhidihi	Landslide
Byas Municipality	1	Belghan area	Landslide
	5	Edge cutting of Madi River	Edge cutting
	6	Side cutting of Manda khola	Edge cutting
	9	Edge fall of Beteni and Paudi khola	Edge cutting
	10	Boksigara area	Landslide
	11	Mulpanikuna area	Landslide
	12	Chhabdibarah area	Landslide
	13	Upper part of Seti River and Khirkhandi khola dovan	Edge cutting
	14	Seti river edge cutting	Edge cutting
Myagde RM	1	Seti river edge Fall	Edge fall
	2	Northern part of Seti river	Landslide
	5	Jhakkas area,western part of Chhakrak area	Landslide
	6	Southern part of Sarbalang area,Sage khola edge cutting,	Landslide, edge cutting
	7	Dharampani area	Landslide
Shuklagandaki Municipality	1	Edge cutting of Sage, Manda and Gahate khola	Edge cutting
	2	Rimalgau area, Bandi area, edge cutting of Khani khola	Edge cutting, Landslide
	3	Thumdada, Sikhere area	Landslide
	6	Edge cutting of Jamdi khola	Edge cutting
	7	Male Bagar	Edge cutting
	8	Edge cutting of Saraudi khola	Edge cutting
	9	Lukunswara, Edge cutting of Saraudi khola	Landslide,Edge cutting
	10	Lampata, Seplan area, Bange khola edge cutting	Landslide, Edge cutting
	11	Simleswara area	Landslide
	12	Southern part of Ghaderi gaun	Landslide
Bhimad Municipality	1	Miyagaun area, Chhimpun, Edge cutting of Saldi khola	Landslide, Edge cutting
	2	Jaupani, northern part of Nayagaun,	Landslide

	3	Southern part of ward 3	Landslide
	4	Eastern part of Satidada	Landslide
	5	Edge cutting of wanting khola	Edge cutting
	6	Alchhi chautara area, edge cutting of Seti River at Bhimad bazaar	Landslide, Edge cutting
	7	Edge cutting of Jyagdi khola	Edge cutting
	8	Edge cutting of Jyagdi khola	Edge cutting
	9	Edge cutting of Jyagdi khola	Edge cutting

3.5. Sub watershed management plan

3.5.1 General Information of Sub watershed

Seti Nadi is one of the major sub-watershed in Gandaki River Basin. Out of 10 local bodies (4-Metropolitian city and 6-Rural Municipality) the sub watershed falls under Suklagandaki Municipality; ward no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, Bhimad Municipality; ward no. 8, 9 and Myagde Rural Municipality; ward no. 2, 3, 4, 5, 6, 7 of Tanahun district.

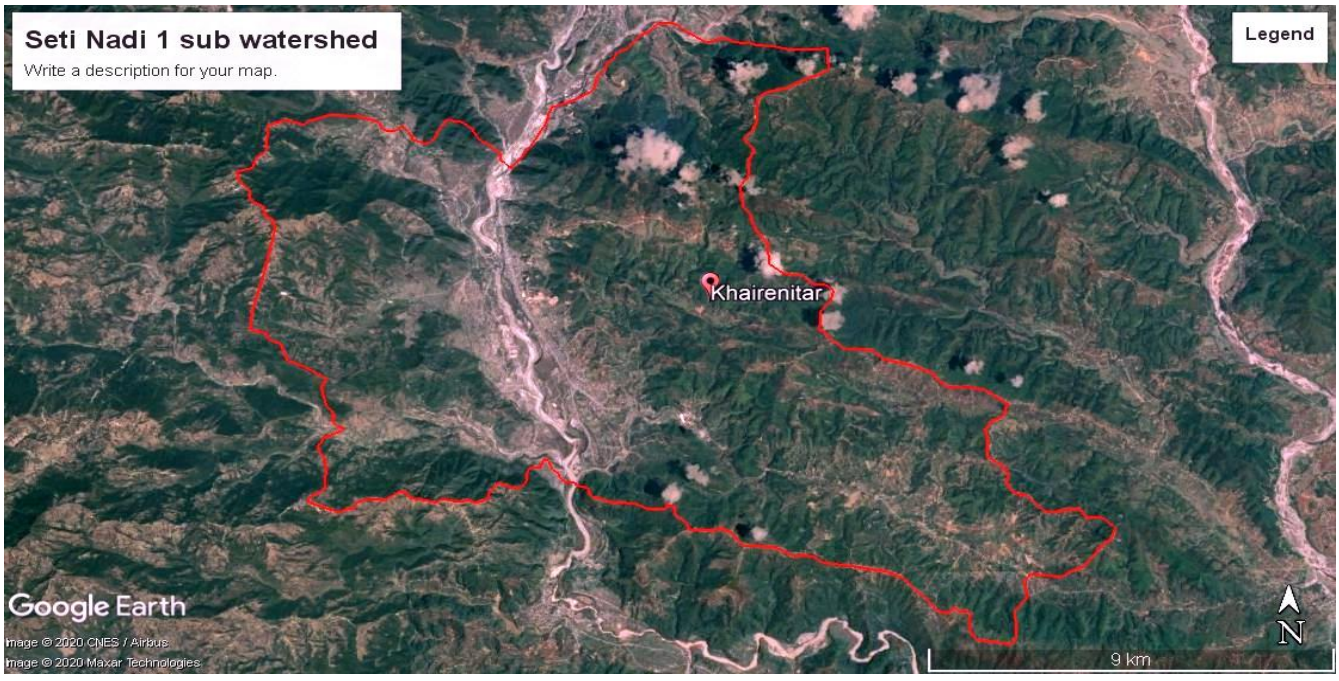


Figure 10: Seti Nadi 1 Sub Watershed of Tanahun District

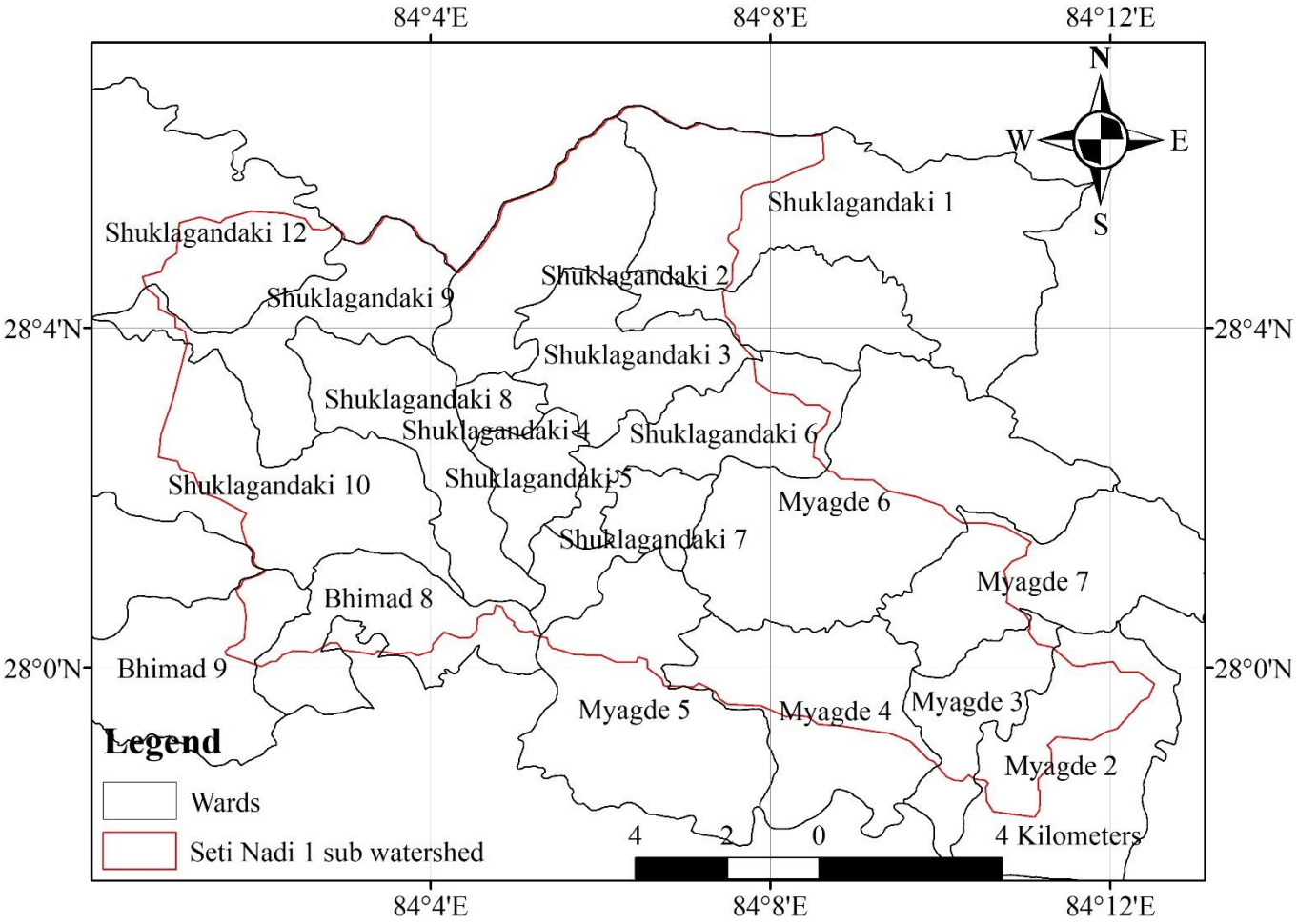


Figure 11: Location of Seti Nadi 1 Sub Watershed of Tanahun District

Table 6: Boundary points of Seti Nadi 1 Sub Watershed of Tanahun District

S.N.	x	y
1	84.16437	27.98195
2	84.1653	27.9816
3	84.16794	27.97853
4	84.16929	27.97789
5	84.17101	27.97774
6	84.17222	27.97888
7	84.17329	27.9781
8	84.17536	27.97789
9	84.17608	27.97731

10	84.1755	27.97653
11	84.17572	27.97375
12	84.177	27.97175
13	84.18514	27.9706
14	84.18607	27.97217
15	84.18614	27.97589
16	84.18578	27.9761
17	84.18586	27.97817
18	84.1885	27.98095
19	84.18835	27.98395
20	84.18764	27.98474
21	84.18942	27.98638
22	84.19635	27.98581
23	84.19906	27.98731
24	84.20135	27.98802
25	84.20599	27.99338
26	84.20748	27.99409
27	84.20863	27.9968
28	84.20556	27.99909
29	84.20199	27.99909
30	84.20049	28.00116
31	84.19549	28.00059
32	84.19492	28.0003
33	84.19264	28.00051
34	84.18857	28.00401
35	84.18564	28.00465
36	84.18424	28.00644
37	84.18388	28.00741
38	84.18426	28.00765
39	84.18424	28.00889
40	84.18309	28.01067
41	84.17964	28.01274
42	84.17982	28.01653
43	84.17911	28.01895
44	84.18061	28.02081
45	84.18354	28.02202
46	84.18368	28.02367
47	84.18446	28.02459
48	84.17925	28.02766
49	84.17575	28.02838
50	84.17097	28.02838
51	84.16819	28.03023

52	84.16719	28.03166
53	84.16176	28.03352
54	84.15627	28.03473
55	84.15348	28.0368
56	84.14706	28.03709
57	84.14556	28.03851
58	84.14492	28.03844
59	84.1427	28.04094
60	84.14178	28.0413
61	84.14213	28.04558
62	84.14435	28.04779
63	84.14506	28.05015
64	84.14292	28.05151
65	84.14028	28.05158
66	84.13778	28.0535
67	84.13385	28.05386
68	84.1305	28.05607
69	84.13	28.06079
70	84.12693	28.06514
71	84.12636	28.067
72	84.1245	28.06899
73	84.12393	28.07371
74	84.12579	28.0757
75	84.12679	28.08113
76	84.125	28.08406
77	84.12694	28.08619
78	84.12776	28.088
79	84.12768	28.09244
80	84.13004	28.0947
81	84.13393	28.09537
82	84.14383	28.0998
83	84.14353	28.1046
84	84.13812	28.10437
85	84.1279	28.10518
86	84.12602	28.10589
87	84.12262	28.1059
88	84.11969	28.10689
89	84.11694	28.1058
90	84.1085	28.1102
91	84.10506	28.10989
92	84.10407	28.10883
93	84.10169	28.10763

94	84.09855	28.10448
95	84.09623	28.10359
96	84.0951	28.10187
97	84.09399	28.10136
98	84.09342	28.09973
99	84.09164	28.09827
100	84.09046	28.09493
101	84.08145	28.0913
102	84.07218	28.07745
103	84.06987	28.0794
104	84.06958	28.08108
105	84.06713	28.0829
106	84.06529	28.08375
107	84.06274	28.08689
108	84.05749	28.08825
109	84.05427	28.08377
110	84.05287	28.08317
111	84.0502	28.0839
112	84.0477	28.08687
113	84.04569	28.08591
114	84.04345	28.08609
115	84.04202	28.08808
116	84.03146	28.08961
117	84.0264	28.08815
118	84.02538	28.08729
119	84.02144	28.08838
120	84.01738	28.08729
121	84.01681	28.0813
122	84.01475	28.07998
123	84.01378	28.07764
124	84.01017	28.07674
125	84.01092	28.07448
126	84.01333	28.07252
127	84.01333	28.07041
128	84.0165	28.06883
129	84.01664	28.06683
130	84.01849	28.06597
131	84.01892	28.06383
132	84.0138	28.04571
133	84.01332	28.04131
134	84.01699	28.04045
135	84.01759	28.03903

136	84.0202	28.03808
137	84.02175	28.03439
138	84.03055	28.03022
139	84.02948	28.02844
140	84.03061	28.02405
141	84.03205	28.02266
142	84.03195	28.02082
143	84.03222	28.02021
144	84.03442	28.01921
145	84.03405	28.01871
146	84.0299	28.01714
147	84.0285	28.01536
148	84.02891	28.01399
149	84.03009	28.01256
150	84.03013	28.00558
151	84.02713	28.00401
152	84.02642	28.00315
153	84.02663	28.00251
154	84.03348	28.00022
155	84.03527	28.00115
156	84.03641	28.00115
157	84.03763	28.00251
158	84.03977	28.00329
159	84.04255	28.00315
160	84.04334	28.00286
161	84.04655	28.00458
162	84.04687	28.00489
163	84.04846	28.00481
164	84.04937	28.00346
165	84.05555	28.00246
166	84.05632	28.00332
167	84.06031	28.00265
168	84.06269	28.00303
169	84.06412	28.00236
170	84.06679	28.00322
171	84.06717	28.00379
172	84.06717	28.00465
173	84.06926	28.00693
174	84.07238	28.00583
175	84.07443	28.00588
176	84.07567	28.00721
177	84.07596	28.00972

178	84.07707	28.0104
179	84.07896	28.01047
180	84.0795	28.01225
181	84.08064	28.0119
182	84.0816	28.00986
183	84.08314	28.0089
184	84.08296	28.00833
185	84.08414	28.00722
186	84.08664	28.00711
187	84.08693	28.00632
188	84.08958	28.00578
189	84.08977	28.00464
190	84.09053	28.00383
191	84.09476	28.00259
192	84.10024	28.00231
193	84.10314	28.00102
194	84.10699	28.00102
195	84.10737	28.00202
196	84.10913	28.00155
197	84.10918	27.99988
198	84.11204	27.99779
199	84.1124	27.9964
200	84.11821	27.99621
201	84.1193	27.99692
202	84.12254	27.9953
203	84.1233	27.99388
204	84.12487	27.99278
205	84.13148	27.99254
206	84.13648	27.99031
207	84.13729	27.99069
208	84.14057	27.9904
209	84.14262	27.98893
210	84.15659	27.98709
211	84.16066	27.98559

3.5.2 Seti Nadi 1 Sub watershed

3.5.2.1 Physiography

The whole part of the Seti Nadi 1 sub watershed falls within middle hill region of the Nepal. This is located nearly in center of the country, between the Mahabharata and the Himalayan range. Forests covers an area of 78,111.22 ha, agro based area covers an area of 64,061 ha and pasture land covers an area of 4,306 ha in Tanahun district. The district is politically divided into 10 Municipalities, out of which four are urban municipality and six are rural municipalities.

Table 7: Physiography of the Seti Nadi 1 sub-watershed

Physiographic region	Middle-Hill Region
Watershed	Seti Nadi 1 Sub-Watershed
Area	141 sq km
Location	Suklagandaki Municipality 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, Bhimad Municipality 8, 9 and Myagde Rural Municipality 2, 3, 4, 5, 6, 7 of Tanahun district.
Latitude	27° 36' to 28° 5' N
Longitude	83° 57' to 84° 34' E
Altitude	187to 2323 m from mean sea level

3.5.2.2 Topography and Climate

The district topography is characterized by northwest to southeast running hill chains with moderate to very steep slope, deeply cut river valleys and gentle to moderate sloped plains. The district is full of rivers such as Marsyangdi, Madi, Trishuli, Seti along with other rivulets. The climate varies from sub-tropical in the south to mild temperate in the north with the average annual rainfall about 1270 mm. The average maximum temperature is 31.5^0 Celsius and the average minimum temperature is 17.4^0 Celsius.

Table 8: Elevation of Sub watershed

Climate Zone	Elevation Range	Percentage of Area
Lower Tropical	below 300 meters	2.3%
Upper Tropical	300 to 1,000 meters	88.0%
Subtropical	1,000 to 2,000 meters	8.8%

3.5.2.3 Aspect

Aspect is the compass direction where the slope faces. For example, a slope on the eastern edge of watershed is described as having an easterly aspect. Southern aspect get more solar radiation than northern aspect, thus it affects the vegetation and soil moisture in the watershed. Most of the part of micro watershed is facing to North.

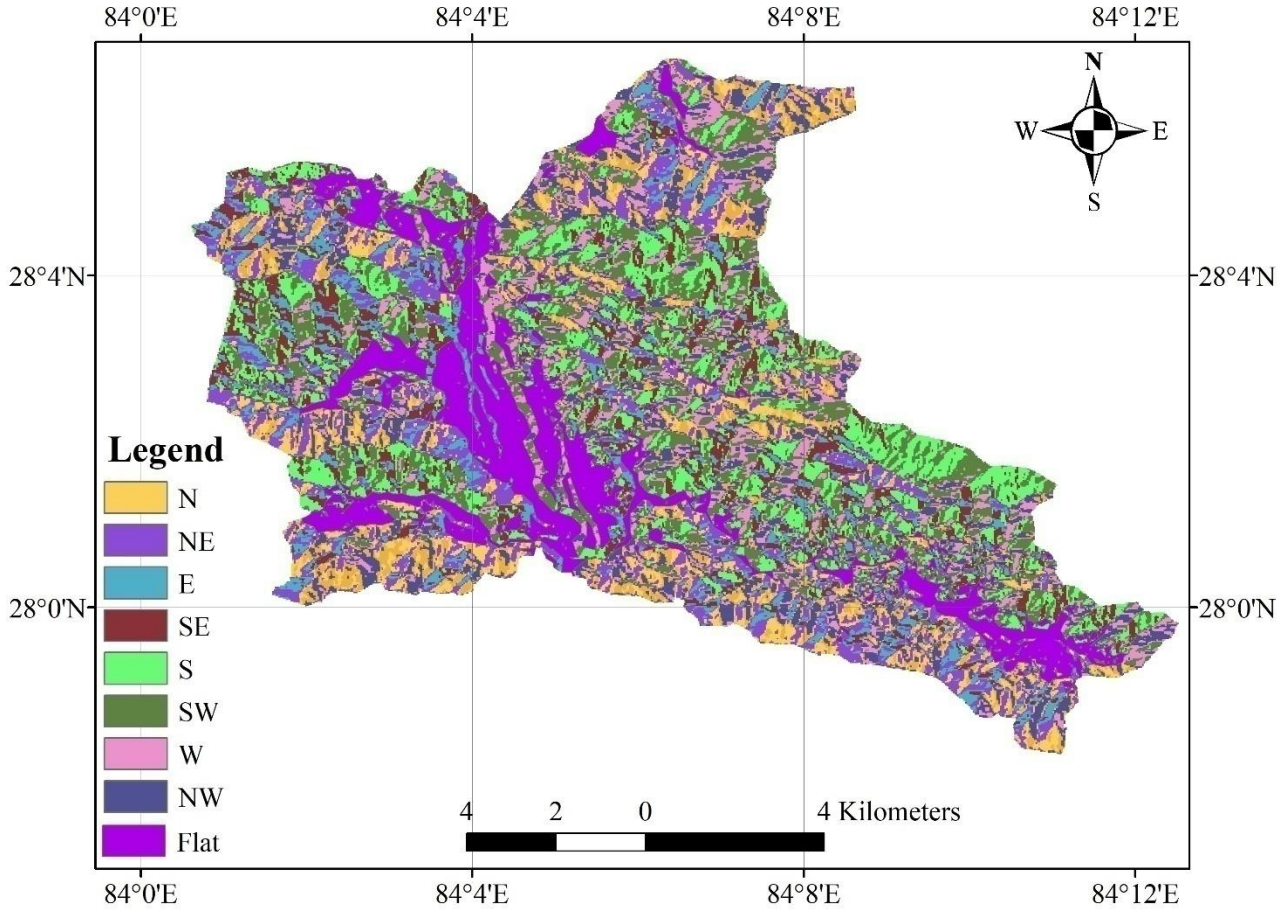


Figure 12: Aspect map of Seti Nadi 1 Sub Watershed of Tanahun District

This study categorized the eight aspect categories and flat. Among the aspects studied, the highest coverage is flat (21.55 sq. km) land surface. North, North East, South East and South West are major aspects of this sub watershed. East aspect covers only 10.56 km^2 of watershed, which is the least area covered by the specific slope category (**Table 8**).

Table 9: Aspect of Seti Nadi 1 Sub Watershed of Tanahun District

S.N.	Aspect	Area (km^2)
1	North	18.84
2	North East	14.01
3	East	10.56
4	South East	13.11
5	South	18.65
6	South West	18.74
7	West	11.95
8	North West	13.60
9	Flat	21.55
	Total	**141**

3.5.2.4 Slope

Land slope affects the erosion predominantly. As the slope increases, the runoff coefficient, kinetic energy and carrying capacity of surface runoff also increase while soil stability and slope stability both decrease. Thus it is very important to identify different slope in watershed. Slope map was prepared is three categories: less than 5 degree, 5 to 30 degree and more than 30 degree. Southern part of the watershed is more stepper than northern parts. In the middle part of the watershed there is medium slope. Slope analysis was carried out DEM in ArcGIS. Southern part with higher elevation has greater slope and decreases to some elevation down and increases again with flat near to water source. Most of the area of this sub watershed are fall in the moderate slope. Out of 141 km^2 of sub watershed, slope less than 5 degree covers 21.93 km^2, slope between 5 and 30 degree covers 101.84 km^2 and slope more than 30 degree covers 17.23 km^2.

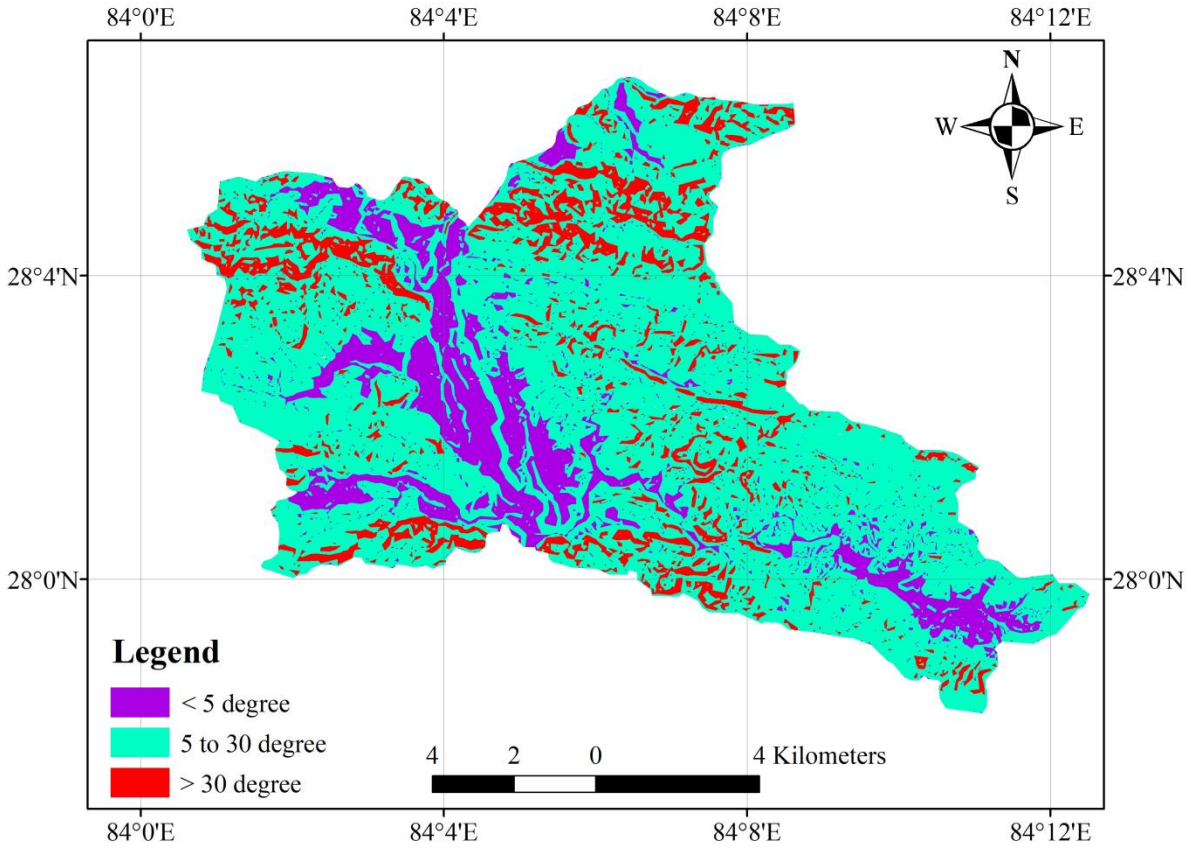


Figure 13: Slope map of Seti Nadi 1 Sub Watershed

3.5.2.5 Land use/land cover

The land use pattern and land management practices have great effect on the runoff yield which consequently effects on the watershed conditions. Altogether land use system of watershed is classified in 8 categories (**Figure 14**). Major LULC type of the sub watershed are agricultural land and broadleaved close forest whereas Needle leaved closed forest and grassland cover only few areas (**Table 10**).

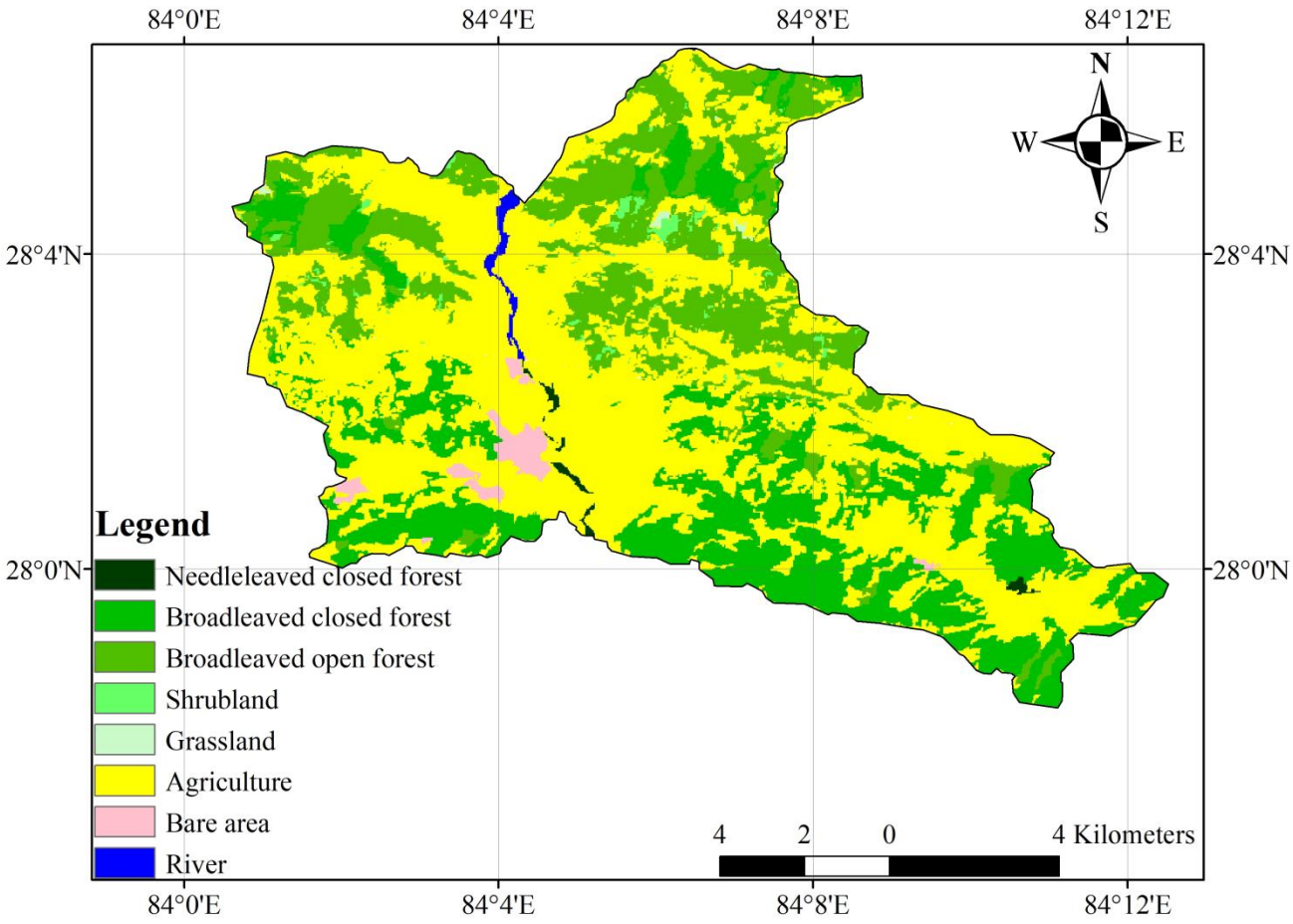


Figure 14: Land use land cover map of Seti Nadi 1Sub Watershed of Tanahun District

Table 10: Land use land cover of Seti Nadi 1 Sub Watershed of Tanahun District

S.N.	Land cover type	Area km
1	Needleleaved close forest	0.49
2	Broadleaved close forest	32.03
3	Broadleaved open forest	27.57
4	Shrubland	1.15
5	Grassland	0.20
6	Agriculture	77.02
7	Bare area	1.93
8	River	0.61
Total		**141**

3.5.2.6 River and Stream of Sub watershed

There are 34 Major River and stream in Sub watershed as listed table below.

Table 11: River and stream of Sub watershed

S.N.	Municipality	River / Stream name
1	Myagde Rural Municipality	Myagde Khola
2		Seti Nadi
3		Sange Khola
4		Gundadi Khola
5	Bhimad Municipality	Seti Nadi
6		Kulung Khola
7		Baduwa Khola
8		Bantang Khola
9		Fedi Khola
10		Yena Khola
11		Jidi Khola
12		Kayngdi Khola
13		Dhandur Khola
14		Gumi Khola
15	Suklagandaki Municipality	Dagdi Khola
16		Kyangdi Khola
17		Bhirab Khola
18		Baraha Khola
19		Gahate Khola
20		Byangdi Khola
21		Jhaddada Khola
22		Hadi Khola
23		Kami Khola
24		Chhahare Khola
25		Bampang Khola
26		Bange Khola
27		Seti Nadi
28		Kali Khola
29		Fedi Khola
30		Thado Khola
31		Khani Khola
32		Jamdi Khola
33		Manda Khola
34		Gahate Khola

3.5.2.7 Demography

At the time of the 2011 Nepal census, Tanahun District had a population of 323,288 with 179878 women and 143410 male population. Of these, 61.9% population are Hindu, 9.44% are Bauddha, 1.28% are Muslim, 1.69% are Cristian and 1.08% are other religion inhabitant of Tanahun District. There are 28.5% Magar, 13.55% Brahmin, 10.79% Chhetri, 12.17% Gurung, 7.55% Newar, 15.69%

Dalit and 12.25% other cast of total population of District. Population status of Seti Nadi 1 Sub watershed is listed in table below.

Table 12: Population status of Seti Nadi 1 Sub watershed

Municipality	Household	Male	Female	Total Population
Suklagandaki	6501	11500	14343	25843
Bhimad 8, 9	1831	4888	4667	9555
Myagde 2, 3, 4, 5, 6, 7	4569	11852	12472	24324
Total	**12901**	**28240**	**31482**	**59722**

Source: National Population Census 2011, Household Survey 2075

3.5.2.8 Agriculture and livestock

Rice, maize, millet, wheat, beans, vegetables, orange and lemon are major agricultural product of Seti Nadi 1 sub-watershed. Agriculture of this area is facing lack of irrigation, manure, market and mechanized technology. Buffalo, cow,goat, pig, poultry and fish are major livestock of this area.

3.5.2.9 Road networks

Road networks were downloaded from the Geofabrik website (http://download.geofabrik.de/asia/nepal.html; OpenStreetMap Contributors, 2017). Total road length of the district is 2876.37 km. Similarly, road density of the district is 1860.52 m/km^2.

3.5.2.10 Forests

Community forest and Lease hold forest are major forest in this Sub watershed. Major forest types of this area are broadleaved close forest and broad leaved open forest. Major species of these forests are Sal, Chilaune, Katus, Sisoo, Khayar and Non Timber Forests Products (NTFPs).

3.5.2.11 Micro watersheds

This Seti Nadi Sub Watershed of Tanahun Districts covers two micro watersheds with an area 92 sq km and 49 sq km. **Figure 15** is showing two micro watersheds of this sub watersheds.

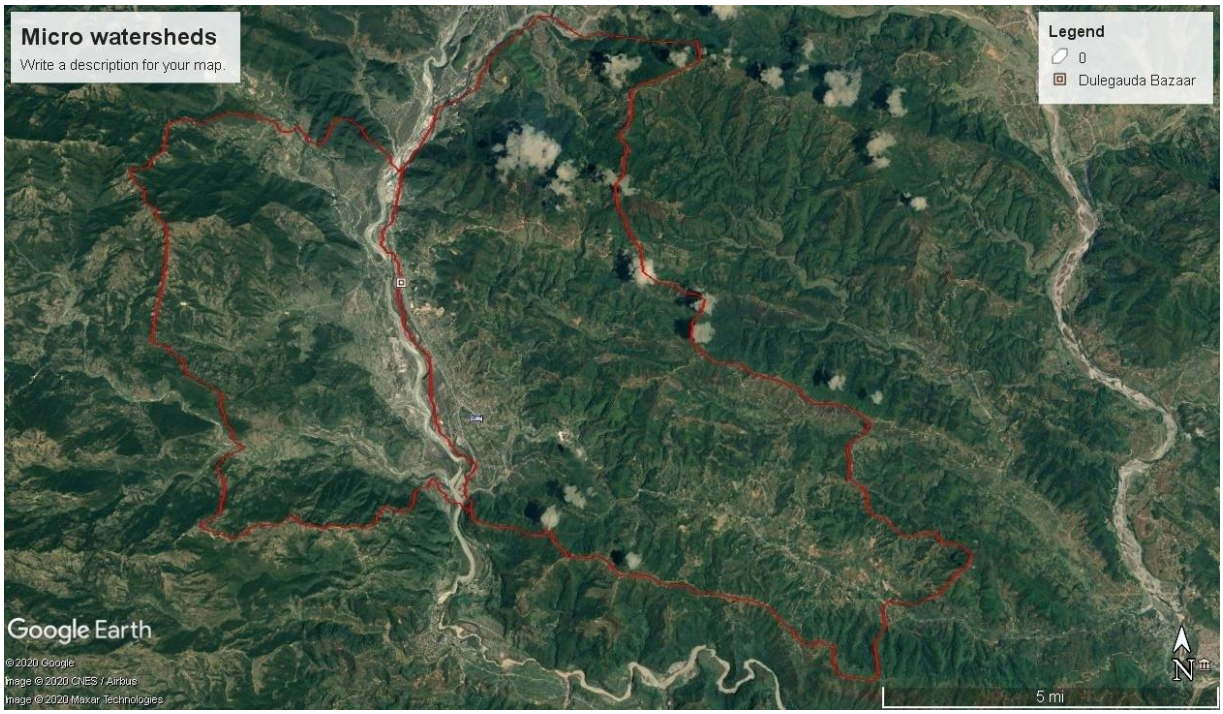


Figure 15: Micro Watersheds of Seti Nadi 1

3.5.3 Problems observed within sub watershed area

Watershed is an integration of land, water, forest, people and livestock within the drainage area of any water body (**Figure 16**). These five major and all other associated components within the drainage area of 68 ha of sub watershed come under the umbrella of micro watershed and are the major components considered on integrated approach of watershed management. The issues related to these components are the concern of development organization to deal with.

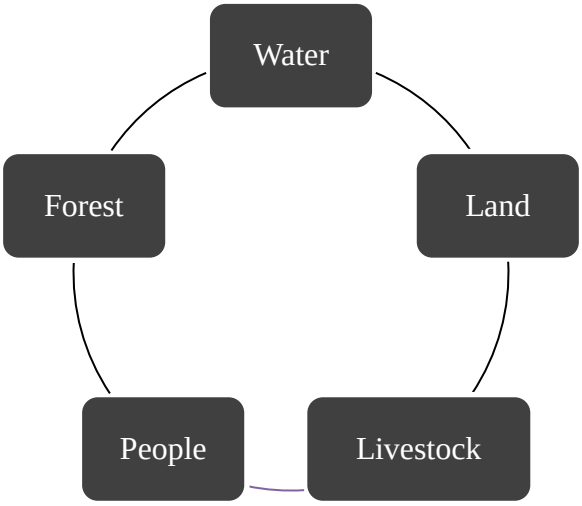


Figure 16: Major components of watershed

Problem of watershed incorporates the socio economic, environmental and different development issues connected with the components of watershed within the considered area. Hence some of such problems identified within the subwatershed area are as follows:

- The landslide both at the upstream and downstream area is causing the soil erosion in the monsoon season.
- The water resource is used without proper intake and collection tank and the series of pipes from the individual household is causing the seepage of water and it is underutilized.
- The river banks of the two different streams (Myagde, Kumle) are degrading day by day.
- The irrigation canals of sub watershed area needs to be maintained.
- The landslide within the sub-watershed area needs to be treated.
- Increasing rural roads construction in haphazard way without any IEE/EIA and supporting structures is resulting huge soil erosion. Every year large volume of sedimentation on the River.
- Deforestation and human encroachment to the forest area.
- Unscientific agricultural practice, unplanned land use and poor land/soil quality.
- Lack of awareness of conservation of soil and water resources.
- Lack of irrigation, drinking water, education and other facilities

3.5.4 Historical Timeline and Hazard Ranking

a. Historical Time Line

Table 13: Historical time line

Year	Disaster (Type)	Remarks
2000	Heavy Landslide	Suklagandaki 9, Gurdung Patagau
2044	Flooding and Landslide	Maygde 4, Manpang, Kilchock
2055	Flooding	Suklagandaki 6, Gyarsingh Jamdi
2062	Heavy river cutting	Suklagandaki 4, Gandaki tir
2066	Bhim Bhairab Pahiro	Bhimad 9

b. Community hazard ranking

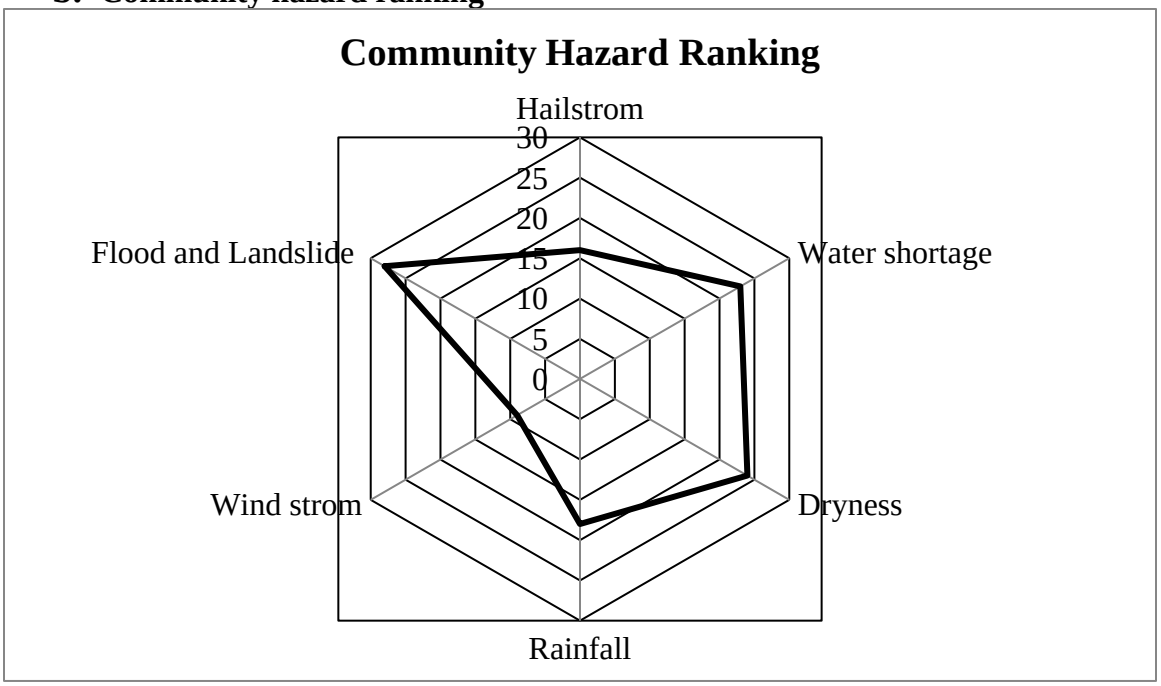


Figure 17: Community hazard ranking

Hazard	Impact Ranking
Rainfall	2
Hailstorm	4
Dry period	5
Flood and Landslide	3
Water shortage	5
Wind strom	4

Score	Impact
1	No impact /No harmful
2	Low impact / Not very harmful for the community.
3	Medium impact / Harmful for the community
4	Strong impact / Very difficult hazard for the community

	5	Very Strong impact / Most difficult hazard in the Community.	

c. Crop Hazard

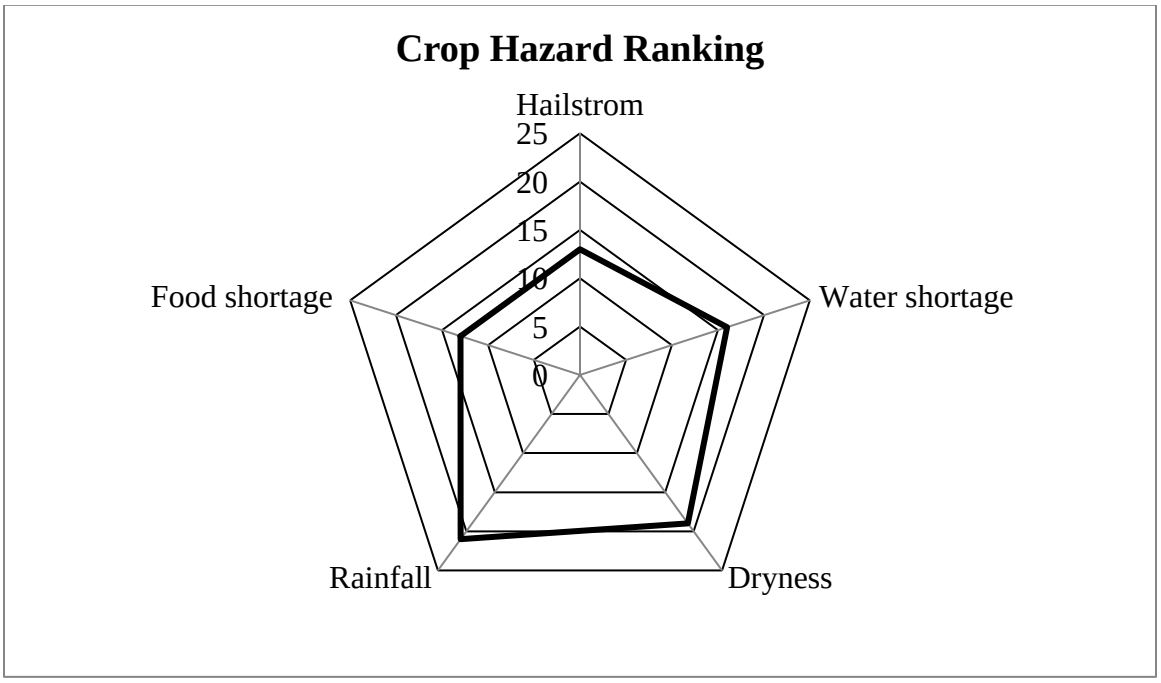


Figure 18: Crop hazard ranking

Hazard	Impact Ranking
Rainfall	2
Hailstorm	4
Dry period	5
Food shortage	3
Water shortage	5

Score	Impact
1	No impact /No harmful
2	Low impact / Not very harmful for the community.
3	Medium impact / Harmful for the community
4	Strong impact / Very difficult hazard for the community
5	Very Strong impact / Most difficult hazard in the Community.

3.5.5 Soil conservation and watershed management planning

Approved soil conservation and watershed management programs has the overall goal to contribute to the livelihood and well-being of the people through sustainable watershed management of the sub watershed area. Its purpose has been defined as to increase the productivity and utility of land and water and to prolong the services of the development infrastructures leading towards livelihood improvement on an equitable and sustainable basis through integrated soil conservation and watershed management.

To serve for the above mentioned goal and purpose the Soil and Watershed Management Office (SWMO) is implementing number of programs. Some major activities that SWMO has been doing are below.

Table 14: Major activities that are envisaged for watershed management programs

Component	Activities	Sub activities
1. **Water and sediment yield**	1.1.Water activities 1.1.1 Water source protection 1.1.2 Wetland conservation 1.1.3 Conservation pond/runoff harvesting dam	Intake construction, fencing, Bioengineering techniques, pond/lake conservation, water harvesting/utilization structures, greenery promotion activities
	1.2. Natural hazard management 1.2.1. Landslide/gully treatment	Structural /bioengineering techniques, conservation plantation,

	1.2.2. Torrent/stream bank protection 1.2.3. Community based DM support 1.2.4. Sediment trap structures	awareness activities, group mobilization, Community's skill development activities, provision of emergency fund
2. **Land productivity conservation**	2.1. On/off farm conservation 2.2.Degraded land rehabilitation 2.3. Terrace improvement	SALT, bioengineering ,slope management ,seed /seeding supply, agro-forestry, soil fertility management activities
3. **Protection of infrastructure**	3.1. Roadside slope protection 3.2. Irrigation canal improvement 3.3.Siltation management 3.4. Hotspot treatment	Rural/National road side slope stabilization measures (Structural/nonstructural), national heritage and other infrastructure protection hard/soft activities
4. **Institutional development**	4.1.Partnership program 4.2. CRMP (community resource management plan) formulation 4.3. Group's tour/training 4.4. Income generation support 4.5.Group monitoring/extension	Partnership with GO/NGO/CBOs organizations, income generation support (conservation oriented), and group strengthening activities, best practice findings documentation and extension related activities.
5. **Program management**	5.1.Erosion hazard map preparation 5.2. Sub w/s management plan preparation 5.3. Nursery management 5.4.Motivator/conservation assistant 5.5.Maintenance/follow up	Hazard map preparation, sub w/s plan preparation, Nursery build up /seeding production, hiring local staff as conservation assistants, maintenance and follow up of past activities.

3.5.6 Plan of activities

Use of the land based on its capability is the main theme of rational land use. Based on proper land use and slope, which are two key parameters deciding its use, recommendations for land use and conservation measures are required. Change in land use recommended for some present use is not so easy because it depends in the willingness of the owner/farmer.

3.5.6.1 Land use planning

The first-hand information about sub watershed can be obtained through land use planning. Scientific utilization and management of watershed resources on basis of existing bio-physical and socio-economic situation analysis is planned through the sub watershed management plan, community resources management plan, watershed prioritization, forest operation plan and other related to land use development and natural resources management planning. Land use, land capability, land system and other different primary and secondary data sources are used during the planning process.

3.5.6.2 Land productivity conservation

Appropriate land uses on the basis of land capability are encouraged through different land productivity conservation activities for improved land productivity and soil depth.

On farm conservation, degraded and reclaimed land rehabilitation, fruit/fodder tree plantation, grass plantation, green belt/shelter belt construction, nursery management and seedling production are the major activities under this component. Improved productivity, increased agricultural land and greenery promotion are expected outcomes from these activities.

3.5.6.3 Need assessment for infrastructure protection and conservation works

This is most needed and equally demanded activities which cover the protection programs of development infrastructures like irrigation canals and reservoirs systems, trail roads, water supply systems, public/community buildings and others. Various conservation works like pond conservation, landslide/landslip treatments, stream bank protection are executed through the combination of civil and bio-engineering works like support walls, check dams, diversion channels, and vegetative measures jointly or individual as per the site's need. High preference is given to the bio-engineering works and greenery promotion activities along with the engineering work which expands economic service life of the development infrastructures. Information about the existing problems related to soil erosion and natural resources management was collected through structured questionnaire, open interview; check list, PRA, RRA within considered sub watershed area. Different activities required for conservation of individual component are given in following section.

a. River bank cutting stabilization and flood management

In this sub watershed twenty one streams are cutting the land. These streams are affecting the agricultural land, forest and grazing lands (**Table 15**).

Table 15: Needs of river bank cutting stabilization

S.N.	Flood causing stream	Address	Status	Affected area
1	Jamdi Khola	Suklagandaki 6, Jamdi	Active in monsoon	Agriculture land, Forest, Grazing land
2	Kumle Khola	Suklagandaki 6	Active in monsoon	Agriculture land, Forest, Grazing land
3	Syandi Khola	Suklagandaki 6	Active in monsoon	Agriculture land, Forest, Grazing land

4	Thudi Khola	Suklagandaki 6	Active in monsoon	Agriculture land, Forest, Grazing land
5	Seti Nadi	Suklagandaki 4	Active in monsoon	Agriculture land, Forest, Grazing land
6	Suraudi Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
7	Mandre Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
8	Baraha Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
9	Bange Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
10	Chasi Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
11	Wangpang Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
12	Handi Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
13	Tamune Khola	Suklagandaki 9	Active in monsoon	Agriculture land, Forest, Grazing land
14	Khahare Khola	Bhimad 8, Simle	Active in monsoon	Agriculture land, Forest, Grazing land
15	Kayngdi Khola	Bhimad 8	Active in monsoon	Agriculture land, Forest, Grazing land
16	Bar Khola	Bhimad 9	Active in monsoon	Agriculture land, Forest, Grazing land
17	Foksingh Khola	Bhimad 9	Active in monsoon	Agriculture land, Forest, Grazing land
18	Ropadi Khola	Maygde 4	Active in monsoon	Agriculture land, Forest, Grazing land
19	Samdi Khola	Maygde 4, Tharpu bazar	Active in monsoon	Agriculture land, Forest, Grazing land
20	Maygde Khola	Maygde 6	Active in monsoon	Agriculture land, Forest, Grazing land
21	Sange Khola	Maygde 6	Active in monsoon	Agriculture land, Forest, Grazing land

b. Irrigation canal maintenance work

Twenty six irrigation are in this sub watershed. All of them are seeking maintenance and protection. Details of these canals are in **Table 16**.

Table 16: Needs of irrigation canal maintenance work

S.N.	Name of irrigation canal	Address	Area of irrigation	Benefited household	Status
1	Bel Bot Kulo	Suklagandaki 6	95 Ropani	10	Need for protection
2	Sera Kulo	Suklagandaki 6	155 Ropani	20	Need for protection
3	Baguwa Khola Kulo	Myagde 7			Need for protection
4	Sauraha Kulo	Suklagandaki 6	140 Ropani	15	Need for protection
5	Chasi Gurubakas Kuloa	Suklagandaki 9	270 Ropani	30	Need for protection
6	Chokhe Mati	Suklagandaki 9	250 Ropani	27	Need for protection
7	Naubise Sana Sichai	Myagde 2			Need for protection
8	Baraha Khola Badh	Suklagandaki 9	320 Ropani	33	Need for protection
9	Pahele Kulo	Myagde 3			Need for protection
10	Jaymereko Kulo	Suklagandaki 9	238 Ropani	28	Need for protection
11	Thulakhet Sichai	Myagde 5			Need for protection
12	Samal Kulo	Suklagandaki 9	145 Ropani	16	Need for protection
13	Sana Kula	Bhimad 8	96 Ropani	12	Need for protection
14	Jaymeri Sichai	Myagde 2			Need for protection
15	Serabesi Kula	Bhimad 9	530 Ropani	60	Need for protection
15	Lami Kula	Bhimad 9	980 Ropani	150	Need for protection
16	Ambote Kulo	Myagde 3			Need for protection
17	Foksing Kola Lami Kulo	Bhimad 9	375 Ropani	40	Need for protection
18	Yelung Jharana Kulo	Bhimad 9	337 Ropani	35	Need for protection
19	Pokhare Badh Kulo	Maygde 4, Sipale	112 Ropani	12	Need for protection
20	Tinmure Kulo	Maygde 4	375 Ropani	45	Need for protection

21	Atha Bise Kula	Maygde 4	530 Ropani	60	Need for protection
22	Tillar Kulo	Myagde 7			Need for protection
23	Sera Badh Kulo	Maygde 4	400 Ropani	50	Need for protection
24	Serafat Sichai	Maygde 6	215 Ropani	23	Need for protection
25	Akala Sichai	Maygde 6	88 Ropani	10	Need for protection
26	Dumre Sichai	Maygde 6	91 Ropani	10	Need for protection

c. Landslide control

Landslides are major water and gravity induced hazards. In this sub watershed, thirteen landslides are serious in terms of affected areas (**Table 17**).

Table 17: Needs of landslide treatment

S.N.	Name of landslide	Address	Status	Remarks
1	Gyarsingh Pahiro	Suklagandaki 6	Active	
2	Darai Gau Pahiro	Suklagandaki 6	Active	
3	Bayam Pahiro	Suklagandaki 6	Active	
4	Jamdi Pahiro	Suklagandaki 6	Active	
5	Badgau Pahiro	Suklagandaki 9, Suraudi Badh	Active	
6	Keurepani Gaylangdi Pahiro	Suklagandaki 9	Inactive	
7	Bat Danda Jholunge	Suklagandaki 9	Active	
8	Chinne Pani Pahiro	Bhimad 8	Active	
9	Kokhebesi	Bhimad 8	Active	
10	Bhat Danda Pahiro	Bhimad 9	Active	
11	Jaupani Ban Pahiro	Bhimad 9	Active	
12	Ronche Khalda Pahiro	Bhimad 9	Inactive	
13	Kharkhare Pahiro	Maygde 4	Active	

d. Gully control

Gully control is also major activity of sub watershed management plan. Three gullies are more serious gullies of this sub watershed (**Table 18**). These gullies are needs to be controlled.

Table 18: Needs of assessment of gully control

S.N.	Name of gully	Address	Status	Affected area	Remarks
1	Samabesi Tole Galchi	Suklagandaki 6	Serious	Settlement, Agricultural land, Grazing land, Forest	Large
2	Gumi Khola Galchi	Bhimad 8	Serious	Settlement, Agricultural land, Grazing land, Forest	Large
3	Dhobikhola	Magde 6	Serious	Settlement, Agricultural land, Grazing land, Forest	Large

e. Road slope stabilization

Roads are major factors of accelerating the soil erosion. Now days, roads are becoming major factors of landslides and soil loss. In this sub watershed, Forty three feeder roads are causing the soil erosion (**Table 19**).

Table 19: Road side erosion maintenance work

S.N.	Name of Road	Address	Status of Soil Erosion	Status of Road
1	Sitalbasti Marga	Suklagandaki 5, Seti kinar	Active	Pakki road
2	Laliguras Marga	Suklagandaki 5, Dandur khola	Active	Kachhi road
3	Madan Asrit Motar Marga	Suklagandaki 5, Bhurunge	Active	Kachhi road
4	Manmohan Motar Marga	Suklagandaki 5, Naya Gau Simal chaur	Active	Kachhi road
5	Khairenitar Tin Kholi Devi Marga	Suklagandaki 6, Tinkholi	Active	Kachhi road
6	Jamdi Kasebayam Marga	Suklagandaki 6, Jamdi	Active	Kachhi road
7	Jana Sewa Motar Marga	Suklagandaki 6	Active	Kachhi road
8	Gyarsingha Motar Marga	Suklagandaki 6, Gyarsingha	Active	Kachhi road
9	Janasewa Madan Asrit Marga	Suklagandaki 6	Active	Kachhi road

10	Dargau Lamsal Danda Marga	Suklagandaki 6, Dargau	Active	Kachhi road
11	Maithan Bel Bot Marga	Suklagandaki 6	Active	Kachhi road
12	Akhle Chainpur Motar Marga	Suklagandaki 6, Akhle	Active	Kachhi road
13	Bagaicha Naubise Motar Marga	Suklagandaki 6, Naubise	Active	Kachhi road
14	Sakhe Motar Marga	Suklagandaki 4, Sakhe	Active	Kachhi road
15	Harkhapur Motar Marga	Suklagandaki 4	Active	Kachhi road
16	Dulegauda Badkhola Marga	Suklagandaki 9, Badkhola	Active	Kachhi road
17	Kot Khadka Kalika Marga	Suklagandaki 9, Kot	Active	Kachhi road
18	Dulegauda Piurudovan Marga	Suklagandaki 9, Dulegauda	Active	Kachhi road
19	Dangdar Badgau Bhatdanga Motar Marga	Suklagandaki 9, Badgau	Active	Kachhi road
20	Bhirgu Disi Marga	Bhimad 8	Active	Kachhi road
21	Kayndi Deurali Marga	Bhimad 8	Active	Kachhi road
22	Radha Krishna Marga	Bhimad 8	Active	Kachhi road
23	Bhimbhairab Marga	Bhimad 8	Active	Kachhi road
24	Siddha Gufa Marga	Bhimad 7	Active	Kachhi road
25	Bhimdeurali Marga	Bhimad 7	Active	Kachhi road
26	Maruwa Archale Marga	Bhimad 7	Active	Kachhi road
27	Athabesi Masdanda Marga	Bhimad 7	Active	Kachhi road
28	Geruwa Pani Moatar Marga	Bhimad 7	Active	Kachhi road
29	Sisneri Baspani Motar Marga	Bhimad 7	Active	Kachhi road
30	Jarebar Jaupani	Bhimad 9	Active	Kachhi road
31	Serabesi Bhat Danda Jaupani	Bhimad 9	Active	Kachhi road

32	Chepan Danda Motar Marga	Bhimad 9	Active	Kachhi road
33	Mohariya Pangdi Marga	Bhimad 9	Active	Kachhi road
34	Sisneri Huchelibas Marga	Maygde 4	Active	Kachhi road
35	Pipaltar Chimle Swara Marga	Maygde 4	Active	Kachhi road
36	Pipalthok Motar Marga	Maygde 4	Active	Kachhi road
37	Chhang Tharpu Motar Marga	Maygde 4	Active	Kachhi road
38	Seraphant Keurang Chhetru Bhanjyan Motar Marga	Magde 6	Active	Kachhi road
39	Chhbise Bhaneswara Tilahar Motar Marga	Magde 6	Active	Kachhi road
40	Akala Motar Marga	Magde 6	Active	Pakki road
41	Mulbarahi Motar Marga	Magde 6	Active	Kachhi road
42	Manpani Gramin Basti Bikas Marga	Magde 6		
43	Belseti Narkate	Magde 6	Active	Kachhi road

f. Needs of Pond maintenance work

Ponds are major factors for water recharge so as to enhance water table. In this sub watershed, fifteen ponds need to be protect and reconstruct.

Table 20: Needs of Pond maintenance work

S.N.	Name of Pond	Address	Area of irrigation	Benefited household	Status
1	Baygun Pokhari	Suklagandaki 6	85 Ropani	10	Need for protection
2	Bayam Pokhari	Suklagandaki 6	165 Ropani	20	Need for protection
3	Gayrsingh Kunda	Suklagandaki 6	123 Ropani	15	Need for protection
4	Maduli Chautara Pokhari	Suklagandaki 9	365 Ropani	40	Need for protection
5	Kharbari Pokhari	Suklagandaki 9	120 Ropani	15	Need for protection

6	Dangdar Pokhari	Suklagandaki 9	83 Ropani	10	Reconstruction
7	Barbhanjang Pokhari	Bhimad 8	146 Ropani	20	Need for protection
8	Chainpur	Bhimad 8	580 Ropani	65	Need for protection
9	Sakheb Recharge Pokhari	Bhimad 9	302 Ropani	35	Need for protection
10	Lamke Swara	Maygde 4	380 Ropani	50	Need for protection
11	Kaulepani Pokhari	Maygde 4	415 Ropani	40	Need for protection
12	Gud Danda Pokhari	Maygde 4	190 Ropani	25	Need for protection
13	Keurang Pokhari	Maygde 6	275 Ropani	40	Reconstruction
14	Shyamdanda Pokhari Bhanjyan	Maygde 6	240 Ropani	40	Reconstruction
15	Sakhlang Pokhari	Maygde 6	130 Ropani	30	Need for protection

g. Urban Watershed Conservation Work

Seventeen urban watershed are noticed in the Sub watershed. These watershed need to be protect so as to maintain health of drinking water.

Table 21: Urban Watershed Conservation Work

S.N.	Name of Urban Drinking water source	Address	Benefited household	Status
1	Rudi Khola (Boring)	Suklagandaki 4, Rudi khola	260	Need for protection
2	Jamdi Khola	Suklagandaki 6, Jamdi		Need for protection
3	Jogi mul / Chahara mul	Suklagandaki 6		Need for protection
4	Keurang Khola (Boring)	Suklagandaki 6, Keurang		Need for protection
5	Ghari Khanepani (Chahara Bhatdanda Mul)	Suklagandaki 9, Bhatdanda	500	Need for protection
6	Paykhar Gauda Mul	Suklagandaki 9	200	Need for protection
7	Bhatdanda Khanepani	Suklagandaki 9	60	Need for protection
8	Bajthala Khanepani	Suklagandaki 9	70	Need for protection

9	Koteli Khanepani (Chahara Khola)	Maygde 6, Chahara	60	Need for protection
10	Koteli Dhab Khola Khanepani	Maygde 6	35	Need for protection
11	Chhinne Khanepani	Maygde 6, Manpang	79	Need for protection
12	Malinge Khola Mul (Lift system)	Maygde 4	110	Need for protection
13	Rangrung Khanepani	Bhimad 8		Need for protection
14	Simle Khanepani	Bhimad 8		Need for protection
15	Giruwapani	Bhimad 7		Need for protection
16	Sundhara	Bhimad 7		Need for protection
17	Sisneri	Bhimad 7		Need for protection

3.5.7 Costs and funding

3.5.7.1 Estimation of costs for the 5 year planning

With respect to the requirements identified during field studies and above-mentioned in the planning of activities (need assessment), a tentative estimate of the volume of work as well as its costing has been prepared as per the current norms. This estimation (**Table 22**) of quantity and budget may get changed as per time, terms and condition.

Table 22: Estimation of activities for the five years planning

S.N.	Activities	Quantity (unit)	Annual activities for 5 years					Total 1activity	Total cost (In thousands)	Remarks
			1	2	3	4	5			
1	**Natural Hazard Prevention/ Management**									
1.a	Landslide and landslip treatment	No	2	2	2	2	2	10	10000	1000/No
1.b	Gully/torrent treatment	Place	1	1	1	1	1	5	5000	1000/Place

1.c	River/stream bank protection	Km	2	2	2	2	2	10	50000	5000/Km
1.d	Safe water disposal	Km	1	1	1	1	1	5	25000	5000/Km
2	**Land productivity conservation**									
2.a	On /off farm conservation / Farmer together with soil conservation	Ha	5	5	5	5	5	25	2500	100/Ha
2.b	Degraded land rehabilitation	Ha	5	5	5	5	5	25	2500	100/Ha
2.c	Conservation plantation	Ha	5	5	5	5	5	25	2500	100/Ha
3	**Water conservation**									
3.a	Water source / wetlands protection	No	1	1	1	1	1	5	1000	200/No
3.b	Conservation pond construction/maintenance	No	3	3	3	3	3	15	4500	300/No
3.b	Run off harvesting dam construction / maintenance	No	1	1	1	1	1	5	3500	700/No
4	**Development Infrastructure**									
4.a	Rural road with soil conservation / Roadside slope stabilization	Km	5	5	5	5	5	25	25000	1000/Km
4.b	Urban watershed management	No	3	3	3	3	3	15	7500	500/No
	Irrigation channel protection	No	4	4	4	4	4	20	4000	200/No
4.c	Miscellaneous development works	L.S.							1000	
5	**Program plan and management**									
5.a	Land use planning	No	1	1	1	1	1	5	250	50/No
5.b	CRMP formulation	No	1	1	1	1	1	5	250	50/No

5.c	Hazard assessment and map preparation	No	1					1	100	100/No
5.d	Nursery management	Years	1	1	1	1	1	5	1000	200/Year
5.e	Income generation activities	Package	1	1	1	1	1	5	500	100/Package
6	**Institutional development**									
6.a	Users and farmers training	Times	1	1	1	1	1	5	750	150/Times
6.b	Women motivators/ youth club	No	1	1	1	1	1	5	250	50/No
6.c	Study tours and cross visits	Times	1	1	1	1	1	5	250	50/Times
6.d	Production of extension materials	L.S.	1	1	1	1	1	5	250	50/Times
6.e	School program	Times	1	1	1	1	1	5	250	50/Times
6.f	Miscellaneous (programs as per need)	L.S.							200	
Total									**148050**	

3.5.8 Methods of funding

Successful implementation of the watershed management plan's activities will require adequate program funding and professional supports of various sectors. There could be following funding methods. To be noted that there are a number of other supplemental sources of funding:

1. SWMO, Tanahun
2. Private land owners and other users
3. Division Forests Office, Tanahun
4. Baudikaali and Buligtar Rural Municipality
5. International Development Agencies
6. Non-governmental organizations
7. CFUG
8. CBOs and local groups: mother groups

A blend of funding method is strongly recommended since various actors have their own areas of specialization as well as limitations.

3.5.9 Plan implementation approach

SWMO Tanahun is doing the watershed management activities in Tanahun District from few years. Besides all these efforts the outcome is not meeting the expectations and problems are not sorted out as the problems are accelerating and adding each next year. So their needs an integrated and focused approach of all line/concerned agencies to work on different components of the watershed.

3.5.10 Implementation mechanism

a. Sub watershed management committee

The first step before implementation of the planned works is to form a multi-disciplinary coordination committee lead by the SWMO and members will be the representative from identified stakeholders like from Government Offices District Agriculture, Livestock, Irrigation, Tourism, Road, Suklagandaki Municipality, Bhimad Municipality, Myagde Rural Municipality, INGOs/NGOs working on the sub watershed area and at local level representative of local CBOs, political leaders and other identified.

The committee coordinated by the SWMO will be responsible for the identification of roles and responsibilities of different agencies, planning of yearly activities and budget, resource sharing, working procedures and others as per need. Since SWMO alone can't carry out all the identified need and works due to its limited financial and human resource and more of it the works are related to different offices it identifies and purpose to different line agencies for their nature of job to be carried out in the watershed area. In accordance with the available budget of different government and non-government offices a working plan will be endorsed at the commencement of the year based on this management plan.

b. Collaborative approach

The destructions in the watershed area is enormous and thus, demand huge investments in various aspects such as technical, social, economic, human and so on. Fulfillment of these investments is beyond the capacity of one organization or two. So, the collaborative approach in rehabilitation of watershed resources and livelihoods of people will strongly be established.

c. Awareness raising and capacity building

Ultimate beneficiaries of the natural resources in watershed are local community. Their livelihood is based on the local environment. In other words, they are interdependent. Over exploitation of resources not only deteriorate the environment they are living in but also degrade their livelihood. Thus, it is very important to make them understand about the sustainable use of these resources. Trainings, workshops, field visits can be means for awareness raising and capacity building of the community in watershed.

d. Participatory approach

Sense of ownership in local community is the only way for the successful watershed management. It has to be created using active participation of local community of all level equally in all activities from decision making to planning and finally implementation. SWMO has strong guidelines to work on active participation of the beneficiaries so as to make the work sustainable, to make people aware about the activities and for post work care / repair and maintenances.

3.5.11 Working modality

Almost programs will be done through Beneficiaries Group Approach. Existing users group (CFUG, women groups, saving and credit groups, youth groups and so on) working in the area and community development groups (CDGs) facilitated by GOs/NGOs will be involved directly. For group mobilization and empowerment, NGO support will be sought through contractual arrangement.

If watershed management task is conceived as per time based project on collaboration of different line agencies. The possible project implementation stages will be:

Stage I – Formation of watershed management council, working plan/strategy/schedule, monitoring mechanism and others as per required

Stage II – Village clusters, hotspots and priority areas are to be identified within the sub watersheds

Stage III – Taking into the consideration of interest and need of local inhabitants, number of interest or user groups will be formed

Stage IV – At village level, sub watershed conservation users group as an umbrella organization of small beneficiaries' level users group will be foreseen. And sub watershed level federation of watershed conservation users group, as a network of village level groups will be formed if needed

Stage V – Hiring of staffs (If required), trainings for working GOs/NGOs/CBOs staffs for their increased working capacity and empowerment / capacity building for user's group

3.5.12 Monitoring and evaluation

Monitoring and evaluation are major component of the planning. Whether or not the implemented activities have got the intended outputs or to check for the fulfillment of set objectives for any plan the designed activities and works are monitored and evaluated. In sub watershed management activities M&E is very important tool to have intermediate checks to ensure proper work in scheduled time and to make recommendation and learning from the experiences that may help in other similar works and for future planning. Proper monitoring and evaluation need to be done in participatory approach. Progress will be monitored by setting time based targets in presence of local community and SWMO.

Financial and technical auditing is expected for the sub watershed management works by the agencies involved. On government side M&E is done by the SWMO itself and reports are sent to its higher agencies regularly. Besides Forest Directorate (FD), Ministry if Industry, Tourism, Forest and Environment (MOITFE) as well are frequently monitoring the works. Public auditing will be done at various stages of activity implementation in order to maintain transparency, accountability and reliance.

3.5.13 Log frame

Log frame is an analytical tool which helps to identify goals, purpose, outputs, means of verification and assumptions or the conditions (If any) of the planned programs/activities. Here based on the needs and activities identified and field level assessments a log frame has been prepared. Mentioned log frame (**Table 23**) is well guided for sub watershed management.

Table 23: Log frame

Components (Activities)	Indicators (Output)	Means of verifications	Important assumptions
Contributing positive support in livelihood of the people and to the environment through sustainable watershed management practices	District Co-ordination Committee (DCC), Rural Municipality (RM) and other institute recognizes SWMO Program's significant contribution to the overall development	Reports of DCC, RM and other agencies	
• **Purpose :**			
To increase the productivity and utility of land and water resources, decrease disaster and to prolong the services of development infrastructures leading towards better livelihood along with environmental improvement on an equitable and sustainable basis through integrated soil conservation and watershed management approach	• Reduced water induced disasters and its loss. • Decreased siltation in downstream • Availability of water from pond, stream and other water source for different purpose increased (by quantity and quality) significantly	• Disaster related reports • Water use and other water related reports of different agencies • Specific production study of the concerned agency • Monitoring reports of MOITFE, FD, SWMO, DCC, RM and other concerned agencies	• Sub watershed will be given priority to work on • SWMO programs continues to be national and district priority program • Adequate human and financial resources are available for the program

	• Production per unit area of intervened watershed increased significantly • Utility of development infrastructures increased significantly • The poor, women and vulnerable groups of people benefited from SWMO programs		• Active participation of local people from planning to post work maintenance will be available
Activities :			
1. Natural Hazard prevention			
a. Landslide/Landslip treatments	No. of landslides/landslip treated stabilized	SWMO activity profiles, MOITFE, FD, DCC, RM, report, field study monitoring report	Natural calamities will not occur.
	No. of HH benefitted Ha. of land protected		Active participation of local people on implementation and post work maintenance will be available

b. River/stream bank protection	No of hectare of land reclaimed and handed over to the user group Length of river span trained	"	"
c. Conservation ponds/Silt trapping structures	No. of ponds/dams constructed	"	"
	Area of land protected No. of HH benefitted		
2. Water Source protection			
a. Conservation ponds/lakes/waterhole protection	No. of ponds/lake/water source and wetlands protected/managed Ha (area) of agricultural land irrigated.	"	"
	Total no of HHs benefitted		
b. Water Source protection	No. of ponds/lake/water source and wetlands protected/managed	"	"
	Total no of HHs benefitted		
c. Wetland conservation/Management	No. of ponds/lake/water source and wetlands protected/managed	"	"

	Total no of HHs benefitted		
3. Land Productivity enhancement/Conservation programs			
a. Agro forest friendly land conservation	Total hectares of land conserved/reclaimed Amount of income (Rs.) generated	"	People's participation and willingness Lands available for the intended purpose and people
	No. of farmers/HHs benefitted and applying proper land use practices		Favorable environmental condition
b. Degraded land reclamation	Total hectares of land conserved/reclaimed Production and income generated	"	"
	No. of farmers/HHs benefitted and applying proper land use practices		
c. River land reclaimed/handover to the local people	Total hectares of land conserved/reclaimed	"	People's participation and willingness
	No. of farmers/HHs benefitted and applying proper land use practices		Lands available for the intended purpose and people

			Natural calamities will not occur
4. Development Infrastructure protection			
a. Irrigation canal improvement	Total kilometer of irrigation canal/work over	"	"
	Total command area (ha)facilitated with irrigation		
	No. of HH benefitted		
b. Roadside slope stabilization	Slope stabilized/work over	"	"
	Total command area (ha) facilitated with irrigation		
	No. of HH benefitted		
5. Community soil conservation			
a. Partnership soil conservation program	No. of activities	"	People's participation and willingness Agencies eager to work on collaboration/partnership
	No of partner agencies and resource contribution		Concern local organization/groups continue the maintenance work
	Total no of HHs benefitted		
b. Income generation activities for pro-poor and marginalized people	No of HHs upgraded to their social and economic status	"	People's participation and willingness
	Total income generated per person/HH		

c. Integrated watershed demonstration site development	No. of demonstration site developed	"	People's participation and willingness
	Quantity and quality of different components implemented		Concern local organization/groups continue the maintenance work
	No. of HHs benefitted		
4 Extension Activities	No of trainings and tours conducted (no of people) Level of conservation awareness increased to community people	"	People's participation and willingness. Basic education and knowledge of people

4. CONCLUSIONS AND RECOMMENDATION

This study delineates sub-basins and sub-watersheds of the Tanahun District. Furthermore this study prioritized the identified sub watersheds and prepared the management plan of most vulnerable watershed for effective and efficient management of sub watershed. Although this district does not support any sub-basin, total 17 sub-watersheds were identified. During the study, Seti Nadi 1 Sub Watershed of Suklagandaki Municipality, Bhimad Municipality and Myagde Rural Municipality is identified as top prioritized sub watershed of this district. Due to local and managerial perspective, Soil and Watershed Management Office, Tanahun decided to prepare the management plan of Seti Nadi 1 Sub Watershed which is first top prioritized sub watershed of the district. Resources allocation to these prioritized sub-watersheds are recommended. Furthermore, effective implementation of this sub watershed management plan is recommended for benefit of environment and people.

Some important recommendations are as follows:

- Use of existing rules and regulations (Soil Conservation Act 2039 and so on) for sub watershed management.
- Establishment of coordination mechanism on comprehensive land use planning.
- Construction of terraces for hill side farming.
- Establishment of production forest in gentle slope and protection forest in steep slope.

Reference

Abdul Rahaman, S., Abdul Ajeez, S., Aruchamy, S., Jegankumar, R., 2015. Prioritization of sub watershed based on morphometric characteristics using Fuzzy Analytical Hierarchy Process and Geographical Information System – A study of Kallar Watershed , Tamil Nadu. Aquat. Procedia 4, 1322–1330. https://doi.org/10.1016/j.aqpro.2015.02.172

Adhami, M., Sadeghi, S.H., 2016. Sub-watershed Prioritization based on Sediment Yield using Game Theory Sub-watershed prioritization based on sediment yield using game theory. J. Hydrol. 541, 977–987. https://doi.org/10.1016/j.jhydrol.2016.08.008

Arulbalaji, P., Padmalal, D., 2020. Sub-watershed prioritization Based on Drainage Morphometric Analysis : A Sub-watershed Prioritization Based on Drainage Morphometric Analysis : A Case Study of Cauvery River Basin in South India. J. Geol. Soc. India 95, 25–35. https://doi.org/10.1007/s12594-020-1383-6

Barnekow Lillesø, J.P., Shrestha, T.B., Dhakal, L.P., Nayaju, R.P., Shrestha, R., 2005. The map of potential vegetation of Nepal: a forestry/agro-ecological/biodiversity classification system. Hørsholm: Center for Skov, Landskab og Planlægning/Københavns Universitet. (Development and Environment; No. 2/2005).

Chalise, D., Kumar, L., Kristiansen, P., 2019. Land Degradation by Soil Erosion in Nepal: A Review. Soil Syst. 3, 12. https://doi.org/10.3390/soilsystems3010012

DNPWC, 2017. Protected areas of Nepal. Department of national parks and wildlife conservation, Kathmandu, Nepal.

ESRI, 2017. ArcGIS Desktop: Release 10.5, Environmental systems research Redlands, California, USA.

Food and Agriculture Organization of the United Nation (FAO), 2006. *The new generation of watershed management programmes and projects.* A resource book for practitioners and local decision-makers based on the findings and recommendations of an FAO review. Rome.

Gerrard, J., Gardner, R., 2002. Relationships Between Landsliding and Land Use in the Likhu Khola Drainage Basin, Middle Hills, Nepal. Mt. Res. Dev. 22, 48–55. https://doi.org/10.1659/0276-4741(2002)022[0048:rblalu]2.0.co;2

Higaki, D., Karki, K.K., Gautam, C.S., 2005. Soil erosion control measures on degraded sloping lands: A case study in Midlands of Nepal. Aquat. Ecosyst. Heal. Manag. 8, 243–

249. https://doi.org/10.1080/14634980500208184

Ichiyanagi, K., Yamanaka, M.D., Murajic, Y., Vaidyad, B.K., 2007. Precipitation in Nepal between 1987 and 1996. Int. J. Climatol. 27, 1753–1762. https://doi.org/10.1002/joc

MoITFE, 2018. Status paper. Ministry of Industry, Tourism, Forest and Environment, Gandaki Province, Pokhara.

OpenStreetMap Contributors (2017). Download OpenStreetMap data for this region: Nepal [WWW Document]. Retrieved from http://downl oad.geofa brik.de/asia/nepal.html

Ohsawa, M., Shakya, P.R., Numata, M., 1986. Distribution and succession of west Himalayan forest types on the eastern part of the Nepal Himalaya. Mt. Res. Dev. 6, 143–157. https://doi.org/10.2307/3673268

Panthi, J; Dahal, P; Shrestha, ML; Aryal, S; Krakauer, NY; Pradhanang, SM; Lakhankar, T; Jha, AK; Sharma, M; Karki, R. 2015. *Spatial and temporal variability of rainfall in the Gandaki River Basin of Nepal Himalaya.* Climate 3: 210– 226. doi:10.3390/cli3010210.

Robinson, T.P., William Wint, G.R., Conchedda, G., Van Boeckel, T.P., Ercoli, V., Palamara, E., Cinardi, G., D'Aietti, L., Hay, S.I., Gilbert, M., 2014. Mapping the global distribution of livestock. PLoS One 9, e96084. https://doi.org/10.1371/journal.pone.0096084

Shrestha, U.B., Shrestha, S., Chaudhary, P., Chaudhary, R.P., 2010. How representative is the protected areas system of Nepal? Mt. Res. Dev. 30, 282–294. https://doi.org/10.1659/MRD-JOURNAL-D-10-00019.1

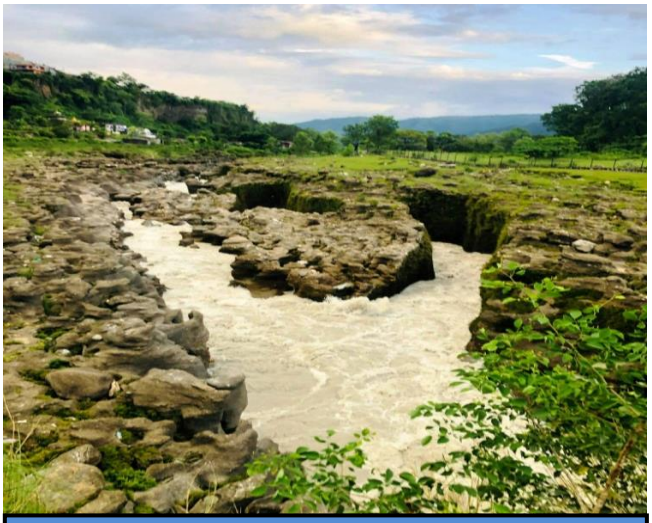
Stainton, J.D.A., 1972. Forests of Nepal. J. Murray, the University of Michigan, Michigan.

Sthapit, K.M. 1998. Teaching Material on Soil Conservation and Watershed Management for B.Sc. Forestry. Institute of Forestry/International Tropical Timber Organization.

USGS/EarthExplorer, 2017. Data Sets [WWW Document]. United States Geol. Surv. URL https://earthexplorer.usgs.gov/ (accessed 9.5.17).

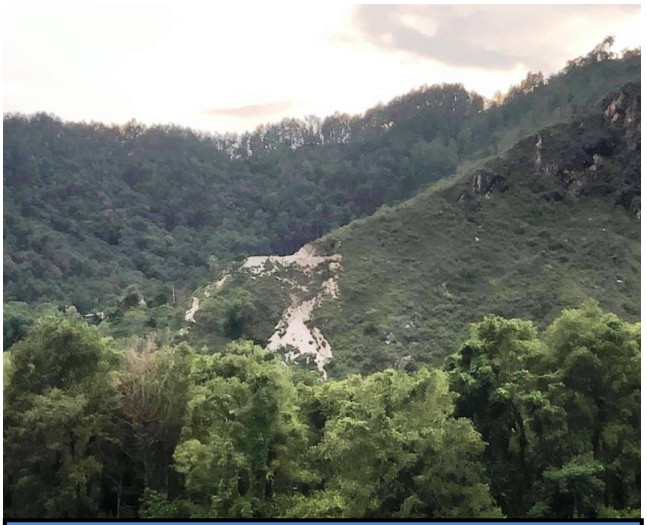
Vittala, S.S., Govindaiah, S., Gowda, H.H., 2008. Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using remote sensing , GIS and socio-economic data. Curr. Sci. 95, 345–354.

Discussion with ward representative (Bhimad 7, 8, 9)



Seti Nadi nearby Suklagandai 9, Dhorbarahi route

Turning of Seti Nadi nearby Suklagandai 2, Kotre



Landslide due to rural road construction

Discussion with ward representative Myagde 4

Kumle khola at Suklagandaki Rural Municipality

Minning work at Dovan in Bhimad and Myagde

Riverside cutting at cultivated land in Bhimad 7

Human settlement nearby Dhorfirdi and Dulegauda of Suklagandaki Municipality