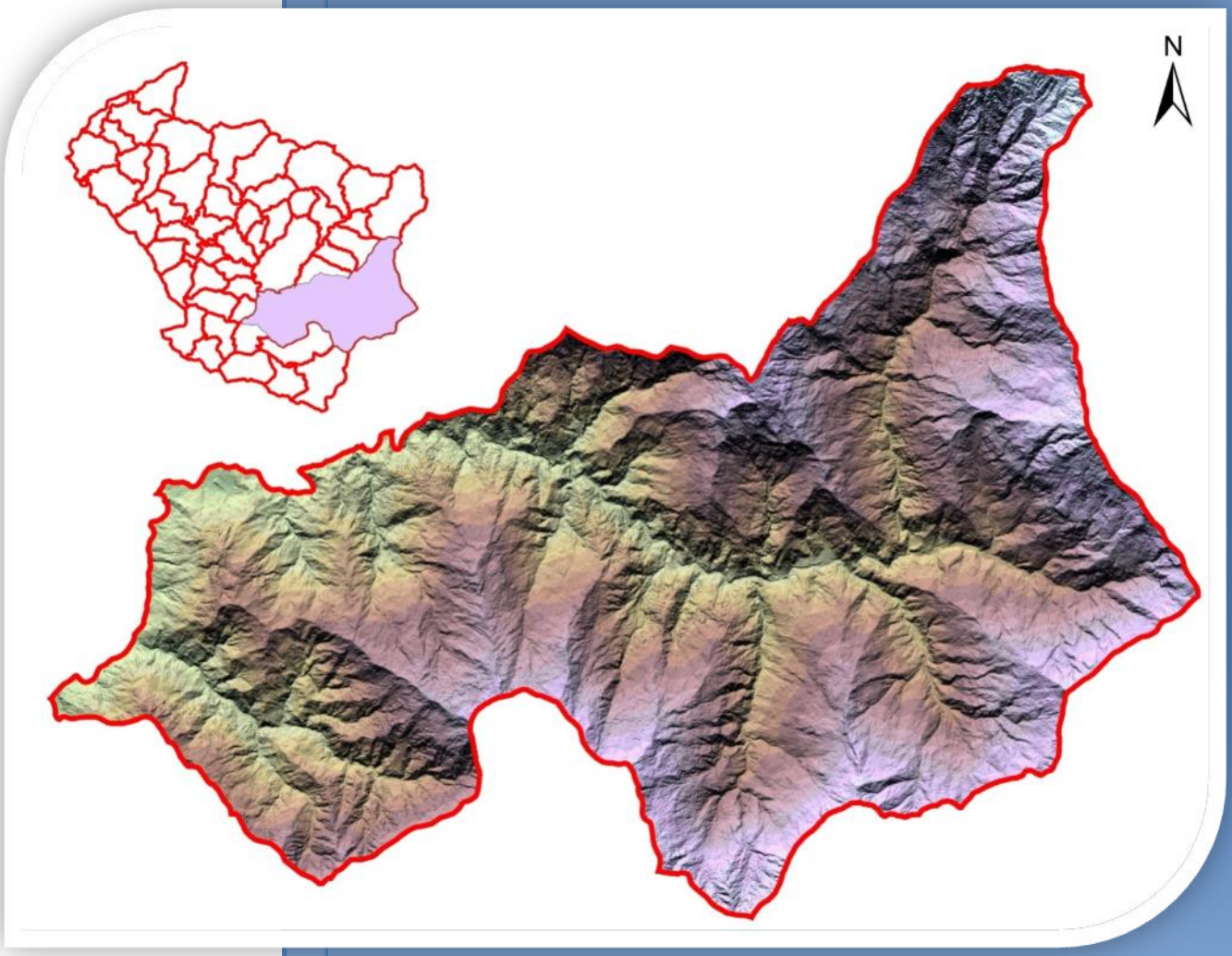
REPORT

On GIS Based Assessment of Katti Sub-Watershed



Prepared By:

Government of Nepal
Ministry of Forests and Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA)
District Project Coordination Unit (DPCU),
Narayan Municipality, Ganesh Chowk, Dailekh
Phone: (off) 977-089-420661

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GIS Spatial Unit, Dailekh

Gyanendra Maharjan – Land use Planner
Dil Kumar Rai- GIS Specialist

ACRONYMS AND ABBREVIATIONS

ASHA	Adaptation for Smallholders in Hilly Areas
ASTER	Advance Space borne Thermal Emission and Reflection Radiometer
ADB	Asian Development Bank
CBS	Central Bureau of Statistics
CFUG	Community Forest User Group
DFSCC	District Forestry Sector Coordination Committees
DOS	Department of Survey
DDC	District Development Committee
DSCO	District Soil Conservation Office
DFO	District Forest Office
DPCU	District Project Coordination Unit
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organization
GIS	Geographic Information System
HA	Hectare
IEE	Initial Environmental Examination
LRMP	Land and Resource Mapping Project
LAPA	Local Adaptation Plans for Action
MSL	Mean Sea Level
MODIS	Moderate Resolution Imaging Spectro-radiometer
NTFP	Non Timber Forest Products
RS	Remote Sensing
REDD	Reducing Emissions from Deforestation and Degradation
SQ. KM	Square Kilometer
SOTER	Soil and Terrain
SALT	Sloping Agricultural Land Technology
VDC	Village Development Committee

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CHAPTER - 1

INTRODUCTION

1.1. BACKGROUND

GIS based sub-watershed approach of Adaptation for Smallholders in Hilly Areas (ASHA)project envisions integrated land use planning in changing climate context to achieve the multiple objectives of conservation, sustainable natural resource management and climate change adverse impacts reduction through (i) strengthening the framework for local-level climate adaptation by (a) building adaptive capacity of participating communities and institutions; (b) adopting more holistic planning approaches including the use of spatial and temporal considerations and Geographic Information System (GIS) for Local Action Plan for Adaptation (LAPA) development; and (c) improvement of knowledge management and monitoring systems including, through robust adaptive and participatory action research; and (ii) improving the resilience of vulnerable people through channeling project and government financing for implementing LAPA priorities at household and community/landscape levels to expand and diversify agricultural and other livelihood options. The development objective of ASHA project is the following: "vulnerability of local communities to climate related risks reduced and enabling institutional environment for climate change adaptation strengthened"

ASHA project will on a pilot basis develop GIS based sub-watershed strategies with concrete adaptation activities highlighting up and down-stream linkages between VDCs. Sub-watershed based adaptations activities included in the individual VDC LAPAs, to increase the climate resilience of communities. In such cases collaboration is required on developing the sub-watershed strategies and adaptation activities, and on how to integrate sub-watershed activities in respective LAPAs. This is the framework for sub-watershed assessment to impart sub-watershed overview; up and down-stream linkages for LAPA preparation. This document will inform guidance to prepare sub-watershed assessment; bio-physical and socio-economic condition of sub-watershed.

1.2. OBJECTIVES

The objectives of the assessment were as follows:

- To study bio-physical and socio economic characteristics of sub-watershed such as land use, soil erosion, landslide, hydrology, settlement etc.
- Identification of key sub-watershed level concerns and ideal locations for interventions.
- Climate scenario based impact assessment and visualization like flood, landslide, land adjustment etc.
- Study current climate change trend and preparation of different hazard map.
- Study upstream and downstream linkages between wards and villages.

1.3. STUDY AREA

Dailekh is one of the five districts of Bheri zone and part of province no 6. In course of exploring the reliable bases behind the naming of Dailekh district, Dailekh area in an ancient time was called 'Devlok' later on, 'Devilok' which might have transformed into 'Dailekh', the historical analysts do come finally to this fact. Another key logic arises robustly is: this area was intensely a breeding ground in terms of rich temples, Dewals and monuments and inscriptions of heterogeneous types along with its panoramic landscape. So, it was known as 'Devlok.' It can be doubtlessly said that the same area is nowadays' Dailekh. Moreover, what the commons of Dailekh believe is: Dailekh was once well-known for buffalo and cow rearing, which is why it was also famous for 'Dahi' (curd) which was available everywhere in an ample amount. So, the territory which falls in between Jajarkot and Kalikot in the east and north respectively, Aachham in the west, and Surkhet in the south is administratively known as Dailekh. From the view point of longitudes and latitudes, it is located at 28°35' - 29° 8' northern latitudes and 81°25'- 81°53' eastern longitudes. It has diversified geography with 1502 sq. km. area as it extends from 544 meters' altitudes to 4168 meters from the sea level (Yogi, K.K., 2011). Dailekh used to be composed of 2 municipalities and 49 VDCs with area of 1502 sq. km but recently published report from local level restructuring commission has restructured Dailekh into 4 municipalities and 7 rural municipalities or village councils.

Although, during the preparation of report and GIS database of Katti sub watershed area, the source data and administrative boundary were considered based on database published by Department of Survey (DoS)in 1996, that shows Katti sub-watershed covers Metaltoli, Rum, Jaganath, Pagnath, Katti, Badabhairab, Bindyabasini, Belpata, Dandaparajul and Lakuri VDCs. The project area lies between latitude from 28° 15' 57.6" N to 28° 15'44.4 N and longitude from 81° 41' 42" E to 81° 54' 50.44" E and occupies about 210 sq km of area. Among ten VDCs the project considers only Rum, Pagnath, Badabhairab, Katti and Lakuri for the preparation on LAPA in Katti sub-watershed.

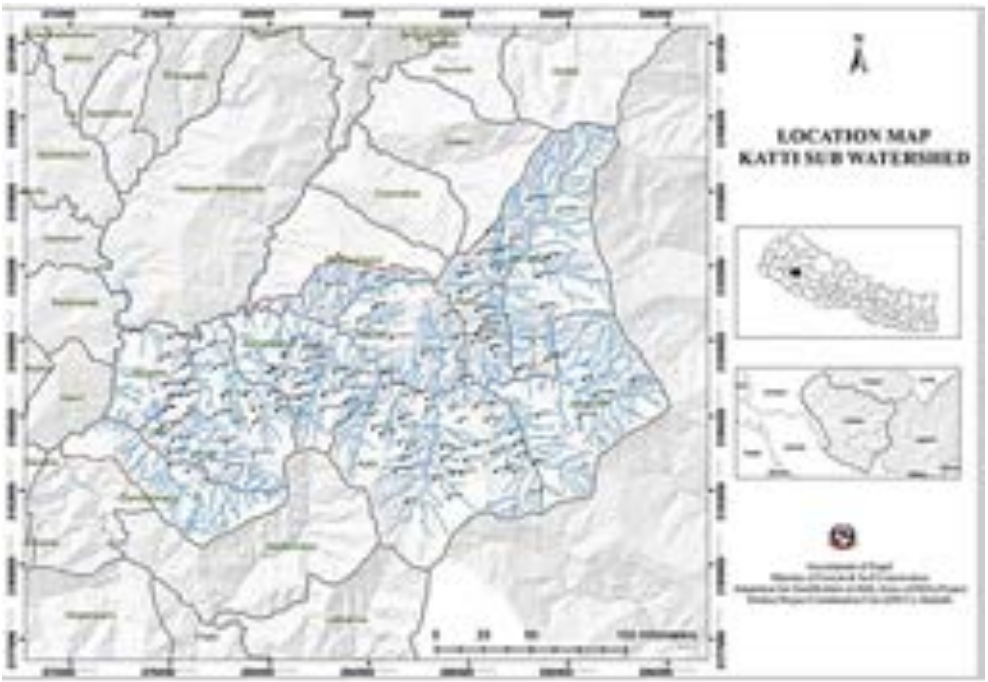

Figure 1.1: Location map of Katti sub watershed area

1.4. METHODOLOGY

There are inherent limitations in compiling GIS datasets for a district like Dailekh because the concept of digital mapping is relatively new and there is no established map culture. In the study an attempt was made to compile sufficient data and information from available sources and a field study in a satisfactory spatial framework to fulfill the basic information requirements for Katti sub-watershed assessment. The methodology used to build the Katti sub-watershed GIS database development and to perform spatial analyses is summarized in figure below.

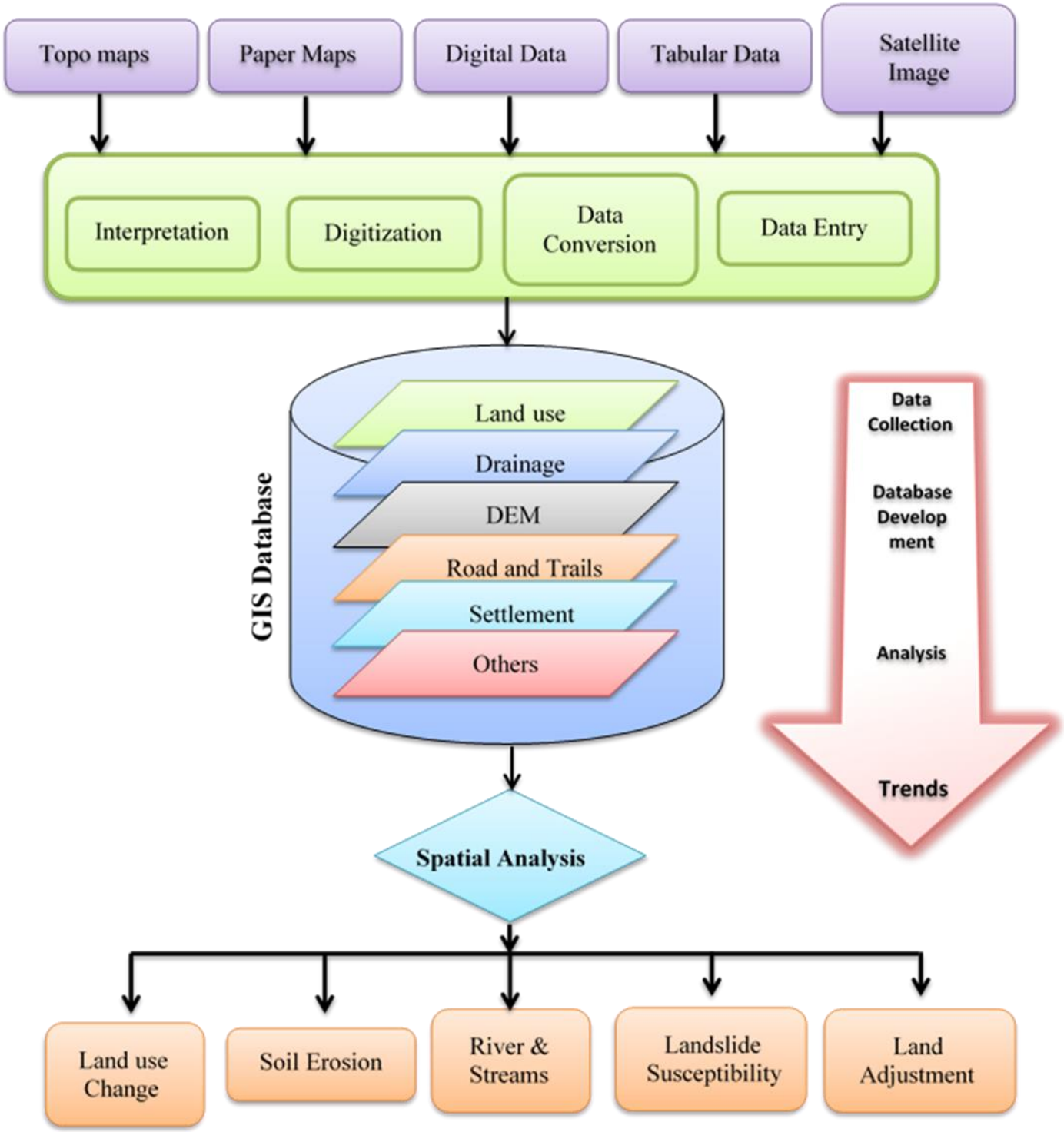

Figure 1.2: Methodology for GIS database development and Spatial Analysis

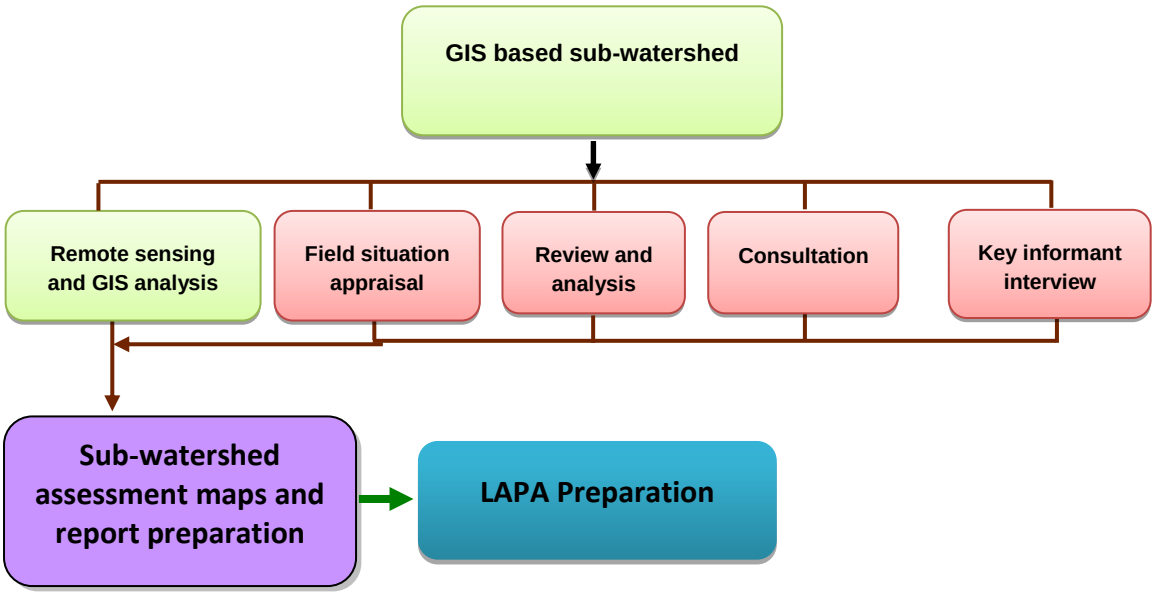

Figure 1.3: Schematic diagram showing the sub-watershed assessment framework

The assessment of Katti sub-watershed was based on Remote Sensing (RS) and GIS technique. However, local communities and district stakeholders was involved in different capacities to appropriately reflect their sub-watershed issues and needs. The local stakeholders, local communities, district stakeholders particularly DFSCC members presented their views, opinions and experiences during the group discussion along with ASHA district project coordination unit facilitated the assessment process.

The data sources and process used to create each data layer are described below.

Satellite data:

A freely available Landsat and Google Satellite image was used for the study area; it covers the major part of Katti Sub-watershed. The map produced from Google image was used as a reference during field verification and to update the missing database. And Landsat image of 1996 was compared strongly with the topo map prepared by department of survey to maintain level of accuracy and to study the changes that had occurred during the intervening decade, particularly in land use change.

Socio economic data:

VDC wise population data from the 2011 census were obtained from the Central Bureau of Statistics (CBS). The data for 2011 was estimated from the population figures for the VDCs.

1.5. LIMITATIONS

There were certain limitations in developing the GIS data, which may also have resulted in certain uncertainty in the vulnerability assessment results. These were considered as limitations of the study and thereof require caution in drawing the conclusions solely based on the results of this study. As such, this study and the mapping exercise were aimed to understand an overall spatial distribution of vulnerability based on the evidence derived from the information both primary and secondary. The readers are advised that the following are the limitations of this study.

- The administrative boundary was based on the GIS database provided by department of survey (DoS), which was published on 1996 and recently planned municipalities and rural municipalities were not considered during the preparation of database.
- The database used for the preparation of sub watershed assessment of Katti is based on GIS data prepared by Department of survey.
- The freely available satellite image was used for the preparation of GIS database.
- VDC and other administrative boundary used for the preparation of Map were based on boundary determined by Department of Survey (DoS).
- This report is based on sub watershed approach using GIS based mapping addressing upstream and downstream linkage between wards and VDCs.
- Precipitation data from World-clim were used together with annual rainfall-based equations suitable for hill areas to calculate the rainfall erosion factor for soil erosion.
- The soil erodibility factor K was weighted at soil order level using published results.

CHAPTER - 2

SUB-WATERSHED BIO-PHYSICAL AND SOCIO-ECONOMIC CONDITION ASSESSMENT

2.1. BIO-PHYSICAL CONDITION ASSESSMENT

Bio-physical resources especially land use and land cover changes, water status and biodiversity potential are crucial issues for the valuation of the watershed services and development of sub-watershed assessment. This section deals a brief discussion of existing land use practices and its changes in last three dates.

2.1.1. PHYSIOGRAPHIC CLASSIFICATION

Dailekh district is located in mid hills (mid-western region) of Nepal with 1502 sq. km area. It is situated with the border in Jajarkot–East, Achham-West, Kalikot-North and Surkhet-South. Ecologically, the 80% hills and 20% areas are mountains where large area is covered by forest (78026 ha, 51.95%), pasture (3698 ha), agricultural land (43121 ha) and others. The study area Katti sub-watershed is naturally given with a great diversity in biophysical environments. It is situated to the north of Mahabharat rang and has sloppy hills with sub-tropical, warm temperate and temperate types of climate. However, in the up-hills of Katti sub-watershed snow fall occurs during winter season which is situated in 740 m – 3280 m msl.

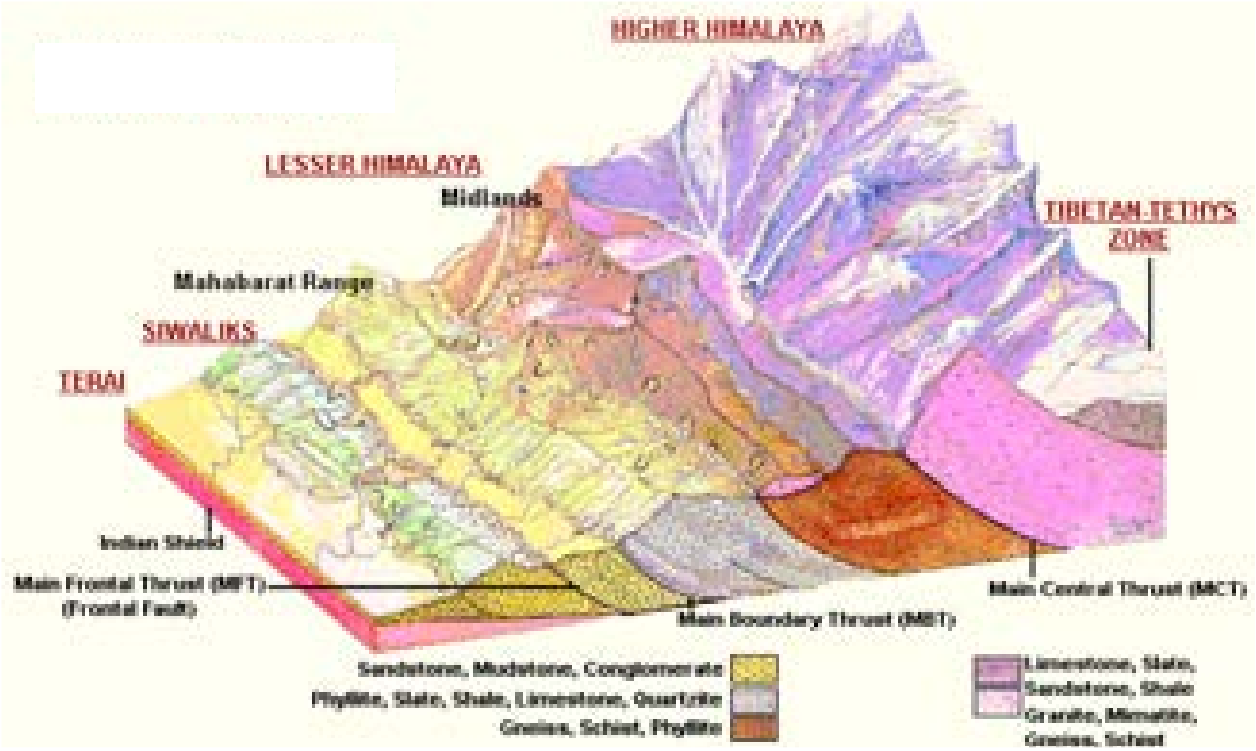

Figure 2.1: Physiographic regions via-a-vis major geological formation of the Nepal Himalaya

2.1.2. GEOLOGY

Geology is an important characteristic of watershed. Weak geology of the watershed combines with rainfall lead to various forms of landslides in the watershed. In Nepal it is estimated that about 75% of the landslides in the watersheds is due to the weak geology combined with human activities.

In Dailekh mostly the structure of rock found having 4-5 km thick succession of gently folded phyllite and met sandstone, containing blue quartz. Coarse augen gneisses and granitoids appear in the Lohore Khola, where the rocks dip essentially due east. Presumably, these gneisses are thrust over the grey-green phyllites along the Lohore Thrust. The augen gneisses are made up of large deformed microcline phenocrysts. Many pegmatite veins penetrate the phyllites. Around the town of Dailekh are distributed black graphitic schists, white quartzites, and some grey garnet schists, sporadically alternating with thin, grey marble bands. Owing to imbricate faulting, the Tertiary succession to the north of the gas and oil field is repeated for several times in the Baitadi, Darchula, and Bajhang districts. These rocks belong to the Surkhet Group, beginning with white, grey, green, thick-bedded quartz arenites or quartzose sandstones in shale intercalations (Melpani Formation). This primarily medium- to coarse-grained arenaceous succession is followed up-section by 150–170 m thick fissile fossiliferous shales of Palaeocene-Eocene age (Swat or Subathu formation). Above the fossiliferous horizon are thick-bedded, medium-grained, compact, grey-green sandstones, regularly alternating with silty and micaceous purple shales or shaly sandstones (Suntar or Dagshai formation). It is inferred that the Swat formation is the main source rock of gas and oil seeps. The Proterozoic phyllites, quartzites, and augen gneisses constitute the roof (seal) of a duplex (antiformal stack) and the folded horses below the roof thrust, contain the source rock. (Dhital.M.R, 2015).

2.1.3. DOMINANT SOIL TEXTURE

The knowledge of soils, their physical and chemical properties are imperative since it helps understanding the soil fertility and productivity of land in watershed. Soil particles and their sizes are important factors for soil erosion. The detachability and transportability of soil in the erosion process increase or decrease based on kind and size of soil particles. For example, the clay particles difficult to detach than sand but easier to transport. Soil with large stable particles such as sand grains or iron cemented soil particles are difficult to detach and transported, which seldom erode.

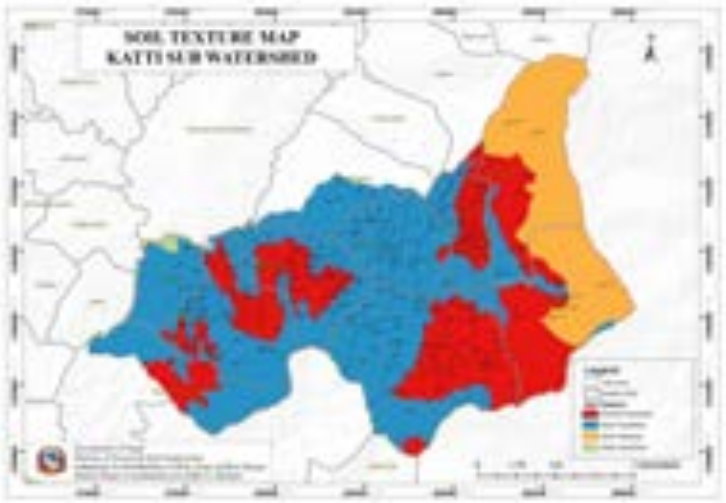

Figure 2.2: Soil texture map of Katti sub watershed area

In the study area Katti sub watershed the major minerals found are quartz, feldspar and mica rocks. The chemical constituent of these minerals is silica. As rocks constituted from minerals

containing high concentration of silica are more acidic these rocks are termed as acidic rocks. As a result of which the soil found in the areas around project area are found to be moderately acidic (pH 5.0-6.5). The electric conductivity is around 0.02 to 0.38 md. Organic matter is found to be low to medium (0.34 to 3.4%). Similarly, Nitrogen content varies from 0.06 to 0.2% and phosphorous from 5.3 to 12.8 mg per kg. Potassium content is observed to be on the lower side of 36 to 59 mg per kg. Cationic exchange level of available sodium is from low to medium level of 0.3 to 0.6 mg per 100 g. Boron is found to be low i.e. 0.07 to 0.5 mg per kg. (IEE, ADB; 2014)

Based on the soil and terrain (SOTER) database of Nepal, the landform and soil texture of study area is categorized into four types as Chromic Cambisols, Eutric Cambisols, Eutric Regosolis and Gleyic Cambisols. The following table clearly shows the area dominant by soil texture.

Table 2.1: Dominant of soil texture in Katti sub watershed area

SN	Dominant Soil Texture	Area covered in VDCs (Sq.Km)									
		Bada-bhairab	Bindya-basini	Katti	Lakuri	Pagan ath	Rum	Belpa ta	Jagana th	Dadap arajul	Mehalt oili
1	Eutric Cambisols	12.10	7.62	24.57	15.96	15.89	5.84	9.02	2.53	11.70	3.25
2	Gleyic Cambisols	0.07	0.02	0.00	0.10	0.00	0.00	1.05	0.00	0.21	0.00
3	Chromic Cambisols	7.90	0.01	17.74	8.39	0.32	6.08	0.00	12.66	4.46	7.11
4	Eutric Regosols	0.00	0.00	0.00	0.00	0.00	0.02	0.00	13.86	0.00	21.40

2.1.4. CLIMATIC ZONE

Nepal falls within sub-tropical climate zone. However, due to unique physiographic and topographic feature, it possesses enormous climatic and ecological diversity within a north-south span of about 130-260 km, the climate types range from sub-tropical in the Terai to arctic in the high Himalayas. The remarkable differences in climatic conditions are primarily related to the range of altitude within a short north-south distance. The presence of the east-west extending Himalayan massifs in the north and the monsoonal alteration of wet and dry seasons greatly contribute to local variations in climate (Practical Action, 2009).

Figure 2.3: Climate zone map of Katti sub watershed area

Dailekh located in the Mahabharat region of the country, represents a variation in climate based on the variation in altitude. Based on its geographic location, the Katti sub watershed represents four types of climate ranging from tropical to sub alpine.

Table 2.2: Climatic zone according to altitude

S.N	Climate Type	Altitude
1	Tropical Climate	544m-1200m
2	Sub-Tropical Climate	1200m-1800m
3	Temperate Climate	1800m-2300m
4	Alpine Lekali	>2300m

Source: DDC, Dailekh2006/2007, IEE ADB

It can be said that the climate of the district including study area is sub-tropical, temperate and alpine climates type. The monsoon rainfall starts from June and end in September. The annual total precipitation had recorded as 1700 mm in study area. A total of 102 annual rainy days have been recorded by Department of Hydrology and Climatology. Mean air temperature recoded as maximum 25.3 °C and minimum 10.5 °C. The maximum absolute extreme temperature recorded as 37.4 °C in June and minimum recorded as 2.2 °C in January (ISRC, 2008).

2.1.5. MAJOR RIVERS AND STREAMS

There are several streams originating from high mountains and Mahabharat range in Dailekh. The rivers originating from the Himalayas have water round the year whereas those from other sources have very low water flow during the dry part of the year. Nepal's longest river, Karnali flows along the western side of the district. Ramagaa driver and Chamgaad river flow along the central region of the district. Other than these Paduka, Chingaad, Taraghat, Tame, Dwari, Katti and Dhungeshowr are some streams which are the major contributors that add up to the water resource of the district.

Figure 2.4: River & stream map of Katti sub watershed area

In the study area, the major Katti river flows including various small streams like Rum khola, Malluka khola, Adheri khola, Dyan khola, Gothi khola, Patta khola etc. and have enhanced the water resources in the Katti watershed. These surface water sources are the major sources of water in Katti watershed. All the district's rivers flow from north to south and erode the land in the southern part of the district.

2.1.6. DRAINAGE

Topography regulates drainage. Drainage density (length of drainage channels per unit area), length, width, depth of main and subsidiary channel, main outlet and its size depend on topography. Typically, drainage networks expand rainfall on a watershed, and expansion of drainage networks increases in erosion and sediment transport rates, and the probability of flash-flooding and debris-flows at downstream

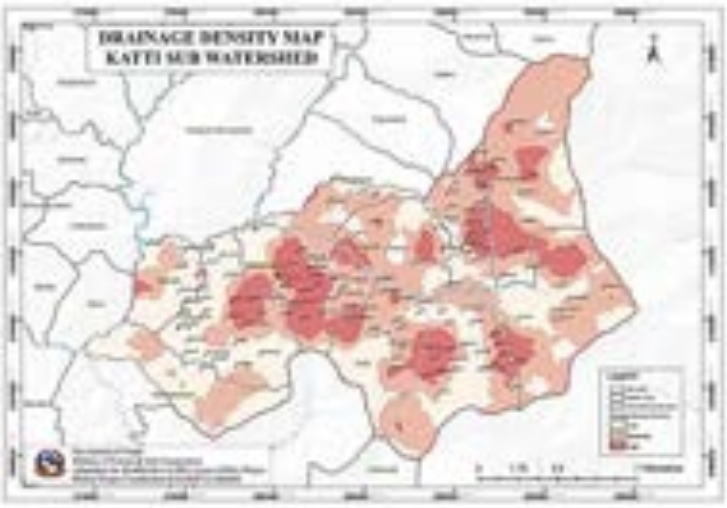

Figure 2.5: Drainage density map of Katti sub watershed area

locations. In Katti sub watershed, drainage density information is analyzed from the reference of 1996 topo data published by DoS, to determine the extent of flooding during high flows. According to the statistics present in the drainage density table, most of the covered area suffers from medium drainage system, among Katt village occupies an area of 19.72 sq. km. Lakuri, Badabhairab and Katti also contain high drainage density with 15.07, 8.66 and 7.26 sq. km. The data defines that Lakuri, Badabhairab and Katti VDCs were highly vulnerable from flooding during high flows and erosion followed by Mehaltoili, Jaganath.

Table 2.3: Drainage density in Katti sub watershed area

S N	Drainage Density	Area covered in VDCs (Sq.Km)										Total
		Bada-bhairab	**Bindya-basini**	**Katti**	**Lakuri**	**Pagan ath**	**Rum**	**Belpa ta**	**Jagana th**	**Dadap arajul**	**Mehalt oili**	
1	High	8.66	0.11	7.26	15.07	1.89	2.74	0.36	4.37	0	5.91	46.37
2	Medium	8.27	4.58	19.72	6.24	9.4	6.77	2.84	15.87	5.23	20.18	99.10
3	Low	3.18	2.96	15.07	3.14	4.91	2.42	6.85	8.81	11.13	5.70	64.17

2.1.7. LAND USE

Land use/ land cover is the biophysical state of the earth surface and immediate subsurface, which includes biotic diversity, soil quality etc. Land cover is the distribution of physical characteristics of earth's surface in the form of vegetation, water-body, desert, ice, forest and other coverage features on the earth surface including human activities such as mine exposure and settlement.

Land use change has various socio-economic implications. It has profound effect on land cover and its capability and leads to degrade the land's capacity for the sustained use and capacity to regain its original cover of land. Land degradation lowers the potential capability of soil and not only affects the option of people in the affected area but also people in the downstream and future generation. It reduces crop yields, soil fertility, increase soil erosion, frequent floods and greatly damage to aquatic life through increased siltation in rivers, lakes, water reservoirs, soil water acidification and increased pollution.

Land use change has important influence on water and energy balance. The conversion of natural systems to agriculture and other use has resulted in a net release of carbon dioxide and other trace gas dynamics to the atmosphere. In turn the regional climatology and hydrology is influenced by the change in land use and land cover.

Change in land use and land cover may lead to the loss of bio-diversity and fragmentation of landscape. It affects biological diversity in three ways; the destruction of habitat, isolation of fragments of formerly contiguous habitat and edge effects within a boundary zone between forest and deforested areas. Biodiversity loss takes place at multiple levels -landscape, ecosystems, species and gene and in multiple dimensions-structure, function and process.

Land-use change plays a key role in global environmental change. It contributes significantly to earth-atmosphere interactions and biodiversity loss, is a major factor in sustainable development and human responses to global change, and is important to integrated modeling and assessment of environmental issues in general. These diverse roles have been recognized in a large number of research publications and international conferences, symposia, and workshops devoted to the subject over the past few years as well as the United Nations Agenda 21.

Land use changes, water status and biodiversity potential are crucial issues for the valuation of the watershed services and conservation scheme. This section deals a brief discussion of existing land use practices and its changes in last 30 years, a brief assessment of availability of water in the watershed and potential of flora and fauna available in the watershed.

Land use map of project area is carried out based on the available secondary data and 2016 Google earth based image sources. The interpretation of present land use is carried out with a focus to classify the spatial characteristics and prevailing land use. Land use classification based on imageries will strongly determine by the diversified use types. In that case use type complexities require considering on image classification for the accurate land use detection. For this image data is integrated with other thematic data layers. Thematic data layers of topographical map and LRMP maps is used as a reference data sheets for the Google Earth satellite imageries and is integrated with the help of GIS software.

2.1.8. TRENDS IN LAND USE/LAND COVER AND FOREST (1996-2016)

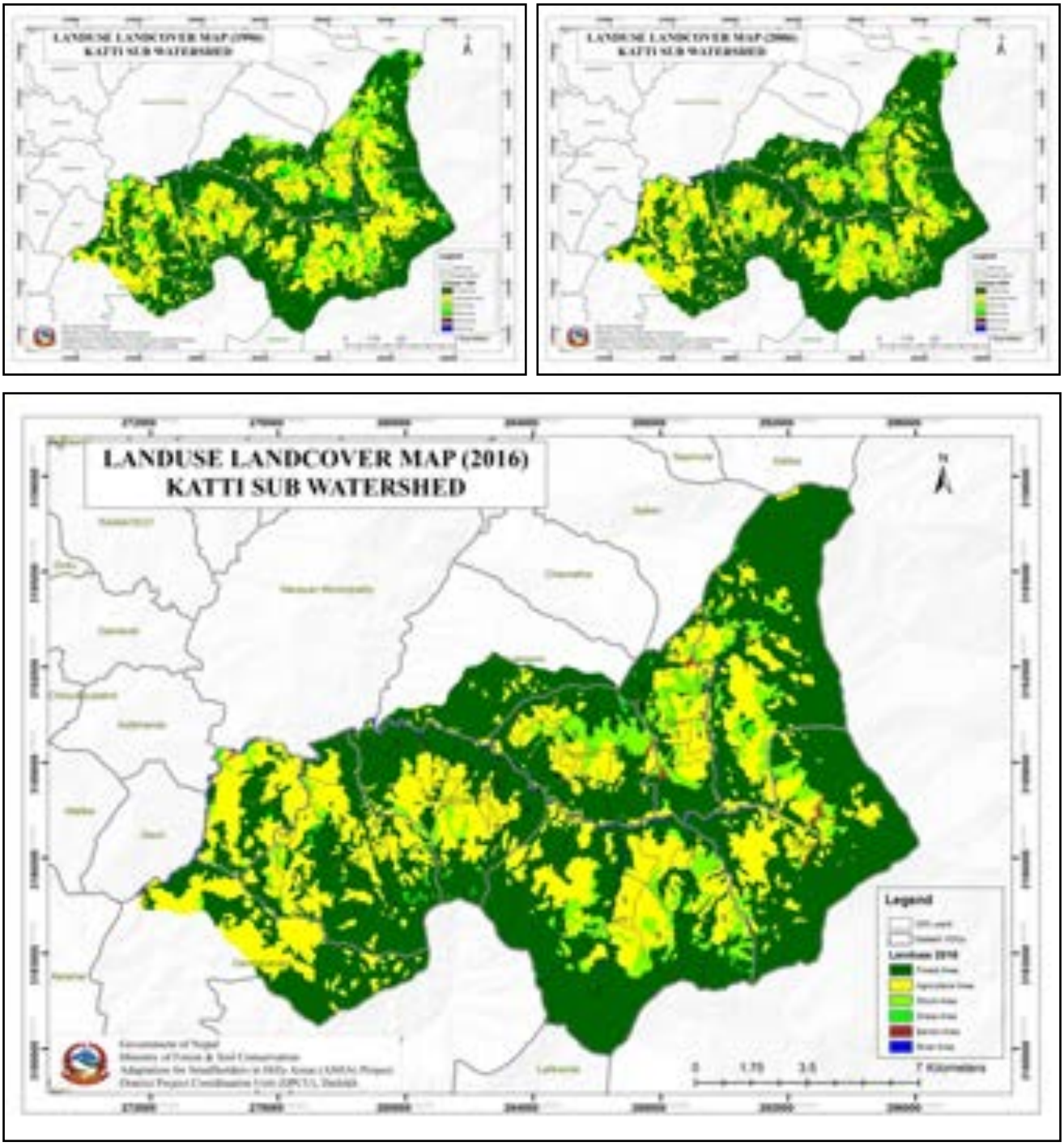

Figure 2.6: Decadal Land use and Land cover changes map of Katti sub watershed area

Land use/land cover is a significant element for the interconnection of the human activities and environment a monitoring which is useful to find out the deviations to save a maintainable environment. GIS and remote sensing is a very useful tool for the affair of land use or land cover monitoring, which can be helpful to decide the allocation of land use and land cover. This study involves the assessment of land use or land cover changes beginning of the year 1996, 2006 and 2016 of the Katti sub-watershed. In the classification map, statistics, matrix has been performed,

and the user accuracy is collected for every class. To read the thematic maps and ground truth survey, GIS software has been used to carry out the classification and to check the accuracy. It is mandatory to detect carefully the land use or land cover changes for continuing a sustainable environment for a real growth. The result of the work shows the expansion of forest and decreasing the agricultural and water bodies.

Dataset

For the assessment of sub-watersheds area is delineated using ASTER 30 m digital elevation model (DEM) based on boundary prepared by District Soil Conservation Office (DSCO). Initially three dates 1996, 2006 and 2016 of land use date were prepared from freely available Landsat image (Landsat 30 m pixel suitability for 1: 50,000 regional level map) and later to maintain level of accuracy for analyzing VDC level the database were again updated with land use map prepared by Department of Survey for 1996 and high accuracy satellite Google image for 2006 and 2016 along with field verification was also carried out on the basis of this updated map. For the analysis of Land use/ Land cover the study area was classified into six categories as; forest, shrub land, grassland, agriculture area, barren area and river body.

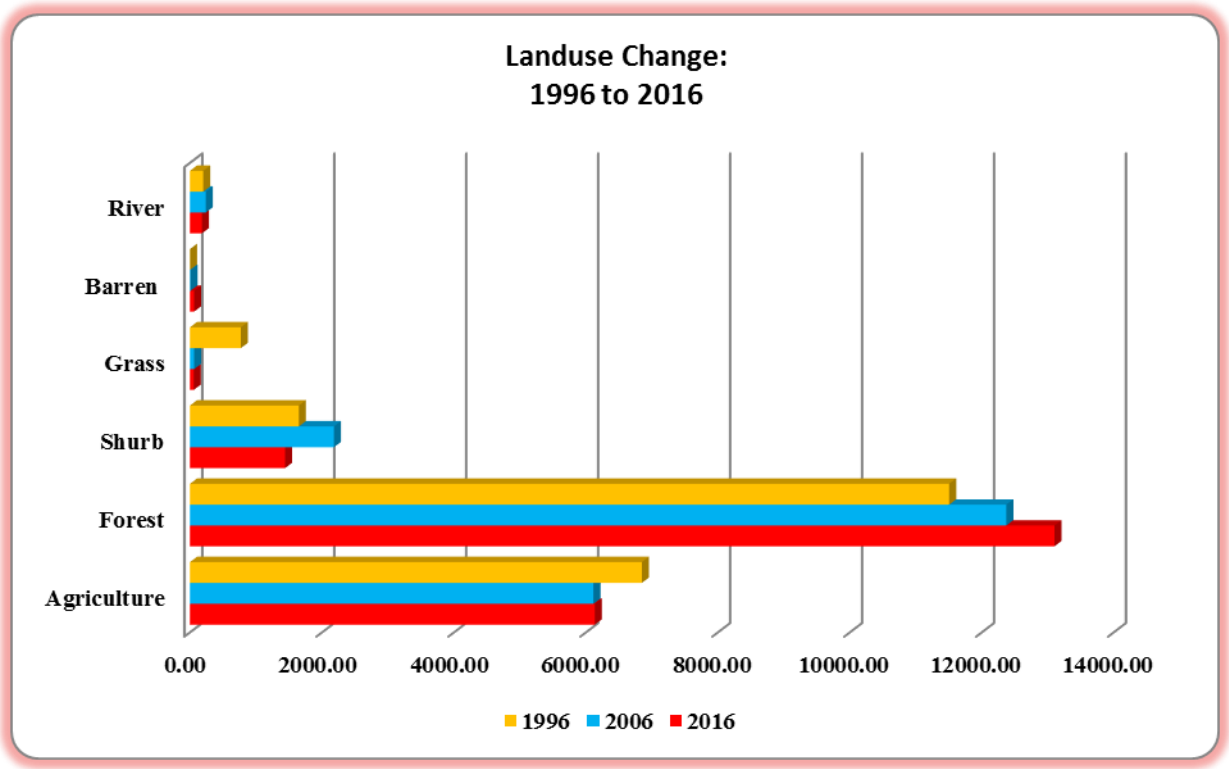

Figure 2.7: Land use change detection of Katti sub watershed area

The chart indicates area under agriculture use had decreased from 6851 ha to 6136 ha during the last three dates. The decrease in agriculture land is due to various reasons like lack of irrigation facility in upland, low productivity of soil, cultivation on steep slopes terrain, shifting cultivation practices, decrease of man-days for agriculture labor, lack of technology and knowledge about high value crops, etc. The area under forest cover had increased from 11507 ha in 1996 to 12374 ha in 2006 but it gradually increases to 13104 ha in 2016. Clearly, the forest cover had increased; this might be due to the declaration of important protection areas and community forest in upstream of watershed. The protection areas in upstream regions were declared by community.

Since then the forest covers were good in upstream of the watershed along with the successful implementation of forest protection program, extensive migration from the rural areas, and state initiatives to protect forest by community is the reasons behind the increment in the forest area.

Table 2.4: Land use change detection in Katti sub watershed area

Year	Forest	%	Shrub -land	%	Grass -land	%	Agricul ture	%	Barre n-land	%	River	%	Total (ha)
1996	11507.84	54.83	1650.5	7.86	772.71	3.68	6851.12	32.64	2.04	0.01	202.18	0.96	20986
2006	12374.39	58.96	2182.0	10.39	64.75	0.30	6116.95	29.14	8.41	0.04	240.16	0.14	20986
2016	13104.10	62.43	1442.0	6.87	58.68	0.27	6136.80	29.24	63.15	0.30	182.02	0.87	20986

The table 2.5 below shows the change in land use between 1996, 2006 and 2016, where -ve sign indicates declining land use types whereas +ve sign gives increasing land use types comparing from past. The data shows the quantitative results of the land cover classification and explains the area coverage for each land cover class by hectare across three dates.

Table 2.5: Land use decadal change detection in Katti sub watershed area

Land use Categories	1996	2006	2016	Change 1996-2006	Change 2006-2016	Change 1996 - 2016
Agriculture	6851.12	6116.95	6136.81	-734.17	+19.85	-714.32
Forest	11507.84	12374.39	13104.11	+866.55	+729.71	+1596.26
Shrub-land	1650.53	2182.09	1442.05	+531.56	-740.04	-208.48
Grass-land	772.71	64.76	58.65	-707.96	-6.10	-714.06
Barren-land	2.05	8.42	63.15	+6.37	+54.73	+61.10
River	202.18	240.17	182.03	+37.99	-58.14	-20.15

The result shows that all land cover type changed during whole study period. Figure 2.5 above shows the spatial distribution of thematic land cover changes for the different periods and table 2.6, 2.7 and 2.8 shows the amounts of area changes in the land cover types during 1996-2006, 2006-2016 and 1996-2016. Overall, forest showed increased in relation to its area of 1596.26 ha, from 11507.84 ha of the study area in 1996 to 13104.11 ha in 2016 within three dates of interval. Agriculture showed the decrease in relation to its area, with only about 6851.12 ha in 1996 and changes into 6136.81 ha in 2016, and decrease rate of 714.32 ha. The amount of shrub-land area decreases 208.48 ha, with around 1650.53 ha in 1996 and change into 1442.05 ha in 2016. However, grass land experienced an overall reduction during 1996-2016, which decrease by 714.06 ha and reduces to 772.71 of the area occupied in 1996. The amount of barren-land increase marginally 61.10 ha of the study area in 1996 to 2016 within 20 years.

The significant changes in various land use are observed in the studied Katti sub-watershed of Dailekh district and this information would provide useful inputs for the preparation of LAPA. Remarkable increase in forest was noticed due to positive impacts of implementation of community forest management program. Areas of the agriculture, grass land and shrubs are decreasing are negative land use changes it may be due to soil erosion in sloping, poor management of terrace agriculture, infrastructure development such as road and building etc., population pressure, extensive migration from the rural areas and foreign employment.

Table 2.6: Land use decadal change with matrix analysis between 1996-2006

2006	1996							
	Land use Categories	**Agriculture**	**Forest**	**Shrub-land**	**Grass-land**	**Barren-land**	**River**	**Total**
	Agriculture	**5385.00**	472.97	114.80	131.18	0.00	12.99	**6116.95**
	Forest	774.07	**10555.88**	832.99	154.23	2.05	54.82	**12374.03**
	Shrub-land	633.76	400.13	**690.59**	436.31	0.00	21.30	**2182.09**
	Grass-land	15.27	10.74	0.74	**37.52**	0.00	0.48	**64.76**
	Barren-land	4.75	2.57	0.00	1.10	**0.00**	0.00	**8.42**
	River	38.26	65.55	11.40	12.37	0.00	**112.58**	**240.17**
	Total	**6851.12**	**11507.84**	**1650.52**	**772.71**	**2.05**	**202.18**	

The table 2.6, 2.7 and 2.8 shows the cross tabulation change matrix for the areas changed from one land cover class to another and comparison to total area during 1996-2006, 2006-2016 and 1996-2016. Between 1996 and 2006, forest area had significant gains while the agriculture experienced strong losses. In the first period, the agriculture area was shrinkage to 6116.95 ha in 2006 comparing 1996, this is because of about 774.07 ha of agriculture area was transformed to forest but in addition only 472.97 ha of agriculture land was converted to forest area. Along with about 633.76 ha of agriculture area was transformed to shrub land but in addition only 114.08 ha of shrub land were converted to agriculture area. The agriculture transform areas were mostly observed on upstream portion of 2, 3, 4, 5, 6 wards of Lakuri vdc; 1, 2, 3, 4, 5, 6, 9 wards of Badabhairab vdc; 1, 2, 4, 5, 6, 7, 8 wards of Katti vdc; 1, 2, 3, 7, 9 wards of Paganath vdc and 2, 3, 5, 6, 7, 9 wards of Rum vdc. There was shrinkage in the grassland area 772.71 ha to 64.76 ha from 1996 to 2006 mainly by transforming 436.31 ha of grassland to shrub land but in addition only 0.74 ha of shrub land was converted to grass land. During the period of 1996-2006, shrub land was increased by 1650.52 ha to 2182.09 ha, Barren land increased by 2.05 ha to 8.42 ha this is due to 4.75 ha of agriculture land was transformed to barren land it may be due to soil erosion in sloping, poor management of terrace agriculture, infrastructure development such as road and building etc. Along with river body increased by 202.08 ha to 240.17 ha this is because of 65.55 ha of forest and 38.26 ha of agriculture area was transformed to water due to the construction of an artificial reservoir, ponds and also due to the cutting of river bed along to river side.

Table 2.7: Land use decadal change with matrix analysis between 2006-2016

2016	2006							
	Land use Categories	**Agriculture**	**Forest**	**Shrub-land**	**Grass-land**	**Barren-land**	**River**	**Total**
	Agriculture	**5274.18**	500.62	320.25	8.60	1.69	31.47	**6136.80**
	Forest	525.20	**11659.81**	822.77	8.11	1.31	86.90	**13104.10**
	Shrub-land	291.62	142.08	**981.37**	19.28	0.25	7.46	**1442.05**
	Grass-land	12.95	13.35	1.44	**28.76**	0.00	2.15	**58.65**
	Barren-land	7.25	8.46	41.61	0.00	**5.18**	0.66	**63.15**
	River	5.76	50.08	14.65	0.00	0.00	**111.54**	**182.03**
	Total	**6116.95**	**12374.39**	**2182.09**	**64.76**	**8.42**	**240.17**	

Between 2006 and 2016, forest and agriculture area had slight gains. In the first period, the agriculture area was slightly progress to 6136.80 ha in 2016 comparing 2006, this is because of about 500.62 ha of forest area and 320.25 ha of shrub land was transformed to agriculture but in addition about only 291.62 ha of agriculture land was converted to shrub land and 525.20 ha of agriculture land was converted to forest. Along with about 142.08 ha of forest area was transformed to shrub land but in addition a huge area about 822.77 ha of shrub land was converted to forest area. The deforestation areas were mostly observed on upstream portion of 2, 4, 5, 6, 7 wards of Lakuri vdc; 2, 3, 4, 5, 9 wards of Badabhairab vdc; 1, 2, 4, 5, 8, 9 wards of Katti vdc; 1, 2, 5, 7, 9 wards of Paganath vdc and 3, 4, 6, 9 wards of Rum vdc. There was also loss in the grass land area 64.76 ha to 58.65 ha from 2006 to 2016 mainly by changing 12.95 ha of agriculture area and 13.35 ha of forest was transformed to grass land but in addition only about 8.6 ha of agriculture land and 8.11 ha of forest was converted to grass land in 2016. During the period of 2006-2016, small area of shrub land was decreased by 2182.09 ha to 1442.05 ha, Barren land increased by 8.42 ha to 63.15 ha this is because of 7.25 ha of agriculture land and 41.61 ha of shrub land was transformed to barren land it may be due to soil erosion in sloping, poor management of terrace agriculture, infrastructure development etc. Along with river body also decreased from 240.17 ha to 182.03 ha this is because of 86.90 ha of forest and 31.47 ha of agriculture area was transformed to water due to the construction of flood control retaining walls on bank of river and also precaution measures from flooding and erosion.

Table 2.8: Land use decadal change with matrix analysis between 1996-2016

2016	1996							
	Land use Categories	**Agriculture**	**Forest**	**Shrub-land**	**Grass-land**	**Barren-land**	**River**	**Total**
	Agriculture	**5267.25**	490.03	167.15	191.11	0.00	21.26	**6136.80**
	Forest	914.37	**10820.34**	1132.67	169.15	2.05	65.18	**13103.75**
	Shrub-land	603.09	141.37	**335.05**	360.67	0.00	1.88	**1442.05**
	Grass-land	24.06	11.27	1.75	**19.85**	0.00	1.72	**58.65**
	Barren-land	24.03	6.68	4.90	27.38	**0.00**	0.16	**63.15**
	River	18.31	38.17	9.01	4.55	0.00	**111.99**	**182.03**
	Total	**6851.12**	**11507.84**	**1650.53**	**772.71**	**2.05**	**202.18**	

Between 1996 and 2016, agriculture area had strong loss while the forest experienced significant gain. In the first period, the agriculture area was shrinkage to 6136.80 ha in 2016 comparing 1996, this is because of about 914.37 ha and 603.09 ha of agriculture area was transformed to forest and shrub land but in addition only 490.03 ha of forest and 167.15 ha of shrub land was converted to agriculture area. Along with about 1132.67 ha of shrub area was gained by forest in 2016 but in addition only 141.37 ha of forest were converted to shrub area this shows huge area from shrub land was transformed to forest. Although the vdc suffers loss in forest area due to human intervention. The areas were mostly observed on upstream portion of 2, 3, 4, 5, 7, 9 wards of Lakuri vdc; 2, 3, 9 wards of Badabhairab vdc; 2, 4, 5, 8, 9 wards of Katti vdc; 1, 7, 9 wards of Paganath vdc and some small area were seen on 3, 5, 6 wards of Rum vdc. There was decrease in the grass land area 772.71 ha to 58.65 ha from 1996 to 2016 mainly by changing 360.67 ha of

grass area was transformed to shrub area but in addition only 1.75 ha of shrub was converted to grass land. During the period of 1996-2016, shrub land was decreased by 1650.53 ha to 1442.05 ha mainly by changing 1132.67 ha of shrub area was transformed to forest land but in addition only 141.37 ha of forest was converted to shrub land, Barren land increased by 2.05 ha to 63.15 ha this is due to 24.03 ha of agriculture land and 27.38 ha of grass land was transformed to barren land it may be due to soil erosion in sloping, poor management of terrace agriculture, infrastructure development such as road and building etc. Along with river body also decreased by 202.18 ha to 182.03 ha this is because of 38.17 ha of forest and 18.31 ha of agriculture area was transformed to water due to the construction of an artificial reservoir, ponds and also due to the cutting of river bed along to river side.

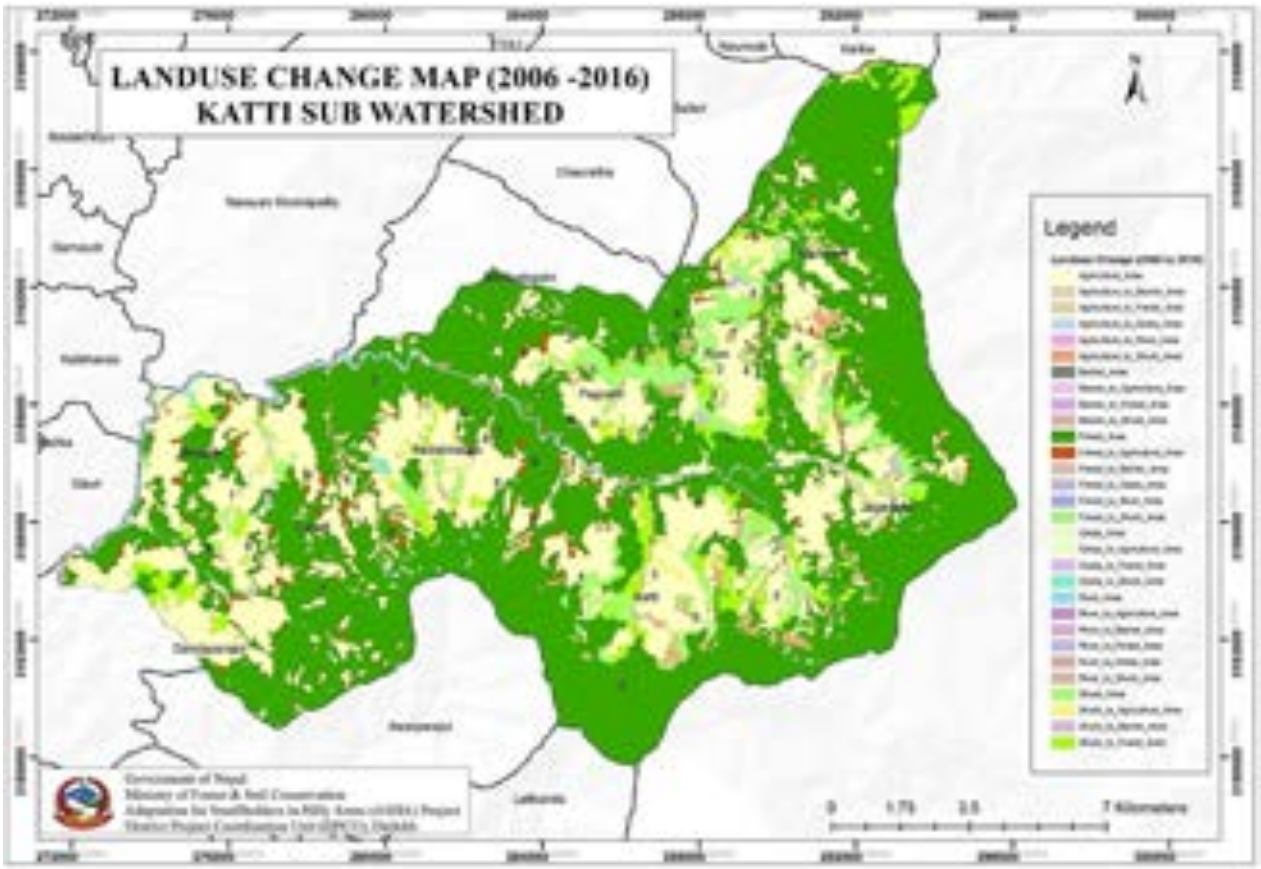

Figure 2.8: Land use changes map of Katti sub watershed area

2.1.9. LAND CAPABILITY

Analysis of the various components of land i.e. slope inclination, aspect, drainage condition, moisture content, surface soil temperature etc. Of the specified unit of land has been the part of computing the land capability. It is a planning procedure which enables the spatial decision support system and enforced the plan to be more rational. Specifically, land capability maps could deserve high value of its application in proper land use planning for sustainable environmental management and conservation of valuable bio-physical and cultural resources.

The land capability of study area is necessary for proper land use policy formulation and other meaningful land use classification i.e. Land resources, agriculture, forest, livestock and so on. It is also essential for the land system parameters (physical characteristics of land) for the analysis of non-agricultural use or other classifications.

Land Capability classification by LRMP

LRMP's land capability was qualitative, based mainly on the physical productive potential of the land, with economic present only as a background. Guidelines for placing lands in different categories based on slope limits, soil depths, altitudinal ranges, rainfall, erosion control requirements, and opportunities for different kinds of land use were provided in the capability report. The eight capability classes distinguished are:

Figure 2.9: Land capability map of Katti sub watershed area

Class I: Nearly level (slopes < 1°), deep soils, erosion and mass wasting not problems. Limited use for arable agriculture or forestry development.

Class II: Gentle slope (slopes 1°- 5°), deep and moderately drained soils. No limitations for forestry and pasture development. Conservation measures are necessary when use for arable agriculture.

Class III: Moderate to steep slopes (5° - 30°), deep and well drain soils, mass wasting and erosion can be problems if not well managed, Limitation for forestry development, Grazing cannot be encouraged, Conservation terraces are need if used for arable agriculture.

Class IV: Too steep slope for terracing, soil depth is more than 20 cm, well drained, prone to erosion, mass wasting and flooding, too cold to be cultivated and suitable for forestry development activities with adequate vegetation cover.

Class V: Slopes are <30°, soils are more than 20 cm deep, frequently flooded, too cold or dry to support forestry activities. Land is limited for the use of pasture with controlled stocking rates. Alpine and rain shadow regions above 3000 m, and flooding alluvial plain falls within this class.

Class VI: Steep slopes, soil depth less than 20 cm. chances of severe erosion. Land considered having many limitations, Minimum use for food and fiber productions. Land should be maintained under vegetation cover.

Class VII: Rocky and icy, Rugged topography and terrain, Exposed bed rock and severe cold. Limited use for upland pasture.

Class VIII: Moisture Sub-humid. Areas with agriculture potential if irrigated.

Sub-classes:

Temperature regime based on altitudinal ranges are:

- Sub-tropical (< 1000 m)
- Warm temperate (1000 - 2000 m)
- Cool temperate (2000 - 3000 m)
- Alpine (3000 - 4000 m)
- Arctic (> 4500 m)

Sub-divisions based on moisture regimes are:

- Arid
- Semi-arid
- Sub-humid
- Humid
- Too-humid

Land Capability of project area based on LRMP;

Four major land capability classes were observed in Katti sub watershed according to LRMP capability maps. Among, most of the land of the study area (57 percent) falls under IV category. Class III occupies 41.76 percent while class VIII occupies 0.90 percentages and followed by class II. This shows that most of the land in study area is suitable for forestry development activities with adequate vegetation cover followed by agriculture.

Table 2.9: Land capability of Katti sub watershed area according to LRMP

SN	Land Class	Area covered in VDCs (Sq.Km)										Total area	%
		Bada-bhairab	**Bindya-basini**	**Katti**	**Lakuri**	**Pagan ath**	**Rum**	**Belpa ta**	**Jagana th**	**Dadap arajul**	**Mehalt oili**		
1	II	0.00	0.00	0.14	0.00	0.15	0.08	0.30	0.00	0.00	0.00	0.67	0.32
2	III	7.79	0.46	23.63	11.42	4.47	6.57	5.18	10.62	8.46	9.85	62.30	41.76
3	IV	12.79	7.19	18.46	12.93	11.57	5.27	3.32	18.4	7.10	21.98	96.94	57.02
4	VIII	0.14	1.00	0.00	0.07	0.00	0.00	0.68	0.00	0.00	0.00	17.46	0.90

2.1.10. LAND SYSTEM

Land System of project area based on LRMP;

The land system map has provided a mythology for describing detailed information regarding land forms (soil), its texture, feature and the nature of the terrain. Land forms have been differentiated on the basis of patterns of physical structure, geological materials, slope and arable agricultural limits. Seventeen different types of land forms have been detected under the land system of Nepal.

Figure 2.10: Land system map of Katti sub watershed area

Eight major land systems were found among seventeen, in the Katti sub watershed area after analyzing LRMP map of Nepal. Among total area most of the area about 41.4 % is covered by land system moderately to steeply sloping mountainous terrain (11) and 39.9 % with land system steeply to very steeply sloping mountainous terrain (12) and followed by steep to very steep slopes (14 b), moderate to steep slopes (14 a) with 15.2 and 2.83 %. Along with remaining land system lies on alluvial plains and fans with river channel and alluvial fans having 0.3 percent.

Table 2.10: Land system of Katti sub watershed area according to LRMP

SN	Land System	Area covered in VDCs (Sq. Km)										Total area	%
		Bada-bhairab	Bindya-basini	Katti	Lakuri	Paganath	Rum	Belpata	Jaganath	Danda parajul	Mehaltoili		
1	9 a	0.04	0.02	0.0	0.0	0.0	0.00	0.51	0.00	0.05	0.00	0.66	0.31
2	9 b	0.00	0.00	0.0	0.0	0.0	0.00	0.00	0.00	0.02	0.00	0.02	0.01
3	9 c	0.00	0.00	0.0	0.0	0.13	0.21	0.26	0.00	0.00	0.00	0.61	0.29
4	10 a	0.00	0.00	0.0	0.0	0.0	0.00	0.00	0.00	0.03	0.00	0.03	0.01
5	11	8.18	0.01	23.4	10.8	4.07	6.00	5.59	12.83	8.95	7.05	86.93	41.4
6	12	11.88	7.63	18.8	13.5	11.9	5.68	0.00	2.49	7.29	4.33	83.68	39.9
7	14 a	3.69	0.00	0.0	0.0	0.0	0.00	0.00	0.00	0.00	2.24	5.93	2.83
8	14 b	0.00	0.00	0.0	0.0	0.0	0.04	0.00	13.70	0.00	18.1	31.89	15.2

2.1.11. LAND USE ADJUSTMENT

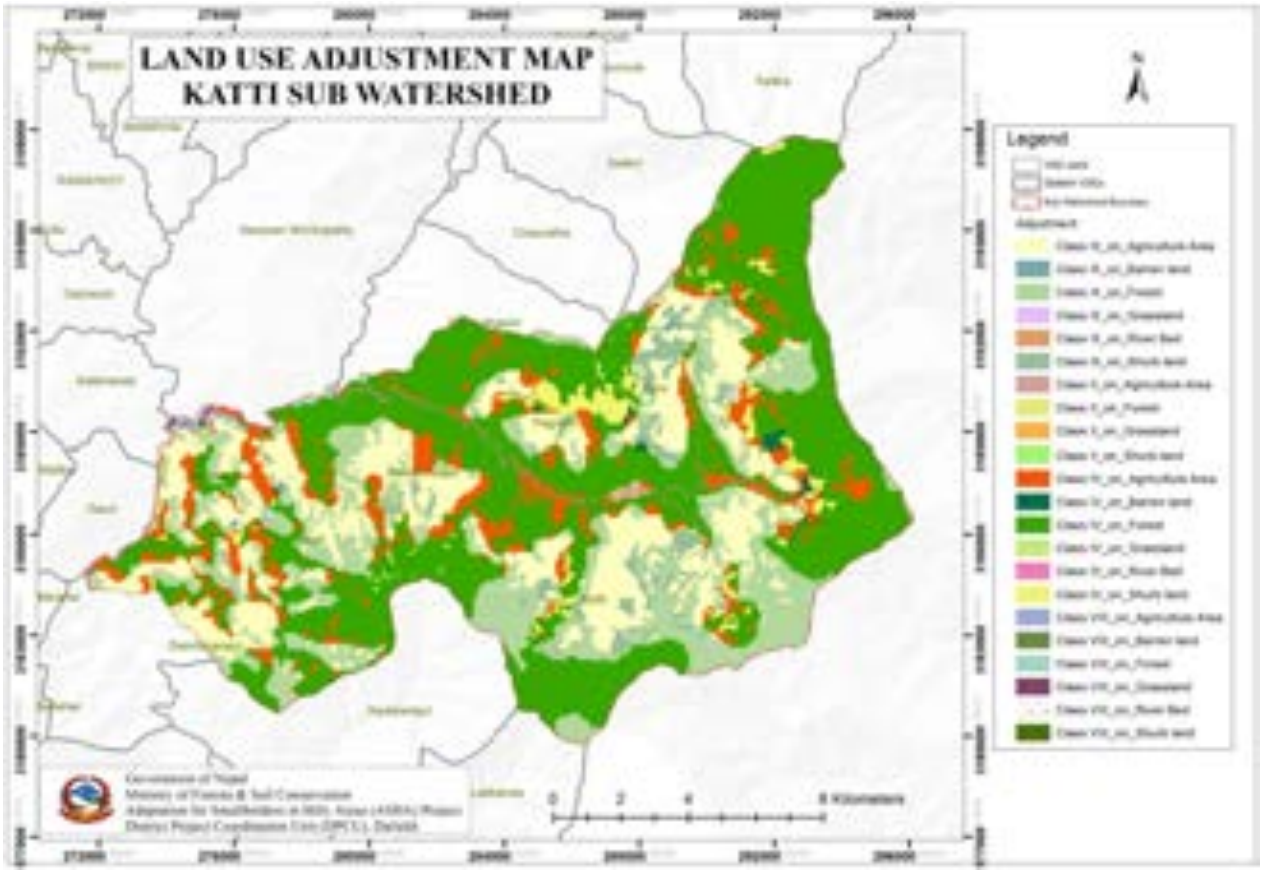

Figure 2.11: Land use adjustment map of Katti sub watershed area

Four major land capability classes were found in Katti sub watershed according to LRMP capability maps of 1986. Among total area most of the area is covered by IV capability class comprising about 57% which is suitable for fuel wood, fodder and timber and followed by III capability class comprising about 41%, suitable for terracing arable agriculture.

The land adjustment map is prepared on the basis of superimposing the land capability map from LRMP over present land use map and extract locations and places as delineated to classify under and overuse. In Katti sub-watershed, the area was delineated based on degree of slope ranging above 20 degrees for overused by agriculture according to LRMP land suitability class (shown in figure), which suggests suitability for forest. Since, evaluation and slope gradient profoundly affect the distribution of soil types and their utilization. Upper limits of arable agriculture, forest zones, possible cropping patterns and soil temperatures are intimately tied to elevation. Soil depth and slope stability are closely related to slope gradient. 20-30 degrees was empirically derived as the upper limit of successful terrace cultivation.

About 1489.95 ha (Figure 2.12) of land were overused by agriculture in Katti-sub watershed, the areas were mostly observed on Garigau, Dumri, Paiyachaur,Simkhola Gaun,Alurali, Aturah, Tallo Lakuri, Maj Gaun, Geuli Ghodadauna settlements of Lakuri vdc; Jastala, Dandagaun, Khagena, Bhairev Sthan, Olkedanda, Mahadevkumta Birchipin, Pachhana settlements of Badabhairab vdc; Kumri, Khaule,Sano Paganath, Pokhari Danda settlements of Pagnath vdc;

Bajeda, Guyaldadim, along the river side of ward no 4 settlements of Rum vdc and Lama Chahada, Jotinge, Chipin Danda, Timalsena, Dhal, Kapra,Meligoth, Kada, Theulepani Dudila, Meltada settlements of Katti vdc., and to address the issue agroforestry methodology may be one of the alternative solutions. Since, agroforestry can contribute to human nutrition through increased production and availability of particularly nutritious fruits and leaves improving livelihood support in lessening rural poverty along with degraded hill environmental restoration on study area. Some agroforestry species that can be used for the management are as; Uttish (Alnus nepalensis); Cashew (Anacardium occidentallis); siris (Albizia lebbeck); Neem (Azadiracta indica) etc. Along with some land use recommendation will be considered based on slope class.

Table 2.11: Land capability recommendations of Katti sub watershed

Code	Slope Class	Recommendations
U	**All Slopes**	Protection of natural environment
Agriculture Land	**<3 %**	Intensively Cultivable land with some needs for soil conservation. In the river valley flood control and drainage may be needed.
	3-15%	Intensively cultivable land, with moderate needs for soil conservation such as maintenances of drainage and terraces. Moistures conservation measures such as shelter belt, mulching would be beneficial for better production
	15–30%	Intensively cultivable land, with moderate needs for soil conservation such as maintenances of drainage and terraces. Terracing if not terraced.
	30-60%	Cultivable land, with intensive soil conservation measures needed including terracing. Terrace maintenance and proper disposal of drainage water must be undertaken. Mostly this type will be found.
	>60%	Land not suitable for cereal crop production. Fodder and fruit tree plantation is recommended and should be taken under protection. Horticulture must be emphasized of terraces.

Source: DSCO

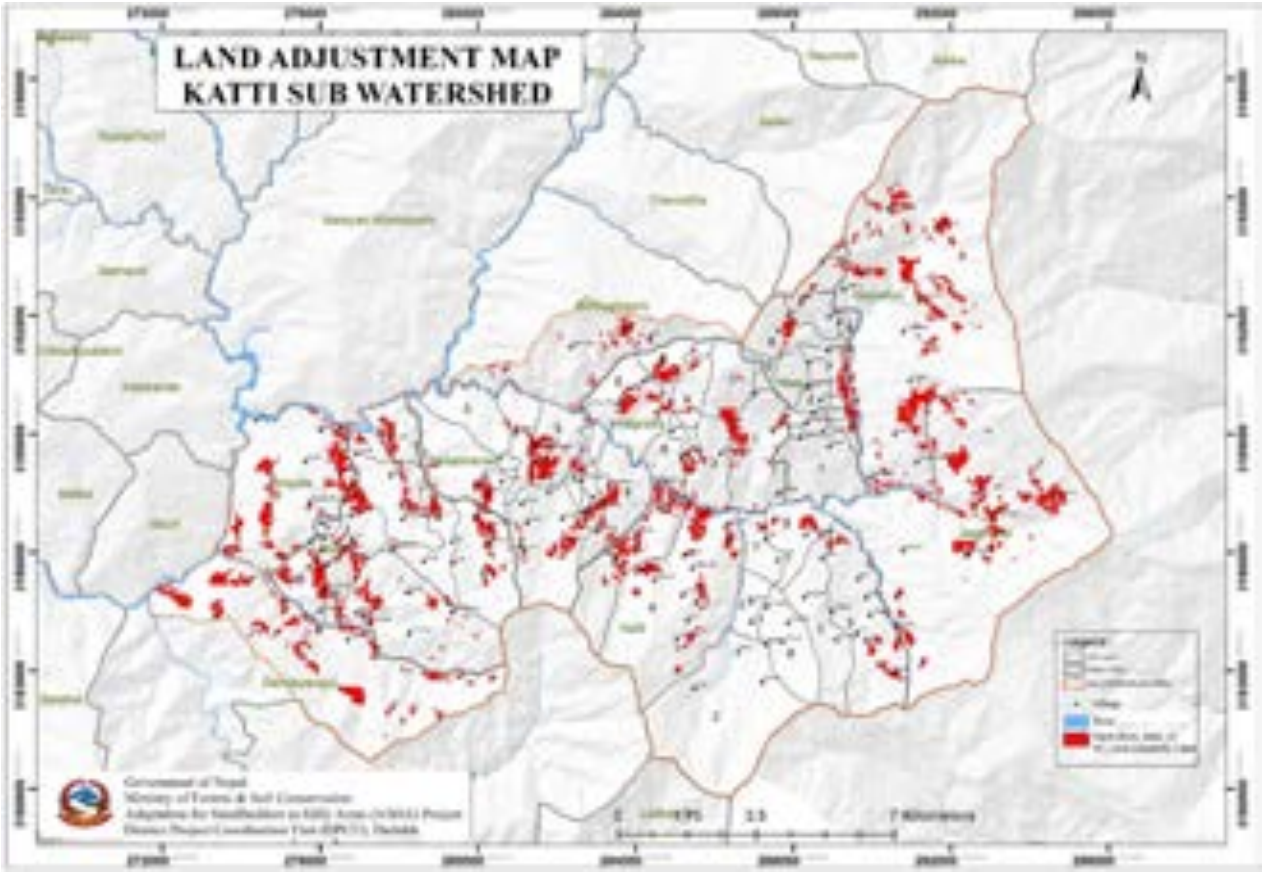

Figure 2.12: Land adjustment overuse map of Katti sub watershed area

2.1.12. SOIL EROSION DYNAMICS (1996-2016)

Soil erosion is a major concern for environment and natural resources leading to reduction in field productivity and soil quality. Erosive agents influence the process of detachment, transportation, and deposition of soil materials. Rate of soil erosion and sediment yield terms are used to define soil eroded from a given area and total sediment outflow from a watershed per unit time respectively. Erosive agents can be rainfall (rainfall erosion), type of soil, and nature of slope. Water erosion poses a great deal of challenge for sustainable development and degrades water quality and local quality of life.

Soil erosion by water is an important component of land degradation and a critical environmental hazard in the study area. It is a complex phenomenon governed by various natural processes, which result in decreases in soil fertility, water quality and the reduction of crop yields. It has a high spatial variability and useful to obtain knowledge about where erosion is occurring, for example, for the planning of soil and water conservation measures. Rainfall is one of the primary factors contributing to soil erosion caused by water. Water induced erosion in the mountain and hill areas of these sub-watershed basins are very high, as a result of the steep slopes as well as terrace agricultural practices with poor management. The rivers in the region transport heavy loads of sediment which are deposited downstream.

A general approach has been applied to estimate erosion in the Katti sub-watershed using empirical soil erosion model include Revised Universal Soil Loss Equation (RUSLE) and integrating the spatially erosion factor (i.e. rainfall characteristics (R), soil erodibility (K), topography (LS), vegetation cover (C), management practices (P), and A is estimated average soil loss in ton/ha/yr). Rainfall characteristics vary the most in space and time. In the middle mountain region, the erosive force of rainfall is particularly strong among all of the factors.

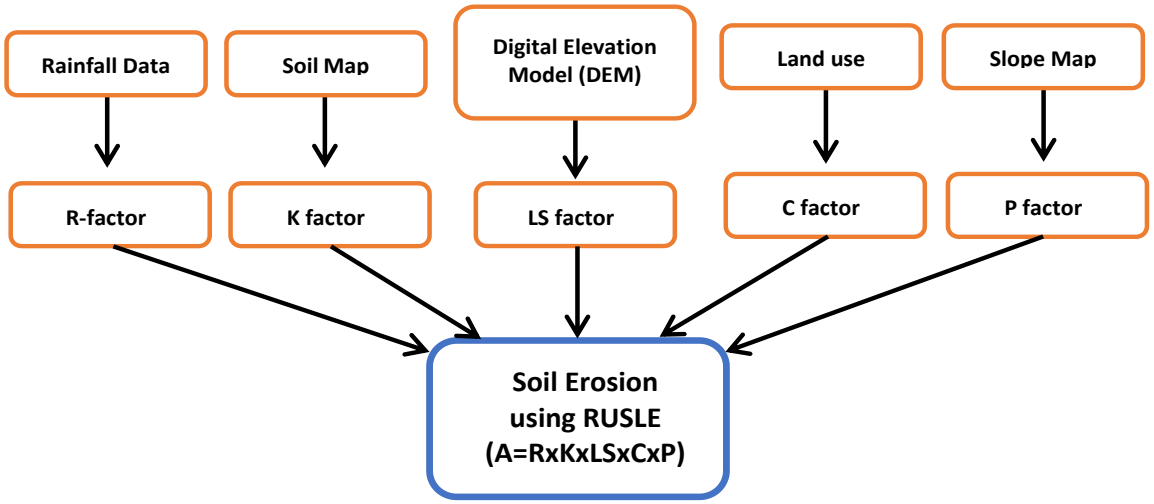

Figure 2.13: Soil erosion using RUSLE method in Katti sub watershed area

The empirical RUSLE model remains the most popular tool for assessing water erosion hazards due to its modest data demands and easily comprehensible model structure, especially in developing countries where the possibilities for applying more complex models are often limited by a lack of adequate input data. In recent decades, RUSLE and its adapted versions have been applied worldwide in different regions and at different spatial scales. The RUSLE-GIS interface

has several advantages in terms of easy updating, integration of spatially referenced data, and the facility to present the mapping results in different forms. A number of studies have shown good results using RUSLE together with GIS methods and RS data to model soil erosion. (Uddin K; 2016)

Figure 2.14: Soil erosion map 1996

Figure 2.15: Soil erosion map 2016

Result

Soil erosion risk maps were developed for the entire Katti-watershed using RUSLE in conjunction with GIS and remote sensing data. The results are shown in figure 2.14 (1996) and 2.15 (2016). The study area was divided into five erosion risk classes, from very low to very high based on the estimated erosion rates. The working vdcs as Paganath, Badabhairab, Lakuri, Katti and Rum are highly erodible comparing other vdcs in Katti sub-watershed. The areas in the very low erosion class were mainly located at the lower elevations where the terrain is relatively flat. The estimated maximum per hectare average soil loss occurs at elevations between 1200 and 3000 msl and the minimum at the elevations between 1000 and 1200 msl.

Table 2.12 shows the estimated soil loss into five erosion risk class in 1996 and 2016. Which shows, very high soil loss rate estimated was in between 166.32-451.19 t/ha/yr in 1996 and 178.70-451.19 t/ha/ya in 2016 which seems very low in study area and range in between 5.30-21.23 t/ha/yr in 1996 and 5.30-23 t/ha/ya in 2016 occupies moderately high in area among remaining erosion class. The results were verified by field verification and key informant survey on some hotspot areas in different part of the study area. Soil erosion rate calculated in these studies are found to be appropriate and matching. The results were also compared with the studies carried out in areas having similar geo-environmental and rainfall characteristic and was found to be comparable with an annual average soil erosion rate. The spatial pattern of classified soil erosion risk zones indicates that the North, northeast and southern regions especially ridge part of steep slope of the study area.

In order to assess the role of human intervention in the soil erosion risk in the sub-watershed, land cover map of the area was overlaid with classified soil erosion risk zone map. With the spatial pattern, the severe and high levels of soil erosion risk zones are distributed on the shrub land, forest area and agriculture area. The area with the larger gradient is mostly covered by high fraction vegetation, and is on lower level of soil erosion risk than that with little gradient. At the same time the spatial pattern of annual average soil erosion risk map shows high spatial

correlation with LS-factor map and it indicates the role played by topography in controlling soil movement in a sub watershed. Therefore, the area with high LS- factor and degraded forest, shrub land need immediate attention in soil conservation point of view

Table 2.12: Soil erosion class in 1996 and 2016

S.N.	Erosion Class	1996 (Soil loss/ha/yr)	2016 (Soil loss/ha/yr)
1	Very High	166.32 - 451.19	178.70 - 451.19
2	High	58.39 - 166.32	60.15 - 178.70
3	Moderate	21.23 - 58.39	23.00 - 60.15
4	Low	5.30 - 21.23	5.30 - 23.00
5	Very Low	0.00 - 5.30	0.00 - 5.30

A quantitative assessment of average annual soil loss for Katti sub-watershed is made with GIS based well-known RUSLE equation considering rainfall, soil, land use and topographic datasets. In the sub-watershed the land use pattern in areas prone to soil erosion indicates that areas with natural forest cover in the head water regions have minimum rate of soil erosion while areas with human intervention have high rate of soil erosion. Terrain alterations along with high LS-factor and rainfall prompt these areas to be more susceptible to soil erosion. The predicted amount of soil loss and its spatial distribution can provide a basis for comprehensive management and sustainable land use for the watershed. The areas with high and severe soil erosion warrant special priority for the implementation of control measures.

2.1.13. MAJOR EROSION AND LANDSLIDE HOTSPOTS

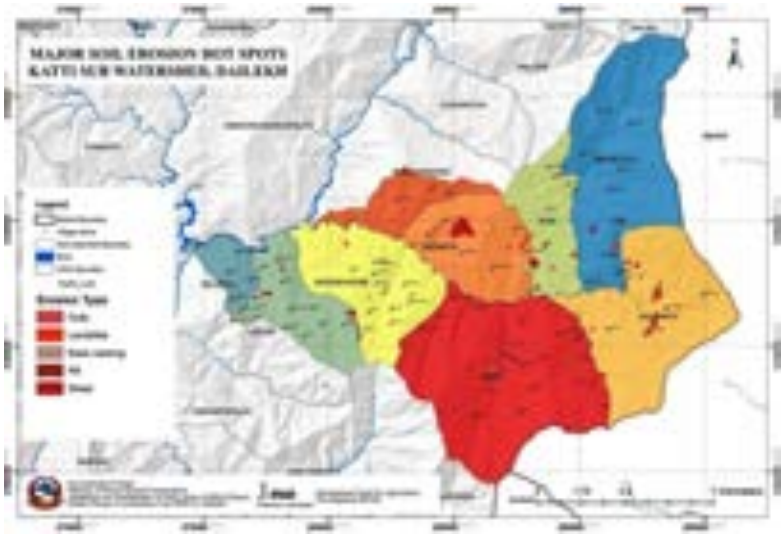

Figure 2.16: Major soil erosion hotspots map of Katti sub watershed area

The knowledge of soils, their physical and chemical properties are imperative since it helps understanding the soil fertility and productivity of land in watershed. Soil particles and their sizes are important factors for soil erosion. The detachability and transportability of soil in the erosion process increase or decrease based on kind and size of soil particles. For example, the clay particles difficult to detach than sand but easier to transport. Soil with large stable particles such as sand grains or iron cemented soil particles are difficult to detach and transported, which seldom erode.

Soil erosion suggests that increased rainfall amounts and intensities will lead to greater rates of soil erosion. Thus, if rainfall amounts and intensities increase in many parts of the study area as expected, erosion will also increase, unless improvement measures are taken. Similarly, soil erosion in the Katti sub watershed is categorized into five types (Gully, Landslide, Mass wasting, Rill and Sheet) which is mainly caused by landslides, mudslides, collapse of manmade terraces, soil loss from steep slopes and decline of forest areas. Removal of topsoil occurs generally through sheet erosion. Slope length and steepness, vegetation cover, surface soil condition, amount of rainfall are important factors determining the rates of soil erosion. Apart from these, particle size distribution, effect of slope exposition and terrace farming seem to have substantial influence on soil erodiability and development of erosion features in the study area. The erosion hotspot map prepared on the basis of 2016 Google earth satellite image shows that Rum, Katti and Jagnath VDCs are highly affected by sheet and landslide due to intensity of rainfall, soil type and steep slopes, followed by Gully.

Table 2.13: Type of Erosion in Katti sub watershed area

S.N	Landslide effected VDCs	Area (Ha)	Area %
1	Badabhairab	2.63	1.9
2	Jaganath	30.45	22.3
3	Katti	41.91	30.6
4	Lankuri	5.29	3.90
5	Mehaltoli	3.69	2.70
6	Paganath	6.29	4.60
7	Rum	46.58	34.00
Total		**136.84**	**100.0**

2.1.14. SPATIAL AND TEMPORAL DISTRIBUTION OF FOREST FIRES

Uncontrolled forest fire is an important driver of forest degradation throughout the country. Recurrent forest fires severely damage and prohibit regeneration and growth of seedlings, destroy non-timber forest products and in some cases, encourage invasive species. Although quantitative information is not available, forest fires are definitely degrading biodiversity, enhancing soil erosion and inducing floods and landslides due to the destruction of the natural vegetation in Nepal.

Although forest fires are an issue of concern in Dailekh, the secondary database extracted from MODIS did not specify forest fire around Katti sub watershed since it detects fires in 1 km pixels that are burning at the time of overpass under relatively cloud free conditions.

Although, the District Forest Office and range post monitor that forest management and resource utilization are per established arrangements.

2.1.15. MAJOR DEFORESTED AND DEGRADED LOCATION

Deforestation causes increased erosion rates due to exposure of mineral soil by removing the humus and litter layers from the soil surface, removing the vegetative cover that binds soil together, and causing heavy soil compaction from logging equipment. Once trees have been removed by fire or logging, infiltration rates become high and erosion low to the degree the forest floor remains intact. Severe fires can lead to significant further erosion if followed by heavy rainfall. (Goudie, Andrew, 2000).

Figure 2.17: Deforestation map of Katti sub watershed area

One of the primary reasons for degradation of the forests and grasslands is encroachment and overuse by rising populations in the Katti sub watershed. Encroachment in the form of overgrazing by livestock is one of the factors of the exploitation of the ecosystems, although livestock education is an essential component of the rural farming system and a source of annual farm income. Grazing in the forest by livestock is heavy and goes on all year round. Although some farmers have private fodder trees and private forest land, these are rarely sufficient to meet the year-round food requirements of their livestock.

In Katti sub watershed, the status of deforested and degraded forests was analyzed from 2016 Google earth image which was verified during field visit and key informant survey. The image reveals that the degraded forest in between 2006 to 2016 is high, which occupies almost 709 ha in total. Among ten vdcs Katti, Lakuri, Mehaltoli VDC suffers with highly degraded area, covers almost 123 ha, 115 ha, 107 ha of land followed by Jaganath, Badabhairab, Belpata, Rum having 69 ha, 69 ha, 53 ha, 58 ha. Along with the deforestation areas were mostly observed at upstream

portion of 2, 4, 5, 6, 7 wards of Lakuri vdc; 2, 3, 4, 5, 9 wards of Bada-Bhairab vdc; 1, 2, 4, 5, 8, 9 wards of Katti vdc; 1, 2, 5, 7, 9 wards of Paganath vdc and 3, 4, 6, 9 wards of Rum vdc.

Table 2.14: Deforested area in Katti sub watershed

S.N.	VDCs Name	Deforested Area in hectare (Ha)	%
1	Badabhairab	69	9.7
2	Belpata	53	7.5
3	Bindhyabasini	11	1.6
4	Dandaparajul	49	6.9
5	Jaganath	69	9.7
6	Katti	123	17.3
7	Lakuri	115	16.2
8	Mehaltoli	107	15.1
9	Pagnath	55	7.8
10	Rum	58	8.2
Total		**709Ha**	**100%**

2.1.16. MAJOR SPRINGS

The Katti watershed is situated to the north of Mahabharata range and has sloppy hills due to its hill character, with very steep active slopes, makes the study area increasingly vulnerable to environmental degradation. Deforestation and overgrazing trigger soil erosion and increased surface runoff, causing springs and small rivers to be blocked and not replenished by rain. Due to climate change rainfall is more erratic, exacerbating soil erosion and runoff.

Natural springs are the main source for drinking water in the study area. Those springs are located in the lower village and often at a long distance. Especially during the dry season, the springs are drying up. This results in serious scarcity of drinking water. The present condition of spring sources will be based on data collected during the preparation of LAPA.

2.1.17. LOCATION MAP OF COMMUNITY FOREST

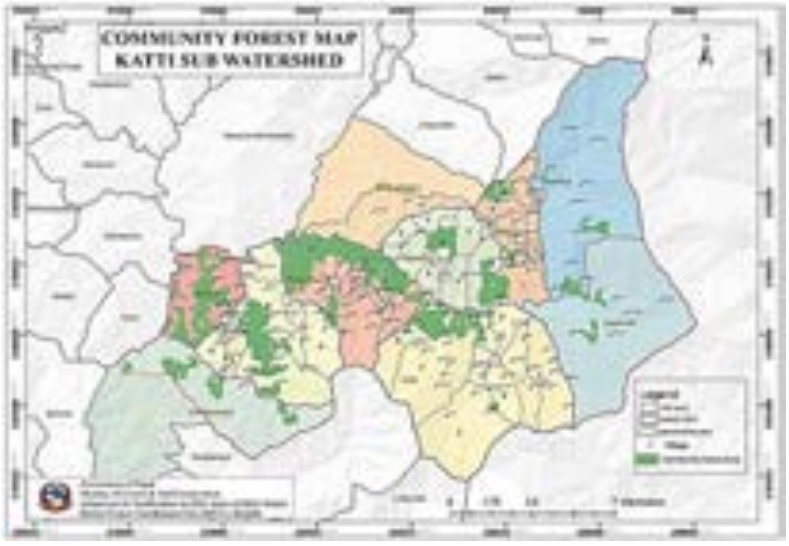

Figure 2.18: Community map of Katti sub watershed area

As a result of transferring managerial rights to user groups, the community forestry program has had remarkable achievements, including forest restoration, social inclusion and representation, improvement of community infrastructure, rural development and contributions to poverty reduction. Barren lands, uncovered hills and degraded forestlands have been converted into productive woodlands, lost greenery is now restored. Forest management by communities has contributed to environmental improvement, although the total contribution has not been quantified. With improved forest

conditions, the availability of forest products, local people's rights of access and the supply of forest products to poorer households have increased in the Katti watershed area of Dailekh district. As a result, the time women spend collecting fuel wood, one of their main tasks, has decreased.

Almost 2602.10 ha of forest have been handed over to community by district forest office for watershed protection, soil erosion control, protection and restoration of water sources, environmental purification, and a healthier living environment in Katti sub watershed. The table shows that about 733.20 ha forest is handed to community in Badabhairab VDC, so as 458.10 ha in Belpata, 383 ha in Lakuri, 319 ha in Katti, 246.9 ha in Pagnath, 172 ha. Besides achieving the physical target of handing over the national forest to local forest user groups, community forestry has simultaneously enhanced leadership and community development, democratic processes, poverty reduction, gender equity, and social inclusion.

Table 2.15: Community forest area in Katti sub watershed

S.N.	VDCs Name	Community forest Area in hectare (Ha)	%
1	Badabhairab	733.20	28.20
2	Belpata	458.10	17.60
3	Bindhyabasini	0.70	0.00
4	Dandaparajul	182.40	7.00
5	Jaganath	52.80	2.00
6	Katti	319.00	12.30
7	Lakuri	383.00	14.70
8	Mehaltoli	101.20	3.90
9	Pagnath	246.90	9.50
10	Rum	124.80	4.80
Total		**2602.10 Ha**	**100%**

2.2.18. LANDSLIDE HAZARD SUSCEPTIBILITY

A landslide defined as "movement of the earth downward or outwards under the effect of the gravity, rain and slope"; Varnes D.J (1984). Although it is natural process it can turn into hazard when it becomes a problem. Landslides are in particular characteristic of a mountainous landscape, and one of the most dominant hill slope geomorphological processes. The landslide in general has connotation of a destructive force, while most of the present day settlements in mountain landscape are on landforms associated with historical landslide events. Underlying these imperatives is the need for landslide hazard maps, a spatial representation of landslide hazard zones to guide development practitioners and disaster managers to make informed decision.

Hazard map is a map that shows geographically (areas/zones) different degree of probability of being affected/hit by hazard. The process of establishing geographically where and to what extent particular phenomenon is likely to pose a threat to people, property, infrastructure and economic activities is hazard mapping. Landslide hazard map is a map showing geographical extent with different probability of being effected by landslide. It is an important step towards landslide investigation and risk management.

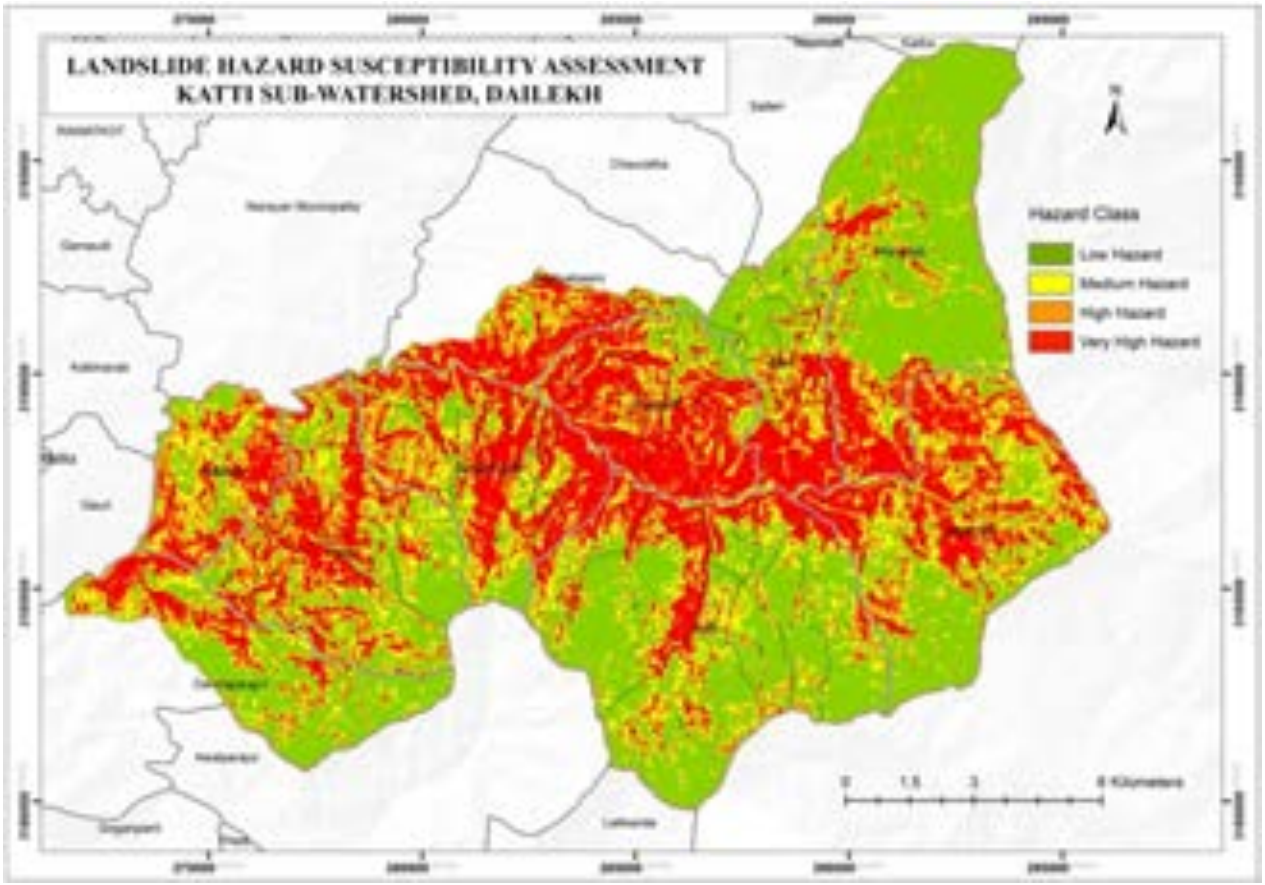

Figure 2.19: Landslide hazard susceptibility assessment map of Katti sub watershed area

In this study, logistic regression model was used to assess landslide hazard indexes. It is an example of generalized linear model and has proven to be one of the most reliable approaches for assessment of landslide hazard. It works well in case of dichotomous data, which means that the dependent variable can have only two values (yes or no landslide) i.e. cell was assigned '0' if no landslide is present or '1' if a landslide is present. Using logistic regression formula, the probability of landslide occurrence is expressed by:

$$p = \frac{e^z}{1 + e^z}$$

Where, p is probability which is dependent on logit z. The logit z is assumed to contain the independent variables on which landslide occurrence. The input data can broadly categorize in two: independent and dependent variables. The independent variables are data representing causative factors like geology, river network, road network; land use/ land cover etc. Dependent variable is landslide point database. Only those landslides of satellite data extracted from Google earth 2016 were taken into considerations for this study.

The landslide index in the Katti sub-watershed is divided into four groups' i.e. low, medium, high, and very high using natural junk break method. The calculated and classified hazard levels were found in good agreement with occurrence of pre-existing landslides. Validated results with respect to past incidence of landslide events clarified the spatial relevancy of predicted landslide hazard in the natural hill slope terrain.

Likelihood occurrence of slope failure with respect to causative variables verified that slope and bedrock layering variables are found to be the most influential factors. Natural slope angle is the distinct pre-disposing factor for slope failures and maximum failures were found at slope angle above 27 degrees. The modeling result showed that very high hazardous zones were mainly confined in lower and middle reaches of the study area and such a spatial localization of very high hazards was attributed to the presence of favorable steep topography. A few localized very high hazardous zones were embedded in the medium to high hazardous zones in some parts of the Katti sub watershed.

The analysis shows that the high slope angle has strongly influence on the slope failure processes. The geological structure and the low grade metamorphic rocks found in the study area have tremendous effect on the stability of terrain. The situation is going worse due to the construction of non-engineered canal along the slope and most of the places have water percolation. The percolated water has positive role on the instability of the area. The rainfall is another factor during the monsoon season which effects on the groundwater condition leading the instability. Another major contribution for the instability is the road alignment. Erosion and landslides occur in the edges of road due to: (i) use of heavy equipment such as bulldozers and excavators; (ii) lack of drainage arrangements; (iii) steep gradients; and (iv) lack of protection structures and maintenance arrangements. The road that construct by the local people is leading role on the stability because of the poor attention on the crack zones, sign of instability due to road construction and the improper management of the drain along the road. As a result, there is huge accumulation of ground water on the mountain base. Similarly, all the surrounded mountains of the selected area consist of large scale landslides and their toe is now extensively disturbed from

so called low cost road. As a result, landslide risk is in very alarming situation and whole slope around the selected villages are noticed on high hazard zone.

Table 2.16: Landslide susceptibility area in Katti sub watershed

S.N	Name of VDC	Low	Moderate	High	Very High	Grand Total (Km^2)
1	Badabhairab	4.1	3.9	4.2	7.9	20.1
2	Belpata	2.5	2.2	2.5	2.9	10.1
3	Bindiyabasini	1.3	1.2	1.5	3.6	7.6
4	Dandaparajul	9.2	2.7	1.9	2.6	16.4
5	Jaganath	10.3	5.7	5.0	8.0	29.0
6	Katti	24.4	7.4	4.4	6.2	42.3
7	Lakuri	8.4	5.2	4.7	6.1	24.5
8	Mehaltoli	22.3	3.0	2.4	4.1	31.8
9	Paganath	2.1	2.3	3.3	8.5	16.2
10	Rum	4.8	1.9	1.7	3.5	11.9
Grand Total Area (Km^2)		**90**	**35**	**32**	**53**	**210**
%		**42.86%**	**16.67%**	**15.24%**	**25.24%**	
Landslide Susceptibility Zone (Normality based)		**0 to 0.24**	**0.25 to 0.49**	**0.50 to 0.74**	**0.75 to 0.99**	

About 25.23% and 15.24% (Table 2.16) of land lies on very high & high risk zone according to landslide hazard susceptibility map of Katti-sub watershed, the areas were mostly observed on 2, 4,7,8 ward of Lakuri vdc; 1,3,4,5,7,9 ward of Badabhairab vdc; 1,3,6,7,8,9 ward of Pagnath vdc; along the river side of ward no 1,3,4 settlements of Rum vdc and 4,5,7,8,9 ward of of Katti vdc. According to landslide susceptibility grade paganath, Jaganath vdcs are highly vulnerable which occupies almost eight square kilometers of area in very high zone followed by Badabhairab, Katti, Lakuri.

2.2.19. UPSTREAM-DOWNSTREAM LINKAGES IN THE KATTI SUB WATERSHED

Physical linkages consist of numerous activities and processes that occur in upstream areas in connection with the physical environment (such as land use change, runoff generation etc.) and their impacts on the downstream environment. There are many processes which occur simultaneously at different spatial and temporal scales and these are, by nature, complex. Changes in the status of the natural environment (for example in climatic conditions) and human systems (for example resource management practices) may have both qualitative and quantitative impacts on the overall hydrological regime. The current status of knowledge on the upstream-downstream linkages related to bio-physical is summarized in the following table.

Table 2.17: Integrating GIS based sub-watershed spatial information into local adaptation planning process

ATTRIBUTES	LAKURI	BADABHAIRAB	PAGANATH	RUM	KATTI
Up and downstream linkages sites within VDC	**Landslide** No linkage	**Landslide** Badabhairab 4,6 Impact: Landuse, Settlement & Road Upstream: ward no 4, Jantekot Village, Duni Village Downstream: ward 6 Arable Valley cultivation	**Landslide** Paganath 4,6 Impact: Landuse, Road Upstream: ward no 4, Downstream: ward 6 Paganath 4,6 Impact: Landuse, Road Infrastructure & Human Settlement. Upstream: ward no 9, Downstream	**Landslide** Ward no: 3,4 Upstream: ward no 3 Downstream: ward no 4 Ward no: 3 Mauladanda, Thantichaur & Rum Gaun Ward no :4 Agriculture area	**Landslide** Ward no: 3,6,7 Upstream: Ward no 3,6 Downstream: ward no 7 Ward no: 6 Jhegada & Panchtola Village Ward no: 3 Sanigaun Village ward no: 7 Base & Paiyagaun Village Ward no: 1,5, Upstream: ward no 1 Mayabas Village Downstream: ward no 5 Maisthan village, Chakhla & Jaina Village

	Soil erosion Ward 5,4 Upstream: ward no 5, North part of Trikule Village Downstream: ward no 4: Near the mathillo Lankuri Village	**Soil erosion** Upstream: ward no 4, 5, 6, 7, Ward no 4: West part of Duni Village, East Part of Duni Village along the Bada Khola, West part of Pachana Village, Northwest of Barsana Village, North part of Gaiaut Village Ward no 5: West/East part of Khagena village Ward No 7: west part of Khadkagaun Village & North Part of Kot Village Downstream: ward no 6 Along the river course/arable valley cultivation land	**Soil erosion** Upstream: ward no 5, 6, Downstream: ward no 7 Upstream: ward no 2, Downstream: ward no 3	**Soil erosion** Ward no: 8,9 Upstream: 9 Lower part of Guyaldadim & Jogimara Khola Downstream: 8 Arsina village Ward no: 2,4 Upstream: 2 Around the Dandagaun streams Downstream: Around the Simal Takura streams	**Soil erosion** Ward no: 3,6,7 Upstream Ward no: 3,6 Downstream ward no: 7 Ward no: 6 Jhegada & Panchtola, Sanigaun Ward no: 3 Sanigaun Village ward no: 7 Base & Paiyagaun Village ward no: 2 Barama Village Ward no: 1,5, Upstream Ward no: 1 Downstream ward no: 5 Mayabas Village Downstream ward no: 5 Maisthan village, Chakhla & Jaina
	Deforestation & Degradation Ward 5, 4, Upstream Ward 5 Goganpani, Trikule, Downstream ward no 4 Mathilli Lakuri, ward no 5 Geuli	**Deforestation &Degradation** Ward 6, 4, 7,9 Upstream ward 4: South part of Kuna & Pachana Village, Southwest part of Jantekot Village. Upstream ward no 7: East/south part of Khadkagaun Upstream ward no 9: East part of Kot village Downstream ward no 6: Along the river course/arable valley cultivation land	**Deforestation &Degradation** Ward 2 Grassland near Khalga Upstream & ward 1 Forest Downstream ward 5-Northeast of Simalpokhari Upstream & ward 6 West of Simal Pokhari Downstream Ward 6, Upstream & Ward 7 Downstream Ward 8 Near Khaule gau Upstream and Ward 7 South of Khaule gaun	**Deforestation & Degradation** Ward: 3,4,5,6,7,8,9 Upstream: Ward 3,5,6,9 Upper part of Linche, Bajeda, Lode & Guyaldadim Downstream : Ward 4,7,8 Arsina, Saltage & Simaltakura	**Deforestation & Degradation** Ward 7, 2, 6 Upstream ward: 5 2,6 Downstream ward no: 7 Ward 1, 5 Upstream ward: 1 Downstream ward no: 5

Major landslides sites	**Landslide** Ward no 2,3,4,7 Ward no: 3 South Part of Tallo Lankuri Ward no: 4 West part of Majgaun village near the Khada Khola	**Landslide** Badabhairab 4 and 3 Ward no 4: mid part of Jantekot & Duni village Ward no 3: North west part of Khor village.	**Landslide** Paganath 4,6, 9, and 7	**Landslide** Ward no: 2,3,4,6,9	**Landslide** Ward no: 1, 3,5,6,7
Major soil erosion sites	Ward no 2,4,5, 6 Ward no 2: North aspect slope of village near the Khada Khola Ward no 4: west aspect slope near the Khada Khola, east side of the mathillo Lakuri Village. Ward no 6: Different site of streams networks of Baitadi Khola near the different villages such as Palta, Uma & Sirseni. Ward no 7: Along the river side of Bijetkot Khola, Sim Khola & Paryachaur Khola Ward no 7: Near the Dumri village & along the stream networks of Paryachaur Khola.	Ward no 2,3,4, 5, 6,7, 8 Ward no 2: Pallo Khor, Jastala village Ward no 3: Northwest part of Khor Gaun Ward no 4: west part of Duni/near the Gaiaut village/Pachana/Barsana village along the Bada Khola. Ward no 5: East/west part of Khagena Village Ward no 6: Along the Bada Khola river site Ward no 7: East/West part of Khadka Gaun	Ward no 5, 6,7	Ward no: 2,3,4,7,8,9 Along almost all streams	Ward no: 2,3,6,7

Major deforested / degraded sites	Ward 2-Deuli, Atrauli & Sermakot Ward 4-Mathillo Lankuri Ward 3-Tallo lakuri, Gurjedanda Ward no 5-Geuli, Goganpani, Trikule Ward no 6-Palta, Uma, Sirseni Ward no 7-Pipalpata, Simkhola, Rowati Ward no 8-Dumri Ward 9-Paiyachaur, Gairigau	Ward 1, 2 & 3 Mid transition part of forest and cultivation Ward 5- North & East parts of Dandagaun East part of Bhairavisthan & Khagena Village Ward 6, 4, Ward 4: South of Gaiaut & Pachana Gau, Ward 7: west part of Khadka Gaun Ward no 9-East part of Kot & Khagena Gaun	Ward 3 – Pokhari Danda, Majgau, Pagnath; Ward 1 – Sano Pagnath, Ward 1- Amare and Chitmola Gaun, Sahutada Ward 5 Northeast of Simalpokhari, Ward 4 Simalpokhari and Thulo Ganma Ward 7 South-west part Ward 7 Kurmigau Ward 8 Sano Ganma, Ward 9	Ward 3: Katiya Gaun Ward 4: North part of Simaltakura Ward 5: West upper site of Linche Village Ward 6: West upper site of Bajeda Village Ward 9: West upper site of Loda & Guyaldadim Village-North part of Nagaun Ward 8: North part of Arsina village Ward 7: North part of Saltage Village Ward 4: North part of Simal Takura near the border with ward no 7 Ward 3: Katiya & Mauladanda west	Ward 2: Berama village upper side Ward 1: upper site Ward 6: upper site Ward 5: Dudhila and Sera site, Maluka village site Ward 9,7:Lower Katti Village near the Katti river site Ward no 4: Upper site of chipin Village, west part of chipin village, Lower site around the Timalsina village Ward no: 8 ,Upper site of Jotinge village and down ward Chipin Danda village
Location of forest fire areas	No major fire according to MODIS	No major fire according to MODIS	No major fire according to MODIS	No major fire according to MODIS	No major fire according to MODIS

Location of major streams/ rivers (climate-water induced vulnerability assessment purpose)	Baitadi Khola Khola Starting from Ward-6 towards Ward 6 &3 mix into Katti Khola Khada Khola Starting from Ward-1/2 towards ward 4/3 that accumulated into Katti Khola Sim Khola Starting from Ward-7 towards ward no 8 & 9 accumulated into Matela Khola Pariyachaur Khola Starting from Ward-8 towards ward no 9 accumulated into Matela Khola Bijeko Khola Starting from Ward-7 towards ward no 9 accumulated into Matela Khola Bhitri Khola Starting from Ward-7 towards ward no 8, 9 accumulated into Matela khola Dabba Gaira khola starting from ward 9 and accumulated into Matela Khola	Bada Khola Starting from Ward-4 towards Ward 6 Jotinge Khola Starting from Ward-9 towards Ward 1 Ghurkeri Khola Starting from Ward-1 towards Katti Khola Palta Khola Starting from Ward-1 towards mid of Badabhairab 1 & 3 Baitadi Khola Starting from Ward-1 towards Katti Khola	Dumsi Khola Starting from Ward-5 towards Ward 7 Dumsi Khola Starting from Ward-2 towards Ward 1 One stream located near the Paganath & Rum VDCs Paganath ward 1 Katti Khola: River bank cut	Jogimara Khola Starting from ward 9 towards ward no 8 of Rum vdc. Khor & Meli Khola starting from ward 6/9 that was accumulated on Rum Khola. Rum Khola starting from Mehaltoli VDCs follow towards joining border of Rum VDCs & Mehaltoli. Having high bank cut problem of Agriculture fertile land of Rum VDC.	/Gothi Khola Starting from Ward-2 towards mid border of ward no 7 and ward no 4 of katti VDC. Maluka Khola Starting from Ward-1/5 towards ward 9 that accumulated into Katti Khola Dahal Khola Starting from Ward-4 towards ward no 7 accumulated into Gothi Khola Saina Khola Starting from Ward-4 towards joining border of ward no 4/8 accumulated into Katti Khola Bhere Khola Starting from Ward-4 towards ward no 8 accumulated into Katti Khola Mastapujna Khola Starting from Ward-6 towards ward no 3/7 accumulated into Gothi Khola Dyan Khola starting from ward no 9 accumulated into Katti Khola. Jotinge Khola located at ward no 8 join border between Badabhairab VDC that accumulated into Katti river.

Land capability situation-over used location	**Land cap. IV (more 30^0 degree slope) & Agri.** ward no 2: Atrauli ward no 3: Tallo Lankuri ward no 4: Manjgaun ward no 5: Majgaun side ward no 6: Middle part of Sirsenni and Palta village ward no 7: Simkhola gaun, Deurikharka & Rowati Ward no 8/9: Madkeni, Paiyachaur Gairigaun, Dumri & Asureni	**Land cap. IV (more 30^0 degree slope) & Agri.** ward no 5: Dandagaun, Bhairabisthan & Khagena Ward no 2: Near Baitadi Khola Ward no 5: Barsana, Kuna & Pachana ward no :6,7 Northwest part & downstream Part of Bada Khola ward no 8: Mahadevkuna Village ward no 9: Kot Village east part, Olkedanda & Balchipin Village	**Land cap. IV (more 30^0 degree slope) & Agri.** ward no 1: Pokharidanda, Majgau & Sano Paganath ward no 2: Khagla, ward no 3: Pokharidanda, Majgau & Pagnath ward no 4: thulo ganma ward no 5: Simalpokhari ward no 6: ward no 7: Kumri khola ward no 8: Khaule & Ganma ward no 9: Kumri land capability IV (more than 20 cm deep, well to imperfectly drained) & river bed ward no 1: Amara, sahutada & Bestada ward no 2: Maulesal ward no 3: Maulesal, Barne Ward no 7: Hulak Takura	**Land cap. IV (more 30^0 degree slope) & Agri.** Ward no 3: Lower part of Thantichaur & mauladanda Ward no 4: lower part of Simaltakura Village Ward no 7: Lower part of Chiura & Saltage Gaun Ward no 8: Upper part of Bajeda Village Ward no 9: Upper part of Guyaldadim & Na Gaun Village	**Land cap. IV (more 30^0 degree slope) & Agri.** ward no 7,9: Around Katti village ward no 5: Sera,Dudhila, Jaina & Maluka ward no 4: Chipin Village upper / west site / down site near the timaisina village Ward no 8: Upper site of Jotinge village & Chipin Danda village site
Land capability situation-over used location	-	-	**Land cap. IV (more 30^0 degree slope) & Shrub**. ward no 1: Sano Paganath, Chim tole ward no 2: Khagla ward no 5: Simalpokhari, Ganma ward no 6: Simalpokhari west ward no 8: Khaule east part	-	-

2.2. SOCIO-ECONOMIC CONDITION ASSESSMENT

Socio-economic characteristics and population parameters of the study area were prepared based on data from household census conducted during 2011 and presents the scenarios of various social, demographic, income and expenditure, settlement pattern etc. according to VDC wise. It also assesses the economic aspects that include prosperity imitating of social class and state of livelihood available community basic services.

2.2.1. SETTLEMENT PATTERN

The settlement pattern generally observed scattered, mainly in the slopes of mountains in Katti sub watershed connected with earthen road. The settlements are mostly on remote, difficult and unproductive land which has adverse effects on their wellbeing. The study showed that 78.37 percent households had tile/slate roofed houses (2-3 storey houses) whereas 13 percent households had thatched straw roof houses as shelter in the area. None of them reported as homeless in the study area. Timber is the primary part for the construction of Tile slate and Thatch straw roof.

Table 2.18: Settlement pattern according to structure of roof in Katti sub watershed

S.N	Name of VDC	Total HH	Thatch Straw	Galvanized	Tile Slate	RCC	wood Plank	Mud	others	Not Stated
1	Badabhairab	519	8	16	490	1	0	1	0	3
2	Belpata	570	104	82	254	64	2	60	0	4
3	Bndyabasini	577	103	7	439	0	0	9	0	19
4	Jagannath	504	1	3	497	0	0	0	0	3
5	Katti	919	140	4	760	0	1	4	0	10
6	Lukuri	707	56	5	630	1	0	10	0	5
7	Mehaltoli	459	1	2	451	0	1	1	0	3
8	Paganath	505	62	57	375	8	0	0	1	2
9	Rum	453	48	14	384	6	0	1	0	0
10	Dandaparajul	1001	285	46	590	55	0	19	0	6
Total		**6214**	**808**	**236**	**4870**	**135**	**4**	**105**	**1**	**55**
%		**100%**	**13.00**	**3.80**	**78.37**	**2.17**	**0.06**	**1.69**	**0.02**	**13.00**

2.2.2. POPULATION DENSITY BY VDC

Population density is an effective indicator to measure the pressure of population on Land. The population per square kilometer of total area measures the population density. The population density by area of land is prepared based on data from household census conducted during 2011. The total population density of study area is 1522 populations per sq. km. Among the VDCs, Belpata is the most densely populated VDC with 270 populations per sq. km, owing to its size as the smallest VDCs (only 10.06 sq. km), followed by VDCs Rum, Paganath, Lakuri and Badabhairab.

Figure 2.20: Population density map of Katti sub watershed area

Table 2.19: Population density on Katti sub watershed area

S.N.	Name of VDCs	Total Population	Population %	Area sq km	Population Density
1	Badabhairab	2995	8.97	20.10	148.99
2	Belpata	2721	8.15	10.06	270.34
3	Bindhyabasini	2945	8.82	24.29	121.20
4	Dandaparajul	5109	15.30	33.73	151.44
5	Jaganath	2803	8.39	29.02	96.56
6	Katti	5253	15.73	42.24	124.33
7	Lakuri	3840	11.50	24.43	157.17
8	Mehaltoli	2586	7.74	31.79	81.34
9	Pagnath	2697	8.08	16.19	166.57
10	Rum	2444	7.32	11.93	204.77
Total		**33393**	**100.00**		

2.2.3 POPULATION DENSITY ON AGRICULTURE LAND

Population is the driving force of reducing agriculture land, as population grows, one would expect land to be divided into smaller and smaller plots as it is passed down from parents to children. The population density on agriculture land of Katti sub watershed area is calculated based on CBS 2011 and 2016 Google Earth satellite image which define; the total population density on agriculture land of study area is 39.24 populations per hectare along eight VDCs. Among the VDCs, Paganath and Rum are the densely populated VDC by agriculture area with 5.98 and 5.73 populations per ha, owing to its size as the smallest VDCs (only 450 and 430 ha), followed by Mehaltoili, Belpata, Lakuri, Badabhairab, Jaganath, Katti.

Figure 2.21: Population density by agriculture map of Katti sub watershed

Table 2.20: Population density by agriculture land in Katti sub watershed

S.N	Name of VDCs	Agriculture Area (Ha)	Population Density by Agriculture Area	Total Population
1	Badabhairab	670	4.45	2995
2	Belpata	560	4.89	2721
3	Jaganath	600	4.66	2803
4	Katti	1210	4.33	5253
5	Lakuri	880	4.37	3840
6	Mehaltoili	670	4.83	2586
7	Paganath	450	5.98	2697
8	Rum	430	5.73	2444

2.2.4. POPULATION DENSITY ON FOREST LAND

The rural population is highly dependent on forest resources for meeting basic needs like firewood for cooking and heating, timber for construction and furniture, and fodder for cattle. The forest also supplies digestible nutrients for livestock. The study revealed that almost all household had access to community forest and government forest to fetch the fodder, fuel wood, timber, medicinal herbs, litter and wild edible food etc. in the area. However, that was not enough as reported by the farmers in the study area.

Table 2.21: Scoring and ranking of benefits from community forestry in Katti sub watershed

S.N	Forest products	Score	Rank
1	Fuel wood	10	I
2	Litter	10	II
3	Fodder/forage/grass	5	IV
4	Timber	5	IV
5	Source of water	5	IV
6	Wildlife	4	V
7	Stones	3	VI
8	Recreation	1	VIII
9	Wild edible fruits	2	VII
10	Wild edible foods	2	VII
11	Supply of oxygen	5	IV
12	Check soil erosion	7	III
13	Habitat for birds	5	IV
14	Carbon sequestration	5	IV

Source: Community Forestry User's Group 2011

The table shows the listing, scoring and ranking of benefits from community forest that was derived from group discussion in the study area. The study revealed that respondents ranked first for fuel wood, ranked second for litter, ranked third for check soil erosion, ranked fourth for fodder, timber, source of water, supply of oxygen, habitat for birds and carbon sequestration ranked fifth for wild life habitat, ranked sixth for stones, ranked seventh for wild edible food and fruits, ranked eighth for enjoyment that benefits from the community forest in the area. It is revealed that community forest has significant protective functions as ecosystem services.

Along with, the population density on agriculture land of Katti sub watershed area is calculated based on CBS 2011 and 2016 Google Earth satellite image, which defines the total population density on forest land of study area is 24.7 populations per hectare along eight VDCs. Among the VDCs, Belpata is the densely populated VDC by forest area with 7.5 populations per ha, owing to its size as the smallest VDCs (only 360 ha), followed by VDCs Rum, Paganath, Lakuri, Badabhairab.

Table 2.22: Population density by forest land in Katti sub watershed

S.N	Name of VDCs	Forest Area (Ha)	Population Density by Forest Area	Total Population
1	Badabhairab	1250	2.38	2995
2	Belpata	360	7.50	2721
3	Jaganath	2120	1.32	2803
4	Katti	2580	2.03	5253
5	Lakuri	1450	2.64	3840
6	Mehaltoili	2310	1.12	2586
7	Paganath	920	2.92	2697
8	Rum	510	4.79	2444

2.2.5. ETHNIC COMPOSITION BY VDCs

The study area represented as multi-caste and ethnic composition. Dalit (Kami, Damai and Sharki) accounted for 29.13 percent, Janajati 10.07 percent, Brahmin 7.63 percent and others 14.34 percent of the total households. This study found that Chettri as the dominant caste group in the Katti sub watershed area occupying 38.81 percent, the majority is in Lakuri VDC and Dalit occupied the second position as compared to caste and ethnicity of study area where Katti containing high majority among other VDCs.

Figure 2.22: Caste &Ethinic composition map of Katti sub watershed

Table 2.23: Ethnic composition by VDC in Katti sub watershed

VDC Name	Chettri	Brahamin	Aadivashi Janajati	Dalit	Other
Badabhairab	1575	0	0	1170	250
Belpata	1010	109	827	664	111
Bindyabasini	892	157	309	1052	535
Jaganath	1302	244	0	858	399
Katti	1606	356	367	1602	1322
Lakuri	1786	72	708	1094	180
Mehaltoili	1166	487	0	779	154
Paganath	1687	209	18	727	56
Rum	629	166	0	730	919
Dandaparajul	1308	750	1136	1052	863
Total Population	**12961**	**2550**	**3365**	**9728**	**4789**
%	**38.81**	**7.63**	**10.07**	**29.13**	**14.34**

2.2.6. LITERACY RATE BY VDCs

Education plays crucial role in person's understanding. An educated person is more motivated to social development activities rather than illiterates. That's why; literacy is also taken as changing agent for every society.

According to CBS 2011, the literacy rate of the population 5 years and above in the study area is almost 100 percent including informal education and not stated. The literacy rate of females is almost 46.24 percent while that of males is 53.76 percent amongst their respective population groups of male are literate. Only 0.21 percent of people with post graduate with less in female. Female leads in beginning and while male lead in other educational level. The people from Katti and Lakuri VDCs are more literate than remaining VDCs. The data shows that there is more percentage of male literate as compare to female, though there is existence of country's only one governmental college in the district.

Table 2.24: Literacy rate by VDC in Katti sub watershed

Name of VDCs	Sex	Beg.	Prim.	Lower Sec.	Sec.	SLC	10+2	Grad.	Post Grad.	Others	Non Formal	Not Stated
Bada bhairab	M	39	443	200	90	41	40	17	4	2	7	0
	F	35	439	196	48	17	26	8	3	1	27	0
Belpata	M	16	348	262	175	122	46	11	3	1	3	0
	F	7	367	240	131	72	34	6	0	0	24	0
Bindya basini	M	51	415	214	104	49	26	4	2	0	72	5
	F	51	392	203	92	37	22	4	0	0	72	5
Jaganath	M	53	421	185	105	75	30	7	3	1	5	3
	F	42	413	140	63	50	20	1	0	0	20	8
Katti	M	44	749	401	157	57	64	8	2	6	5	0
	F	45	680	265	97	56	39	1	0	3	52	0
Lakuri	M	78	538	356	136	158	66	13	8	0	20	1
	F	45	475	231	91	90	44	2	0	0	34	4
Mehaltoili	M	3	362	157	60	58	26	11	1	0	13	2
	F	4	378	108	39	33	9	2	1	0	13	0
Paganath	M	20	359	173	106	102	51	13	8	3	12	4
	F	17	354	152	80	76	32	2	0	2	15	4
Rum	M	24	398	164	63	40	25	4	1	2	17	4
	F	28	339	143	44	44	19	2	0	3	28	4
Danda parajul	M	43	788	334	252	126	80	27	5	1	50	15
	F	32	693	366	201	102	48	4	1	0	77	25
Total		**677**	**9351**	**4490**	**2134**	**1405**	**747**	**147**	**42**	**25**	**566**	**84**
%		**3.44**	**47.54**	**22.83**	**10.85**	**7.14**	**3.80**	**0.75**	**0.21**	**0.13**	**2.88**	**0.43**

2.2.7. HOUSEHOLD HAVING LAND, LIVESTOCK AND POULTRY

Around 28.75% of Dailekh's land (43121 ha) is arable. Out of which, 34479 ha (80% of the total cultivable land) is cultivated in the district, which includes 3781 ha (25.30%) lowlands (khet) and 25766 ha (74.69%) bari land. Out of the total cultivated land, 8825 ha (25.58% of the total cultivated land) is irrigated in the district.

Regarding Irrigation, 8825 Ha (25.58 % of total cultivated land) land is irrigated in the district, out of which, 2118 ha (25.58 % of total cultivated land) is irrigated throughout the year and 6707 ha (19.44 % of total cultivated land) is seasonally irrigated in Dailekh district.

The main crops are rice, maize, wheat, millet, and potato. Livestock constitutes an integral part of the agriculture system and the majority of agricultural households keep cattle and goats, and buffalos are also common. According to the record of DDC Dailekh, out of the total 34497 ha cultivated land, 6% land is irrigated throughout the year, 21% is seasonally irrigated and the rest 73% is un-irrigated land. (District Profile 2069, Dailekh)

Livestock and Poultry

The livestock is the integral part of farming system of Nepal. Almost all kind of domesticated animals are raised in Nepal. Depending on elevation, livestock type and concentration varies from region to region. The livestock raised in the study area are of different types and species viz.

cattle, buffalo, goat, sheep, pig and poultry. The livestock population is highest for cattle among the large animals whereas goats and sheep ranked number 1 and 2 among the animals raised for meat purpose.

When asked to the key informants about the preference of livestock that the goat ranked first with the reasons viz easy to rearing, high income generation, easily sale in the market, buffalo ranked second due to giving milk, yoghurt and ghee, saleable in the market, providing meat and manure as fertilizer for the crops. However, they reported that the buffalo is difficult to care and management for the smallholder farmers. The chicken ranked third because of fast income earning and easy to rearing whereas local cow ranked last due to low income and labor intensive for rearing compared to income point of view. Livestock is regarded as instrument for food security and livelihoods for the rural resource poor farmers.

Table 2.25: Preference ranking of livestock enterprises for household food security

Options	Goat	Buffalo	Local cow	Chicken	Total score	Rank
Goat	X	Goat	Goat	Goat	3	**I**
Buffalo	X	X	Buffalo	Buffalo	2	**II**
Local cow	X	X	X	Chicken	0	**IV**
Chicken	X	X	X	X	1	**III**

Source: Key Informant Interview 2017

2.2.8. ECONOMICALLY ACTIVE POPULATION BY VDC

The economic activity ratio is defined as the ratio of the usually economically active population to the total population and is usually computed with reference to a given sex/age group or some other criteria. In Katti sub watershed, the population census is the main source of information on the economically active population. In the 2011 census the economically active population was defined as those persons who had worked or who had sought employment for a total of at least six months (at a single stretch or at intervals) during the 12 months' period immediately preceding the census enumeration. The definition includes subsistence farmers and the self-employed and also included those persons who had worked in extended economic activities. The economic activity rate is expressed in the census as the percentage of economically active persons aged 15 years and up to 59 years.

Figure 2.23: Economically active population map of Katti sub watershed

There are 50.72 % economically active populations in study area which include 45.08 % males and 54.92% females (CBS, 2011). Females are economically active than male since the economy is highly dependent on agriculture together with livestock which is also the prime occupation and source of employment and income for a large majority of the people in the study area. Almost all people of the population of the study area depend on agriculture (farming, livestock raising,

poultry, dairy sale, agriculture labor etc.) for their livelihood. Besides, the other occupations of the people include labor, daily wages, hotels, service, administrative service etc. Elderly population of above 59 years' age also contribute to household works including the income generating activities either in farm or business activities or through pension.

Table 2.26: Economically active populations according to VDC in Katti sub watershed

S.N	VDCs Name	Male	Female	Total Economic Active Population (15-59 yrs)	%
1	Badabhairab	661	812	1473	8.70
2	Belpata	698	846	1544	9.12
3	Bindyabasini	607	865	1472	8.69
4	Jaganath	634	728	1362	8.04
5	Katti	1146	1333	2479	14.64
6	Lakuri	1016	1119	2135	12.61
7	Mehaltoili	557	646	1203	7.10
8	Paganath	632	756	1388	8.20
9	Rum	519	670	1189	7.02
10	Dandaparajul	1165	1527	2692	15.89
	Total	**5938**	**8977**	**16937**	
	Percentage	**45.08%**	**54.92%**	**(50.72% from Total Population of Study area i.e. Total pop. is 33393)**	

2.2.9. AVERAGE PER CAPITAL INCOME BY VDC

Household income and expenditure are usually considered as key determinants of households' economic well-being but the degree of well-being differs in different locations based on the value of money in a given place and its purchasing power. The detail per capita income of studied vdc will be analyzed after doing detail household survey work.

2.2.10. EDUCATIONAL INSTITUTIONS BY VDC

In 2011/12 there were 536 formal education institutions in Dailekh, 40 of these private. The government has policy to provide scholarships of nrs 400 to each Dalit and each girl student annually. There are no publicly funded higher education institutions in Dailekh, but three privately operated campuses affiliated with Tribhuvan University offer Bachelors courses of study in education and training program run by Ministry of education, which targets young holders of school leaving certificate from disadvantaged communities, four women and one man from Dailekh were selected for assistance for further study and obtaining Technical school leaving certificates. (*District Profile, Dailekh*).

Figure 2.24: Educational institutional map of Katti sub watershed

In Katti sub watershed area, primary education institutions are regarded as the center of education. In the study area, there has been enough number of primary and secondary schools in the walking distance of 30 min to 1 hour. Almost all school going children have access to primary education due to free education services from the government. The table below shows that, within the Katti sub watershed there are altogether 58 education institutions providing education to the students, among them there are 38 primary school, 9 secondary school and 11 higher secondary school. The highest number of primary school is in Paganath contains 6 nos. followed by Katti and Lakuri contains 5 nos. Paganath, Jaganath contains highest no of higher secondary level.

Table 2.27: Educational institution according to VDC in Katti sub watershed area

S.N.	VDC	School Type	No. of School
1	Badabhairab	Primary	3
		Higher Secondary	1
2	Belpata	Primary	5
		Higher Secondary	1
3	Dandaparajul	Primary	3
		Secondary	2
		Higher Secondary	1
4	Jaganath	Primary	3
		Secondary	1
		Higher Secondary	2
5	Katti	Primary	5
		Secondary	3
		Higher Secondary	1
6	Lankuri	Primary	5
		Secondary	1
		Higher Secondary	1
7	Mehaltoli	Primary	3
		Secondary	1
		Higher Secondary	1
8	Paganath	Primary	6
		Secondary	0
		Higher Secondary	2
9	Ruma	Primary	4
		Secondary	1
		Higher Secondary	1
10	Bindhyabasini	Primary	1
Total			**58**

2.2.11. TYPES OF ENERGY USED FOR COOKING

The census survey 2011 reveals that the majority of the households (98.5 percent) use firewood as cooking fuel in the study area, followed by LP gas (31 households). A small portion of the total VDCs uses Bio gas, Santhi guitha, Kerosene and electricity for cooking. This indicates that majority of the households use traditional fuel-wood for cooking showing need to create awareness among people on the importance of forest.

Table 2.28: Energy used for cooking according to VDC in Katti sub watershed area

S.N	Name of VDC	Firewood	Kerosene	LP Gas	Santhi guitha	Bio gas	Electricity	Others	Not Stated
1	Badabhairab	517	0	0	1	1	0	0	0
2	Belpata	543	2	21	0	0	0	0	4
3	Bindhyabasini	573	1	0	0	0	0	0	3
4	Dandaparajul	991	1	1	1	0	0	0	7
5	Jaganath	500	0	0	1	0	0	0	3
6	Katti	903	1	9	0	1	0	0	5
7	Lakuri	697	0	0	2	4	0	0	4
8	Mehaltoli	457	0	0	0	0	0	0	2
9	Pagnath	488	1	0	10	2	1	0	3
10	Rum	450	0	0	3	0	0	0	0
Total		**6119**	**6**	**31**	**18**	**8**	**1**	**0**	**31**
%		**98.50%**							

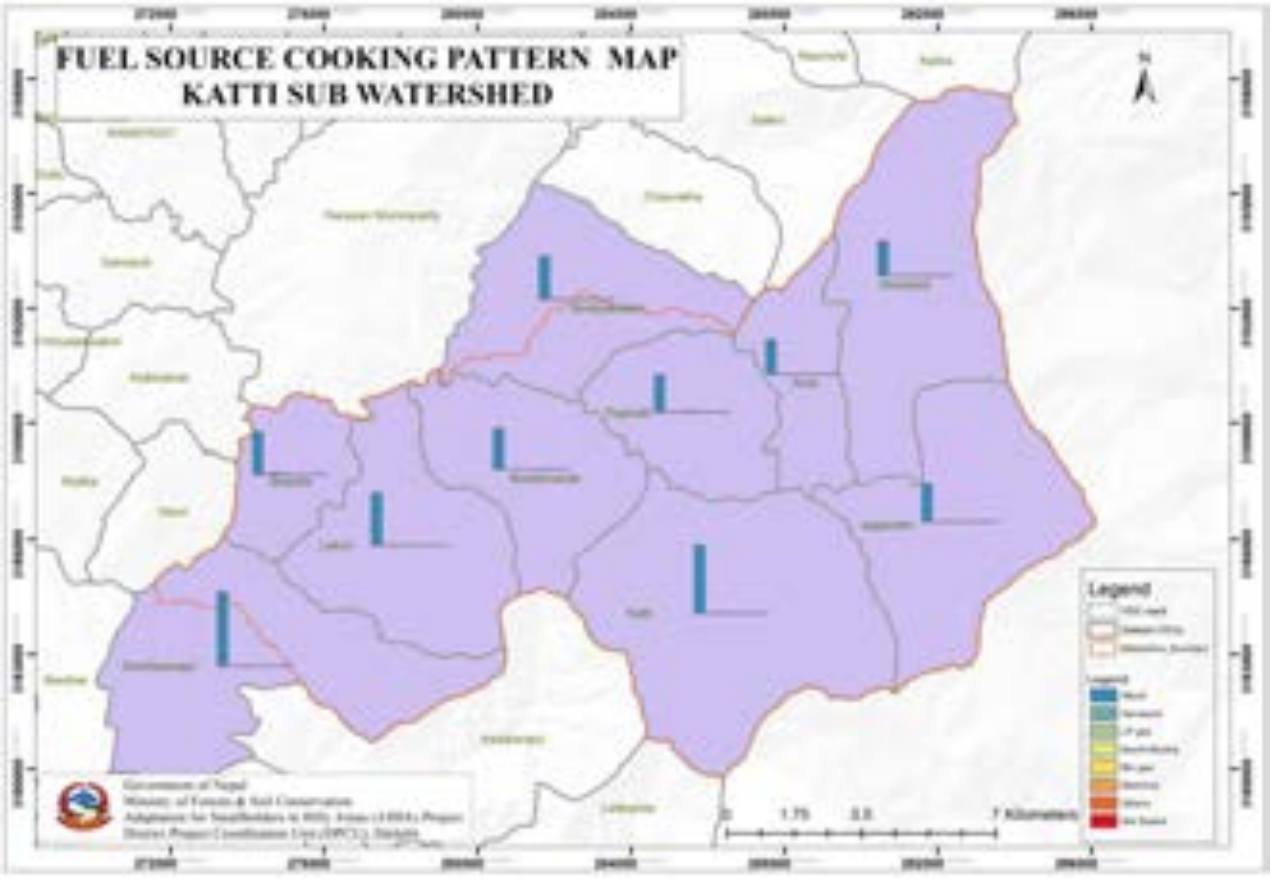

Figure 2.25: Fuel source cooking pattern map according to VDC in Katti sub watershed area

CHAPTER - 3

DRIVERS OF SUB-WATERSHED DEGRADATION

The discussions were arranged within 5 vdcs of sub watershed area, to identify and prioritize the drivers using key informant tools and techniques. Checklists were used to make the meetings efficient and objective oriented. Micro level information was collected from key informant interviews and other participatory rapid appraisal techniques were used to collect data and information. Selected areas were visited to observe and understand different dimension of sub watershed degradation and efforts being made to address the problems. From the study, the drivers were categorized into five different sections as Deforestation and forest degradation (D&D), Landslide, Soil erosion, Forest fire and Land overuse.

3.1. DIRECT DRIVERS

Direct drivers are human activities that originate from human choice of land use, which directly impacts upon sub watershed.

3.1.1. DEFORESTATION AND DEGRADATION (D&D)

The proximate drivers of D&D in Katti sub watershed namely fuel wood consumption, encroachment, illegal logging, road construction, forest fire and overgrazing were priorities.

i. Fuel wood consumption:

Extraction of forest products to meet high demands of daily fuel is one of the major causes of deforestation and degradation in most parts of the Katti sub watershed. Approximately 98.5 % households in Katti sub watershed used fuel wood for cooking and other purposes (CBS 2011). In general, an improved household economic situation in Katti areas leads to an increased pressure on forests, as there are more livestock (so more demand for grazing) and there is more demand for fuel wood. Also excessive use of timber for construction of houses and cowsheds are some of the major drivers of forest degradation. However, several factors associated with socio-economic development also drive an increase in fuel wood consumption per household: falling household size; increased educational level; increases in off-farm employment and improved road connectivity.

ii. Encroachment for Agriculture:

Expansion of cultivation in forest areas to meet increase demands of agricultural land is also one of the major drivers of deforestation in Katti sub watershed area. High reliance of households on agriculture due to very limited alternative livelihood options and the ever increasing demand for food due to population growth are the cause behind the expansions. In most cases, the expansion is spontaneous by small farmers, usually driven by supporting social and/or economic factors such as scarce land resources in other localities. The expansion of agriculture in forestland has been slowly into government managed forests where there is poor monitoring and enforcement of forest law by district forestry staff. In community forests, encroachment for agriculture is minimal due to effective monitoring of the forests by local groups. Any expansion is limited to minor shifting of farmland boundaries into adjoining forestland at some locations. The

encroachment area was mostly observed on upstream portion of 2, 4, 5, 6, 7 wards of Lakuri vdc; 2, 3, 4, 5, 9 wards of Badabhairab vdc; 1, 2, 4, 5, 8, 9 wards of Katti vdc; 1, 2, 5, 7, 9 wards of Paganath vdc and 3, 4, 6, 9 wards of Rum vdc. In some areas of Katti sub watershed more and more cultivated areas were found to be abandoned and left unplanted in recent years for forest regeneration.

iii. Illegal logging:

Illegal logging was identified as the most important driver of D&D in Katti sub watershed. It exists unauthorized logging to construct public buildings (e.g. Schools, health posts); unauthorized felling from road construction sites etc. Unemployment and high demand for fuel wood has motivated many people for illegal collection of firewood for sale. Piles of freshly cut firewood for sale are a common scene along many roads, including settlement located near recently-opened mid-highway rough road at Bestada. This problem is particularly severe along the road side. Illegal tree felling is generally carried out either by local residents or by illegally organized groups, beyond the eyes of forest authorities or community forest user groups.

iv. Road construction:

Development of the road network has been a priority development objective in recent years, particularly at local levels. Road construction, particularly along forest tracts in the sloped hills of Katti sub watershed has been one of the key drivers of D&D through three pathways. First, unplanned and unregulated construction of rural roads by village development committees and district development committees generally takes place in environmentally fragile lands such as near river banks or along steep and fragile hills. This causes massive earthworks, landslides and soil erosions-all forms of degradation. Second, roads often go through forestland due to the resistance of private landowners to provide alternative land for roads. Development agencies prefer to construct roads through forestlands as they get the land free and can also avoid diverse types of local disputes. Third, most of the roads are constructed with minimum consideration of environmental concerns during construction and management. The construction of roads can permanently change the land use type and can results in the local biophysical environment becoming prone to erosion and landslides.

v. Forest fire:

Uncontrolled forest fire is an important driver of forest degradation in Katti sub watershed. Recurrent forest fires severely damage and prohibit regeneration and growth of seedlings, destroy non-timber forest products and in some cases, encourage invasive species. Although quantitative information is not available from MODIS database, forest fires are definitely degrading biodiversity, enhancing soil erosion and inducing floods and landslides due to the destruction of the natural vegetation in Katti sub watershed. According to field discussion the effect of fire was mostly observed on upstream portion of 2, 4, 5, 6, 7 wards of Lakuri vdc; 2, 3, 4, 5, 9 wards of Badabhairab vdc; 1, 2, 4, 5, 8, 9 wards of Katti vdc; 1, 2, 5, 7, 9 wards of Paganath vdc and 3, 4, 6, 9 wards of Rum vdc. Deliberate forest fire is frequently used as a method to clear land for agriculture or promote new growth of grass for grazing. Although the incidence of forest fires is decreasing in the Katti sub watershed due mainly to community forest.

vi. Overgrazing:

Unregulated grazing in forests by small farmers in Katti sub watershed is a widespread practice which negatively affects regenerating and growth of seedling and ultimately causes forest degradation. Overgrazing by livestock is one of the factors of the exploitation of the ecosystems, although livestock education is an essential component of the rural farming system and a source of annual farm income. Grazing in the forest by livestock is heavy and goes on all year round. Although some farmers have private fodder trees and private forest land, these are rarely sufficient to meet the year-round food requirements of their livestock.

3.1.2. LANDSLIDE

Landslide is a general term describing a mass of material that has slipped downhill under the influence of gravity. It causes damage to lives and settlements, development infrastructures, agricultural fields and forests they occur because of complex forces in conjunction with the slope morphology, hydrology and geotechnical parameters of the material. The proximate drivers of landslide in Katti sub watershed are as follows;

i. Slope Steepness:

The analysis shows that the high slope angle has strongly influence on the slope failure processes. The geological structure and the low grade metamorphic rocks found in the Katti sub watershed have tremendous effect on the stability of terrain. The situation is going worse due to the construction of non-engineered canal and road along the slope and most of the places have water percolation. The percolated water has positive role on the instability of the area. Generally, in Katti sub watershed, slope gradients between 30 and 40 degrees are most critical for failure. The landslide caused due to steep terrain and changes in slope due to river cutting of the toe of a slope, or bank scouring by debris flows, excavation for road, cultivation or removal of material from the slope were found in Katti sub watershed.

ii. Deforestation:

Deforestation is another factor which causes natural disasters like landslides. This is due to the fact that there is no forest trees left to hold the soil after deforestation. As a result, shear strength decreases and landslides are more prone to occur. The root cause of the landslide in the Katti sub watershed is mainly due to leveling to land on the hill for cultivation and displacing of trees. Meanwhile, afforestation provides stability to slope through which mass movement of rocks, debris could not occur. As the tree root provides some reinforcement and also remove groundwater. On Katti sub watershed areas vegetation can stabilize steep slopes and if the cutting of trees continues it would result in a drastic change in the environment.

iii. Heavy rainfall

The rainfall is another factor during the monsoon season which effects on the groundwater condition leading the instability in Katt sub watershed. Rain water penetrates joints and produce hydrostatic stress in rock. It increases the pore water pressure on soils and consequently, decreases the shear resistance, which causes a huge landslide. Most of the areas in Katti sub watershed were suffered from this problem this may due to the influence depends upon climatic

conditions, topography of the area, geological characteristics of the slope, porosity and permeability of rocks and soils.

iv. Infrastructure:

Another major contribution for the instability is the road alignment and in fracture development. Erosion and landslides occur in the edges of road due to: (i) the use of heavy equipment such as bulldozers and excavators; (ii) Lack of drainage arrangements; (iii) Steep gradients; and (iv) Lack of protection structures and maintenance arrangements. The road that construct by the local people is leading role on the stability because of the poor attention on the crack zones, sign of instability due to road construction and the improper management of the drain along the road. As a result, there is huge accumulation of ground water on the mountain base. Similarly, all the surrounded mountains of the selected area consist of large scale landslides and their toe is now extensively disturbed from so called low cost road. As a result, landslide risk is in very alarming situation and whole slope around the selected villages are noticed on high hazard zone.

v. Land overused:

Land use adjustment is also one of the factors of landslide. In Katti sub-watershed area, land adjustment was delineated based on degree of slope ranging above 20 degrees for overused by agriculture according to LRMP land suitability class, which suggests suitability for forest. Since, evaluation and slope gradient profoundly affect the distribution of soil types and their utilization. Upper limits of arable agriculture, forest zones, possible cropping patterns and soil temperatures are intimately tied to elevation. Soil depth and slope stability are closely related to slope gradient. 20-30 degrees was empirically derived as the upper limit of successful terrace cultivation but most of the area was covered by agriculture. To address the issue agroforestry methodology may be one of the alternative solutions. Since, agroforestry can contribute to human nutrition through increased production and availability of particularly nutritious fruits and leaves improving livelihood support in lessening rural poverty along with degraded hill environmental restoration on study area.

3.1.3. SOIL EROSION

i. Hill slope agriculture:

Slope gradient as a topography factor also plays an important role on impacting soil erosion intensity. There is a great relationship between slope gradient and soil erosion in Katti sub watershed area. Degradation due to soil erosion is and old threat which has turned into a major agricultural and environmental problem in Katti sub watershed areas. Erosion rates accelerated by unsuitable land use and management affects soil fertility and productivity by reducing the water infiltration, water holding capacity, organic matter, nutrients and organic biota in study area.

ii. Heavy rainfall:

The rainfall is another factor during the monsoon season which effects on the groundwater condition leading the instability in Katt sub watershed. The combined effect of geologically unstable, steep and rugged mountain topography and intense monsoon rainfall make the study area prone to high soil erosion rates.

iii. Physiographic factors:

The study area is situated to the north of Mahabharata range and has sloppy hills with sub-tropical, warm temperate and temperate types of climate. Due to steep slope and intense monsoon rainfall, soil erosion mainly by water is the major land degradation process prevalent in Katti sub watershed.

iv. Forest dependency:

Excessive extraction of forest products to meet persistently high demands for fuel, construction timber, fodder and other forest product is a major cause of deforestation which causes soil erosion in Katti sub watershed area.

v. Forest fire:

Uncontrolled forest fire is an important driver of forest degradation throughout the landscape, particularly in the Katti sub watershed area. Recurrent forest fires severely damage and prohibit regeneration and growth of seedlings, destroy non-timber forest products and, in some cases, encourage invasive species. Although quantitative information is not available, forest fires are definitely degrading biodiversity, enhancing soil erosion and inducing floods and landslides due to the destruction of the natural vegetation.

3.1.4. FOREST FIRE

i. Human negligence:

In Katti sub watershed, farmers use fire as a tool for burning agricultural residues-straw, stalks, husks etc. to prepare their farms for the next crop cultivation. Fires are thus likely to spread from farm to forest. Other major causes are firewood collectors sometimes throw burning butts into the jungle. These butts can catch fire on dried leaves and twigs during drought season which is one of the important driving cause of watershed degradation. Nowadays, community forest user's groups' works as mobile forest guards, locally known as *ghumtipalee*. If fires break out, they report to the respective committees.

ii. Drought:

Drought is also one of the major driving factors for forest fire in Katti sub watershed area, where most of the fires were seen in hot and dry season. Fire requires fuel and heat. A draught dries up most material wherever it happens. For example: when the smaller branches of trees dry up, they provide wonderful material to start fires. Unextinguished cigarette butts and matchsticks are the cause of accidental forest fire in the study area where the fire will spread very quickly as it burns up the dried wood and leaves and it will have nothing to stop it.

iii. Geographic Condition:

Geographic condition is also one of the major driving factors for forest fire in Katti sub watershed areas. The Katti regions mostly have lower temperate forests. These are mainly brodleaved forests with *Pinus roxburghii* up to 2000m and *Pinus wallichiana* at the higher elevation. Usually the pine forests and pine plantations, which are more susceptible to forests, which grow in the main habitat zone between 1000 to 2000 m, have become greatly fragmented in the study area.

Here, the vegetation along the southern dried slopes is burned during the dry season starting in March.

3.1.5. LAND OVERUSED

i. High agriculture dependency:

High agriculture dependency is one of the driving factors of sub watershed degradation in Katti sub watershed. Agriculture in study area has long been based on existence farming, where farmers derive their living from fragmented plots of land cultivated in difficult conditions. It has been the highest priority in Katti sub watershed area because economic growth was dependent on increasing the productivity of existing crops. Increased agricultural activity has placed tremendous stress on the fragile ecosystems of the study area, with severe deforestation leading to erosion and flooding that threatens the livelihoods of farmers.

ii. Population growth:

The population increased by 7500 nos in between 20 years of interval (CBS 1991-2011) in Katti sub watershed area with grown rate of 1.35% is also one of the main causes of sub watershed degradation. Since, number of people dependent on agriculture is rising and this growth has resulted in an increased demand for food, fibre, water and other consumables and essential services. It is not surprising that both population density and growth are highest in the study area which has experienced the highest deforestation rates since, the growing population and its changing consumption behavior have led to an increased pressure on forestland and forest products causes land degradation.

iii. Shifting cultivation:

Shifting cultivation has been under a lot of attack based on the principle that it degrades soil fertility and general fertility of forestlands in Katti sub watershed areas. It can easily lead to deforestation because when soil fertility is exhausted, farmers move on and clear another small area of the forest. The study shows that traditional land practices exacerbated by poverty and associated with a lack of technical knowledge is the main cause of the continuation of unsuitable shifting cultivation. Population pressure, inadequate land for cultivation, low education levels, policy planning and implementation without local participation are all factors the influences farmers' decision in Katti sub watershed areas to continue shifting cultivation. Although, intensive land management through agroforestry is a promising alternative that can sustainably manage the remaining forest resources. If adopted, such systems potentially provide good economic returns and may significantly reduce poverty of study area.

3.2. UNDERLYING CAUSES

Underlying causes of sub watershed degradation are structural in nature. These can be seen as a complex of social, political, economic, technological and cultural variables that constitute initial conditions in the human environmental relations.

3.2.1. DEFORESTATION AND DEGRADATION (D&D)

i. Population growth:

The population growth, along with changing density and distribution patterns of the population are believed to have driven for deforestation and degradation in the Katti sub watershed. It is widely believed that population can affect deforestation in different ways, including changes in the number of rural families seeking land to cultivate, fuel wood or timber; and demand for agricultural and forest products. The population increased by 7500 nos in between 20 years of interval (CBS 1991-2011) in Katti sub watershed area with grown rate of 1.35% is also one of the main causes of deforestation and degradation of forest area. Since, number of people dependent on agriculture is rising and this growth has resulted in an increased demand for food, fibre, water and other consumables and essential services. The growing population and its changing consumption behavior have led to an increased pressure on forestland and forest products.

ii. Increased demand for forest land and products:

In many places of Katti sub watershed pressure on forests has substantially increased due to increased demand for forestland and timber for infrastructure development. Remittance based economic growth in recent years is creating more and more demand for construction timber to build new houses and furniture, particularly along the roadsides. The drive to economic development coupled with weak enforcement of forest law has led to unplanned and unregulated construction of infrastructure inside forestland throughout the Katti sub watershed. While unplanned and unregulated construction of rural road is a common scene in the study area, construction of schools, buildings, water storage tanks inside forest boundaries in the study area.

iii. High dependency on forests:

Land is the primary source of livelihoods and over 76% of households are engaged in agricultural activities (CBS 2011). Access to productive land is therefore a key factor affecting the economic status of these households. However, access to agricultural land has been gradually decreasing. In such a situation, those close to the forests tend to rely on forest land for the vegetables, roots, leaves, herbs and fuel wood among others. Unsustainable extraction, such as intensive harvesting of reproductive tissues (flowers, seed, fruit, repeated visits and inappropriate harvesting methods) have caused degradation of non-timber forest products (including high value medicinal and aromatic plants) in many areas of Katti sub watershed.

iv. Weak law enforcement:

Weak law enforcement is one of the key challenges to addressing D&D. This is firstly due to capacity issues: The Department of Forest (DoF) and its local offices do not have adequate number of staff, transport equipment, access to information, and other technology. They do not

have instruments neither numbers to monitor, detect and stop overharvesting, or otherwise unauthorized extraction of forest products, such as illegal logging, poaching and other criminal activities. Second, structural issues, including low staff morale, short tenure, limited incentives (for example a lack of performance evaluation and rewards) to take risks in fighting criminals have also weakened law enforcement.

v. Limited access to improved technology:

Lack of scientific forest management is a major reason behind low productivity of forests, which has caused an imbalance in the supply of products and less than optimal income from the forest sector. It is widely regarded that the introduction of sustainable forest management principles would lead to a substantial increase in the supply of timber, fuel wood and other forest products – and in turn this would significantly reduce illegal and unsustainable harvesting. Along with, most rural households still use inefficient conventional methods of using wood fuel as they have no access to technologies that enhance wood fuel efficiency. Unfortunately, developing and distributing forestry technologies has actually never been a priority of the government, as showed by the fact that the investment in forestry research is negligible as compared to other sectors.

3.2.2. LANDSLIDE

i. Hill Slope Agriculture:

Degradation and landslide has become increasingly widespread in recent decades in Katti sub watershed area. The traditional farming system and cultivation on steep slopes have further accelerated soil erosion, landslide and degradation. Agricultural productivity, especially in the hills, is declining due to continuing erosion of top soil. Realizing an urgent need to develop and adopt soil-conserving farming technologies for sustainable land management and agricultural productivity in the study area.

In this context, there is a need for appropriate agricultural practices, such as the Sloping Agricultural Land Technology (SALT) that is cost effective and simple option to increase productivity in the area. SALT is a package of technologies for soil conservation, crop cultivation and sustainable food production that includes hedge row contour planting, allay cropping and terrace improvement through formation of bunds and contour planting among others.

ii. Forest dependency:

About 98.5 % (CBS 2011) household of Katti sub watershed highly dependent on forest for fuel wood, litter and grass for livestock which causes forest degradation, dropping forest area is one of the underlying causes of landslide.

iii. Fragile physiographic:

The geo-dynamically active middle mountain range is highly susceptible to mass wasting phenomena, particularly landslides which are generally recognized as important agents of mass wasting and hill slope evolution in Katti sub watershed area. Causes of landslides in the study area are attributable to natural drivers such as the great relief, steep slopes and erosion due to high intensity monsoonal rains. An anthropogenic impact associated with increased occupation of steeper terrain serves only to increase the landslide hazard in the study area.

iv. Rural road expansion:

Access to rural infrastructure has an important bearing on the types of land uses and livelihood strategies that communities and households are able to pursue. Better road access to markets, for example, enhances opportunities for high-value agriculture, including production of more fresh products. It can also enhance opportunities for off-farm employment and for engaging in own non-farm businesses. On the other hand, construction of new roads in environmentally fragile areas can be destructive since they may attract new settlement and increase the effectiveness of less sustainable land uses. Similarly, the non-engineered road constructed on Katti sub watershed with minimum consideration of environmental concerns during construction and management were getting problem of landslide. Road construction at Katti sub watershed involved cutting slopes and removing soil from hillsides. Trees are removed for broad right of ways, even when there is no soil excavation. The removal of soil and trees resulted in a significant reduction in lateral support and landslide occurred. Road at mid slope and at the base of the hill constitute the highest landslide risk due to subsurface water interception and overloading and under cutting slopes. The non-engineered road construction is permanently changing land use type of the study area and becoming prone to erosion and landslides.

v. Population growth:

The growing population and its changing consumption behavior have led to an increased pressure on agriculture and forest land which is one of the important underlying causes of landslide.

3.2.3. SOIL EROSION

i. Steep Slope:

The analysis shows that the high slope angle has strongly influence on the slope failure processes. The geological structure and the low grade metamorphic rocks found in the Katti sub watershed have tremendous effect on the stability of terrain which causes soil erosion.

ii. Fragile geomorphic:

Erosion is a complex phenomenon resulting from numerous interacting factors, as topography, climate, land cover and human activity, and is one of the most significant forms of land degradation. The Katti sub watershed area are particularly prone to erosion, since they are characterized by complex and fragile geo-morpho-pedological systems, where heavy rain intensity and high relief energy determine slope instability, land degradation and soil loss.

iii. Vegetation:

Loss of vegetation is one of the important factors of soil erosion in Katti sub watershed; vegetation plays a vital role in slope stability and the soil erosion process. Rainfall erosivity increases during the monsoon, as does the ability of vegetation to protect the topsoil, consequently reducing the surface erosion rate as the monsoon progresses in the study area. However, mass wasting probability increases during the monsoon because the subsoil becomes saturated with moisture. Generally, the vegetation cover increases the shear strength of the soil with its root network and protects the slope from erosion. The roots of the trees maintain the

stability of slopes through their mechanical and biological effects and help to dry the slopes by absorbing some of the ground water.

3.2.4. FOREST FIRE

i. Gap in awareness program:

In Katti sub watershed area forest fire is considered to be one of the major underlying causes of watershed degradation. Lack of training, awareness program and institutional arrangements to implement fire protection policies & safety codes to mitigate the fire issues is also important cause of forest fire. Some community forest groups have given firefighting tools but these tools are not optimal in which people are not using tools that they received this may be due lack of awareness and preparation.

ii. Less rainfall:

Due to low rainfall and increase in temperatures brought on by climate change are expected to increase the amount of moisture that evaporates from land and water, which will also cause rainfall patterns to shift. In many areas of study area, these change leads to more frequent and severe droughts, which occur when an area receives less water than usual. Hot temperatures and dry conditions also increased the forest fire in Katti sub watershed area.

iii. Climate change:

Climate change can affect different aspects of forest conditions, including health and vitality, coverage and biodiversity. These effects can vary across space depending upon geographic area, original climatic conditions, species diversity and human activities (FAO, 2012).

An analysis of changes in climatic patterns in the Dailekh over the last three decades showed a continuous increase in the average annual temperature, with slight variations in the actual annual rate of increase across the three physiographic and eco-climatic regions. Perceptions of the key informant and local people consulted during field visit in Katti sub watershed concurred with the increasing trend in temperature in recent years. Along with changes in temperature, there were also changes in precipitation patterns. Increasingly longer dry periods due to delay in monsoon arrival and decreased rainfall in winter, changes in rainfall distribution, and decreasing snowfall at some locations were some of the main findings of the precipitation analysis, which might have links to climate change.

Although there is no concrete evidence, weather related extreme events such as excessive rainfall, longer drought period, landslides and floods, and forest fires may have links to climate change. Climate change is also believed to be responsible for extended drought periods that exacerbate the potential for severe forest fires. Whether and how climate change has effects on different forest ecosystems and species, and whether the effects have been variable across different elevations and aspects, need to be further explored.

iv. Aspect, slope gradient:

Forest fire is also governed by aspect, slope gradient in which the southern dried slopes is burned during dry season which starts from March in the study area. Due to high altitude and slope even small fire can badly damage the regeneration of preferred species inviting non-preferred species

to grow. The topography, remoteness and low population make it almost impossible to take necessary steps to controlling once the fire in noticed.

3.1.5. LAND OVER USE

i. Land scarcity:

Spiraling demand of land for agriculture and other non-forestry uses (such as development of infrastructure) coupled with disputes and uncertainty over land and forest tenure is an important root cause of forest loss and degradation. Shifting cultivation on steep hill the slope of the study area has not only contributed to deforestation but also induced soil erosion during the monsoon season which is the effect of land overuse.

ii. Pressure on forest:

Pressure on forest to fulfill basic needs as food, firewood and grazing will force to cause change the land use pattern in the study area, which cause of watershed degradation.

iii. Unscientific agriculture:

Lack of scientific forest management is a major reason behind low productivity of agriculture land, which caused an imbalance in the supply of products and less than optimal income from the agriculture sector in Katti sub watershed area. According to the majority of key vdc level stakeholders consulted during the course of this study, insufficient technical inputs, inadequate financial and material resources, inadequate trained human resources are the major cause of scientific agriculture in study area.

CHAPTER – 4

EFFORTS TO REDUCE SUB WATERSHED DEGRADATION

The large number of drivers, their underlying causes and their different combinations and sequences demand multiple strategies to reduce sub watershed degradation. The following section provides some potential lines of action for sub watershed interventions for consideration.

4.0.1. DEFORESTATION AND DEGRADATION (D&D)

i. Implementation of participatory forest management programs (Community forestry):

A total of 2600 ha of designated forest land of Katti sub watershed was being managed by community forest user groups (CFUGs). The community forestry program is believed to have greatly contributed towards controlling or reversing deforestation and degradation trends in the Katti sub watershed. Protection and development of forests, a ban on grazing and fire control are some of the specific activities implemented by CFUGs that have helped to control forest loss and degradation. Moreover, the program has led to strengthening natural resources governance, equitable sharing of benefits among the rural populations and to some extent, enhancement of local livelihoods.

ii. Awareness raising campaigns and trainings:

Many community forest user groups are implementing awareness campaigns against forest fire. The ministry of forests and soil conservation, department of forests and some district forest offices are using different media (television, radio) to raise awareness on forest fire, uncontrolled grazing, and afforestation. Several television channels and newspapers regularly broadcast or publish news related to forest conservation, including illegal logging, timber smuggling, and forest fires. Training on REDD awareness and forest fire control are important components of protected forest management.

iii. Law enforcement:

The government has introduced several policies and measures to reduce D&D in recent years. Many of them are aimed at strengthening law enforcement to check unauthorized extraction of forest products and the use of forestland for non-forestry purposes. Notable are the following: the banning of timber export; the regulation on the export of non-timber forest products (NTFPs); the discouraging of the conversion of forestland to other purposes; and the regular monitoring of forests being carried out as part of forest conservation activities. In spite of several limitations, forestry administration has been making efforts to control deforestation and degradation and conserve forest resources under its jurisdiction through enforcement of existing legislations.

iv. Alternative energy:

Promotion of improved cooking stoves, bioenergy, solar energy, hydropower development and rural electrification are integral components of conservation area management in Katti sub watershed area.

v. Afforestation and Reforestation:

Reforestation of deforested sites and enrichment plantation in degraded forest patches are regular activities implemented by most Community Forest User Groups (CFUGs).

4.0.2. LANDSLIDE

i. Poor terracing:

Terrace farming was part of the indigenous and cultural ways of adapting agriculture to the steep nature of land in Katti sub watershed area. Terracing creates flat spaces for crops and canals for water to flow between these areas. Water collected in the terraces can then be absorbed into the soil and sustain crops. Poor terracing increases saturation of the ground, this happens when terracing retains too much water, which absorbed into the ground. Unmaintained terraces can lead to mudslides, the creation of deep gulley's and increased soil erosion, particularly in sandy soils or on extremely steep terrains. Terracing also has been shown to reduce soil quality via the leaching of important nutrients from the soil in some areas of Katti sub watershed area. Poor management of the terrace, toe drain in combination with the steep slope gradient of terraced slopes and the high amount of generated runoff is important causes of erosion in study area. Good terracing is one of the important factors to reduce the velocity of water runoff and thereby soil erosion by breaking the length of the slope that runoff has available with sound structure.

ii. Land use improvement:

Techniques include conservation plantation, grass plantation, on-farm conservation, agro-forestry, safe water drainage, and runoff harvesting ponds or dams in the catchment.

iii. Impact assessment:

Most interestingly, majority of rural roads are constructed without any design and EIA/IEE in Katti sub watershed area, but there is no agency in the district to monitor and control effects of landslide on environment. The forestry institutions or the personnel who want to regulate or manage in a less destructive and environment friendly alternatives are often isolated and do not get appropriate support from the department or the ministry.

4.0.3. SOIL EROSION

i. Terracing:

Agricultural land in the Katti terrain which was previously managed through different runoff control and terracing measures using massive labor force is one of the important factors to reduce soil erosion. Good terracing is one of the important factors to reduce the velocity of water runoff and thereby soil erosion by breaking the length of the slope that runoff has available with sound structure.

4.0.4. FOREST FIRE

i. Community management interventions:

There is no organization for fighting forest fires in Dailekh district. The department of forest doesn't possess any special unit or team to deal with the problem of forest fire including firefighting or management.

In Dailekh about 315 local forest user groups have been formed with a total of 60,000 ha handed over to them as local community forests. The community forest users are able to protect their respective forests from cutting and grazing. However, occasional forest fires occur due to the negligence of smoking travelers. The forest users are able to fight forest fires although they do not have proper tools and technical support. In fact, community forests are not managed properly, nor are forest fires fought in an appropriate manner.

4.0.5. LAND OVERUSE

i. Local practices and knowledge:

Construction of good terracing done by ancestors is one of the important factors to reduce the velocity of water runoff and thereby soil erosion by breaking the length of the slope that runoff has available with sound structure in hilly area. But, poor management of the terrace, toe drain in combination with the steep slope gradient of terraced slopes and the high amount of generated runoff is important causes of erosion in Katti sub watershed area which is one of the important efforts reduce to degrade sub watershed.

CHAPTER – 5

CHALLENGES AND GAPS IN ADDRESSING THE DRIVERS OF SUB-WATERSHED DEGRADATION

5.0.1. DEFORESTATION AND DEGRADATION (D&D)

i. Insufficient human resources and technical capacity:

Most of the sectorial forest offices are currently understaffed, which has negative effects on forest conservation in Katti sub watershed. Insufficient human resources together with poor technical capacity and motivation of technical staff have posed a great challenge in controlling deforestation and implementing scientific forest management. Lack of fire-fighting equipment and training has been a major barrier for local communities as well as agencies in controlling forest fires in the study area.

ii. Inadequate capacity and preparedness of forest sector institutions:

The frequent changes in the government and the unstable leadership in many of the institutions has weakened legitimacy and undermined the authority of the state institutions. This has seriously undermined the capacity of the state institutions to enforce law and order, implement policies, monitor and impose certain incentives and disincentives. Low staff morale, expertise, confidence and commitment, combined with inadequate resources such as mobility, information, technology and equipment have also undermined the capacity of the forest authorities to enforce law and order. This is further worsened by weak coordination amongst concerned government agencies.

iii. Financial Constraints:

Inadequate budget in districts for day-to-day operations (including DSA for field staff, staff transportation etc.) has severely hampered efforts to contain illegal logging and forest encroachments in Katti sub watershed areas. Budgetary constraints in district forest offices have also negatively affected technical support to CFUGs. Lack of financial resources has been a bottleneck in expanding good forestry practices (e.g. successful leasehold forestry models) to wider areas of Katti sub watershed.

iv. Limited participation of women and other disadvantaged social groups:

Although there are some positive signs, the participation of women and other disadvantaged social groups in forest governance and management continues to be limited. Achieving effective participation of these groups is a challenge.

5.0.2. LANDSLIDE

i. Lack of holistic plan:

The government doesn't have any appropriate or authentic data on landsides of Katti sub watershed area that occurred during monsoons and sometimes even in during the winters. The study area is still vulnerable due to lack of comprehensive & holistic plan to mitigate the impacts of landslide hazard.

ii. Effectiveness of community forest users group in landslide:

The community forest users group (CFUG) is active towards controlling or reversing deforestation of forest degradation by protection and development of forests, a ban on grazing and fire control that have helped to control forest loss and degradation. The CFUG should be used in the sector of improvement by providing necessary trainings related to landslide with forest resources up upgrade their knowledge.

iii. Negligence of technical inputs in infrastructure development:

Rural transport infrastructure provides a basis for economic activities in rural areas. But uneven topography makes road construction difficult in rural hills. While developing infrastructure, great care should also be taken not to damage the natural environment. Some roads constructed by the communities through local bodies, without engineering inputs are causing a lot of problems in Katti sub watershed area, the poor attention on crack zones, poor gradient, sign of instability due to improper turning, improper management of the drain along the road and lack of protection structures to stop landslide etc.

5.0.3. SOIL EROSION

i. Lack of awareness on effect of soil erosion:

Soil erosion refers to the physical wearing down of the earth's surface and includes surface erosion and mass wasting. While surface erosion is the loss of top materials due to the action of water, mass wasting from a slope in Katti sub watershed area. Deforestation, overgrazing, steep slope, unmanaged land use and intensive agriculture, due to population pressure have caused accelerated soil erosion on study area. The challenges facing due to the degradation of sub watershed is lack of the adequate knowledge on importance of forest, agriculture, proper land use and its effect on soil erosion.

ii. Inadequate Plan:

There is no any proper plan to control soil erosion in Katti sub watershed. The local community uses several strategies to handle with soil erosion, but due to lack of proper technical knowledge they are still facing problem of soil erosion during monsoons.

iii. Access to concerned department:

Lack of access to address the issues related to concern government agencies is also one of the important challenges to address the driving factors of sub watershed of Katti sub watershed.

5.0.4. FOREST FIRE

i. Good governance:

Governance factors generally include rule of law, legal enforcement, equity and incentives quality of service delivery, transparency and accountability. Due to weak in maintaining the major characteristics of governance the forest fire is serious in Katti sub watershed area.

Although the government devotes considerable attention in parliamentary discussions and the politicians and bureaucrats highlight the importance of forest fire prevention and firefighting, fire events are soon forgotten after the monsoon starts in June. During the fire season, Nepal Radio and Nepal Television broadcast old clips on forest fire prevention and firefighting.

ii. Integrated plan:

Inadequate integrated plan of government to cope the adverse impact of drought is one of the challenges and gaps in drivers to forest fire.

iii. Awareness on management program:

The main causes of forest fires are anthropogenic due to negligence and occasionally by deliberate burning to induce succulent grass growth for domestic animals. Forest fires occur during the dry season from February to June and the nature (surface fire, crown fire, etc.) as well as the severity varies greatly depending upon fire weather, fuel conditions, and physiography.

Forest fire management is not practiced in Katti sub watershed. The community forest user groups control forest fires in their own forests, although they do not have a plan for systematic prevention and control of fires. Systematic arrangements for prevention, control, and management of forest fires can be instituted in Katti sub watershed area only when scientific forest management is implemented within the Department of Forests for state and community forests.

5.0.5. LAND OVERUSE

i. Non-existence of scientific land evaluation and land use planning system:

Each kind of land use has a set of conditions which are favorable or adverse to that use. A severe limitation to one kind of land use may be less serious or even beneficial to another use. Making appropriate decisions about use of land for different purposes requires scientific land evaluation and land use planning. Moreover, land use planning can help resolve disputes with regard to local and indigenous communities' tenure systems and land uses. In the absence of an established system of land evaluation and land use planning, most decisions related to management of forests and other natural resources in the landscape are ad-hoc.

ii. Counterproductive education: Agriculture is the hated occupation

The education system seems to be counterproductive for agricultural development in Nepal which has alienated the rural youth from agriculture. Agriculture has been perceived as lowest grade occupation as the youth mostly want to be dissociated from agriculture activities. Majority of the rural youth migrate to urban areas or abroad for a labor work even to work in a riskier environment. The government policy in agriculture development remains to be the major factor for alienation of the youth from agriculture.

CHAPTER – 6

STRATEGIES TO ADDRESS THE DRIVERS OF SUB-WATERSHED DEGRADATION

The large number of drivers, their underlying causes and their different combinations and sequences demand multiple strategies to reduce sub watershed degradation. However, the analysis in this report only considered only proximate drivers and some of their underlying causes.

6.0.1. DEFORESTATION AND DEGRADATION (D&D)

i. Reducing forest dependency:

Reducing dependency of households on forests for meeting their energy and timber demands should be an important strategy to reduce deforestation and degradation. This, among others, will involve: (i) development and promotion of nonconventional energy sources (such as biogas, solar energy, and hydropower); (ii) promotion of alternatives to construction timber (e.g. bamboo, steel, aluminum); (iii) promotion of agro forestry and private forestry where feasible, and (iv) improving access to technologies that enhance wood fuel efficiency (e.g. bio-briquettes, improved stoves).

ii. Sustainable management of forests:

A special focus on introducing sustainable forest management principles into all types of forests is required in order to substantially increase the supply of timber, fuel wood and other forests products through sustainable and legal channels. The sustainable management of forests, possibly under different tenure arrangements, can lead to extensive increases in the supply of timber and fuel wood. This can rapidly narrow the gap between the demand and supply, and so to discourage illegal logging and discourage the unauthorized collection of fuel wood. As the government has already piloted such practices, this can be scaled out and scaled up to benefit both government-managed and community-managed forests. Moreover, sustainable forest management can also help forest managers to reduce the risk of damage and possible losses from changing climatic conditions and also to undertake effective mitigation actions.

The management plans of community forests need to be developed or revised to balance protection with active forest management, which could be a strategic solution to increase the supply of fuel wood and other basic products from the community forests, and avoid a pressure shift to government-managed forests. Management plans need to be based on the principles of specific ecosystem management approaches to increase positive impacts on conservation outcomes and help meet biodiversity and climate change objectives along with community needs.

iii. Supporting community based conservation:

Experience shows that community based forest management programs have been relatively more successful in ensuring forest restoration and conservation. Further efforts should be made to ensure the rights of local and indigenous communities to protect and enhance their forest based

livelihoods. Some of the actions required include: (i) protecting the rights of local and indigenous communities with respect to wood and non-wood forest products (e.g. medicinal herbs), (ii) providing alternative energy; (iii) giving special care to the culture, skill and tradition of indigenous and ethnic people.

iv. Reclaiming and restoring encroached forestlands and controlling further encroachment:

There is an urgent need to address the chronic problem of forest area encroachment for non-forestry uses. This is a complex issue requiring a coordinated approach and efforts involving several strategic measures, including: (i) sensitizing local political leaders, DDCs, VDCs and other local level authorities to the issue; (ii) enhancing law enforcement capacity of district forest offices; (iii) fully and compulsorily implementing Environmental Impact Assessment (EIA)/Initial Environmental Examination (IEE) provisions for all infrastructure development projects that use forestland, and (iv) providing alternative land outside forest boundaries for new settlements.

v. Controlling forest fires:

Strategic options to control forest fires include: (i) increasing awareness and local participation in forest fire control and management; (ii) reviewing and strengthening legislative arrangements and enhancing their enforcement to discourage deliberate forest fires; (iii) replacing shifting cultivation practices by more suitable land use practices (iv) promoting stall feeding practice and discouraging free grazing in forests;(v) implementing sustainable forest management by also taking into consideration fire management in the context of changing climatic conditions and the need for undertaking effective mitigation measures; (vii) developing effective mechanisms for forest fire monitoring, early warning and control; (viii) providing training and necessary equipment to frontline forest fire fighters, and (ix) institutionalizing forest fire monitoring and control systems at different levels by involving all key stakeholders.

vi. Controlling overgrazing:

The strategic options, among others, include: (i) promoting fodder production in community-managed forests, waste lands and agricultural lands; (ii) developing or enhancing fodder reserves (e.g. silage and hay) for use during slack periods; (iii) creating off-farm income generation opportunities; (iv) raising awareness of local communities on the environmental consequences of overgrazing and prospects for improving livelihoods through alternative practices, and (v) promoting stall feeding where feasible.

6.0.2. LANDSLIDE

i. Bioengineering Management:

Bio engineering brings different things to different users and implementers. However, in general, the term bio-engineering is used to mean a technique in which living vegetation, either alone or in combination with non-living vegetation, either alone or in combinations with non-living plant materials or soft engineering structures are used to stabilize and protect slopes from erosion and

landslides. However, some techniques that are commonly used as; planting trees, shrubs and grasses, planting woody stems, seeding grass, trees and shrub etc.

ii. Drainage management:

To prevent runoff from flowing into landslides and to drain the excess water from landslides, drainage management is essential. Drainage management may be surface and subsurface drainage management.

Surface drainage management:

Techniques applied include construction of diversion waterways, sealing of tension cracks so that rainwater cannot get inside and build up pore water pressure, rip-rap (stone or vegetative or combined) of the waterways. These techniques are appropriate for controlling shallow slides.

Sub-surface drainage management:

Techniques applied include sub-surface drainage trenches filled with gravel, perforated drainage pipes (vertical and horizontal), which are appropriate for reducing pore-water pressure along failure planes.

Conservation ponds:

This technique is generally applied to store and divert excess runoff.

iii. Surface erosion control:

Techniques applied including grass or tree sapling planting, jute netting, mulching, wattling and brush layering.

iv. Slope failure due to slope cutting or steep slope:

Techniques applied include crib walls of bamboo, poles, or concrete), retaining or toe walls of stone, gabion, masonry, or concrete. Anchoring may be used in a deep-seated landslide to bolt the rock bed but this is not easy and is generally not used unless the landslide affects national structure, such as hydropower or a highway.

v. Slope failure due to heavy load on slope upstream of landslide:

Techniques applied include excavation to remove rock and soil from the head of a landslide to reduce the driving force, and filling rock at the toe of the landslide to increase resistance against movement.

vi. Erosion control in rills:

Techniques applied include fascine, contour grass planting, rip-rap, and palisade (wide rills).

vii. Erosion control in gullies:

Techniques applied include palisade (small gullies), and check dams made of brushwood, stone, boulders, gabions, masonry, or concrete.

viii. Slope failure due to toe cutting by river and streams:

Techniques applied include revetment, spurs, or a riprap toe wall to prevent cutting by the stream or river.

ix. Agroforestry:

Water and soil erosion, excess nutrient and pesticide movement, declining fertility of farmlands, lowland productivity and lack of active participation of local people in watershed management have become major problems for sustainable development in Katti sub watershed area and agroforestry can address these issues as rehabilitation of degraded land by conversion to alternative production agroforestry practices such as alley cropping, contour hedgerow systems, tree/pasture systems, fuel wood plantations etc.

x. Participatory Land use evaluation and land use planning:

Implementation of the national land use policy, preparation and implementation of participatory land evaluation and land use planning, and promotion of appropriate land use and land management systems (e.g. Sloping Agricultural Land Technology (SALT) for sloping land) are some of the strategic options for controlling conversion of forestlands to non-forestry use, controlling landslides and soil erosion and enhancing productivity of agriculture lands. This should be carried out by taking into account the need to conserve forests and biodiversity, enhancing ecosystem services, and resolve any disputes with regard to local and indigenous communities' tenure systems and land uses.

6.0.3. SOIL EROSION

i. Bioengineering Management:

Rill and gullies need to be treated with bio engineering techniques in Katti sub watershed such as fascines palisades, brush layering, brushwood check dams, wattling, loose stone check dams, vegetative rip-rap and grass planting. Also runoff water can be managed by constructing earthen pond at upstream as water reservoir to mitigate adverse impact on downstream runoff in hill areas.

ii. Treatment for specific zones of soil erosion:

Upstream and side periphery zones of the soil erosion:

Crack sealing:

Run off water entering the land mass through cracks is more serious than surface runoff. Therefore, a prime treatment in the crack zone is sealing cracks with any available material, but preferably clay soil.

Water management:

Diverting surface runoff from the crack area close to the soil erosion is very tricky and sensitive.

Cultivation:

Cultivation in the crack zone close to the rim of the soil erosion should not be allowed.

Downstream zones of the soil erosion:

Contour bounding:

Contour bounding with large stones and leveling of the land behind the bounding will dissipate the energy of the debris flow to avoid damage downstream. It is also beneficial to do contour planting of grass, shrubs, and trees so that the vegetation will reduce the movement of the sediment flow downstream.

Protect fan from cutting or erosion:

Terrace building and vegetation growth in the fan will protect it from erosion and reduce any further movement of debris.

iii. Farming practices:

Rain fall induced top soil erosion is greatly increased by human activities and better land management could significantly reduce this form of erosion. Farming on sloping land in such a way that tillage, planting and harvesting are done perpendicular to the predominant slope, but not necessarily on the contour. This practice is used to reduce sheet and rill erosion and improve surface water quality by reducing siltation.

iv. Alternative sources:

Reducing dependency of households on forests for meeting their energy and timber demands should be an important strategy to reduce deforestation and degradation which effects on soil erosion. It seeks to install improved biomass technologies to meet cooking and heating energy needs that include micro-hydro, solar power and biogas among others.

v. Awareness on forest fire:

Most foresters and forest activities believe that raising awareness is alternate option in the fight against forest fire. The awareness may be in the form of local radio, drama, posters, pamphlets etc. which will provide information of forest and its effect on natural cycle. Mass and print media mobilization is very important for fire preparedness activities, which include spreading messages through television, radio, street drama, video, folk songs, drills, posters, pamphlets and hoarding boards.

6.0.4. FOREST FIRE

i. Technical training:

Local communities of Katti sub watershed area plays a significant role in preventing and suppressing harmful fires because they have clear understanding of local conditions and circumstances important for successful fire management. They also possess valuable knowledge of place, fire behavior and locations for emergency fire lines, could save lives, time and money during emergencies.

Considering the priorities of users, block wise grazing or no grazing system has been adopted to control fire in community forests. Construction and maintenance of fire lines around and inside the forest are common method of aliening fuels which can segregate stop and control the spread of fire in Katti sub watershed area. Beside this there are no specific trainings were arranged to control forest fire in community level.

ii. Investigating the effects of climate change:

As mentioned in the preceding section, climate change can affect different aspects of forest conditions, including health and vitality, area and biodiversity. When viewed in the context that there has been continuous increase in the average annual temperature and changes in precipitation pattern in the landscape over the last three decades, the situation is alarming.

Weather related extreme events such as excessive rainfall, longer drought period, landslides and floods, frequent and severe forest fires, and invasion by alien species are speculated to have links with climate change. There is, however, clear lack of knowledge on whether, and if so, how, climate change has affected different forest ecosystems and species, and whether the effects have been variable across different elevations and aspects. This needs to be further investigated.

iii. Public awareness program:

Extension and outreach programs have contributed to public awareness toward the importance of forests. Involvement of governmental and nongovernmental organizations in forums such as mass media (radio, television), workshops, seminars, publications, and exhibitions has contributed to create awareness among the people. Furthermore, the community forests have played an important role in increasing awareness toward the importance of forests to the local people. In the areas where the community forestry programs have been implemented, the level of awareness can be considered high; people are motivated for conservation of the forests since they are getting many ecosystem services from their forests.

6.0.5. LAND OVER USE

i. Indigenous knowledge:

The role of indigenous knowledge in soil fertility management in the hill farming of study area have been developed like indigenous soil classification systems mainly based on features which can be sensed such as color, texture, soil fertility and other physical properties. Soil fertility is related to the aspect of the land. Northern aspect is reported to perform better for mandarin orchards. Use of firm yard manure, green manure, in-situe maturing such as by keeping animals in sheds or in open fields and also by using migratory flocks of goats, mulching, use of nitrogen fixing plants, crop rotation, following, terrace riser slicing etc. are recognized as indigenous soil fertility management practices common in Katt sub watershed area.

ii. Agroforestry development:

Integrated practicing of agriculture, forestry and animal husbandry on the same unit of land for the benefit or the farmers and improving soil fertility and environment using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the Katti sub watershed area.

Agroforestry can contribute to greenhouse gas mitigation by sequestering carbon in trees and soil. Integrating trees and agroforestry into farming systems helps to improve overall soil health through reducing soil erosion, sinking and storing soil nutrients and water, providing a source of mulch and fixing nitrogen in the study area. While the over story moderates soil evaporation, the roots increase water infiltration in the soil, building up the water table and protecting crops from low precipitation.

People benefit from tree based systems from the numerous products that they yield, namely, fruits, fodder, fuel, timber, medicines, and resins, which can either be consumed or sold for cash. Agroforestry can therefore benefit household food and nutrition security by affording both a more varied diet and greater income diversification. Deforestation has impelled women to travel greater distances in search of fodder and firewood. Agroforestry can help regenerate deforested lands and provide sustainably managed wood sources, thus reducing the labor and time demands on women. Integrating agroforestry into food production systems improves the resilience of the agricultural production system as well as households which survive off of these systems.

iii. Rehabilitation of degraded land:

Refers to vegetative and structural measures applied to maintain or reestablished the productive function of the degraded grazing lands to maintain its function.

iv. Adaptation Framework:

In view of the diverse climate conditions and associated impacts on agriculture, adaptation planning cannot be done on the basis of global knowledge alone. Agricultural research and development has to play a key role in developing adaptive technology and diffusion of innovations under climate change context. Extension services are also expected to be more effective in promoting farmer's adaptation practices, knowledge and capacity building to be able to sustain agriculture and food security at household in Katti sub watershed. Apart from research the range of measures that are used to address the climate change adaptations are diverse that may include policy, technological and management responses.

CHAPTER – 7

OPPORTUNITIES FOR GOVERNMENT AND NON GOVERNMENT ORGANIZATION TO ADDRESS SUB-WATERSHED DEGRADATION

DRIVERS OF WATERSHED DEGRADATION	ACTIVITIES	LOCATION	REMARKS
DEFORESTATION AND FOREST DEGRADATION	▪ Forest restoration ▪ Reforestation ▪ Afforestation ▪ Fodder plantation ▪ Shrub/grass plantation ▪ Stall feeding practice ▪ Forest fire control ▪ Invasive species management; mechanical, biological, chemical control, alternative use of invasive species- bio char, fuelwood, charcoal ▪ Renewable energy promotion; Biogas, improved cooking stoves and others ▪ High value non-timber forest product value chain development	**Lakuri:** (Ward 2-Deuli, Atrauli & Sermakot, Ward 4-Mathillo Lankuri, Ward 3-Tallo lakuri, Gurjedanda, ward no 5-Geuli, goganpani, Trikule, ward no 6-Palta, Uma, Sirseni, ward no 7-Pipalpata, Simkhola, Rowati, ward no 8-Dumri, Ward no 8-Dumri, Ward 9-Paiyachaur, Gairigau (Ward 5, 4-(Up) Ward 5 Goganpani, Trikule, (down) ward no 4 Mathilli Lakuri, ward no 5 Geuli). **Badabhairab:** (Ward 1, 2 & 3- Mid transition part of forest and cultivation, Ward 5-North & East parts of Dandagaun, East part of Bhairavisthan & Khagena Village, Ward 4: South of Gaiaut & Pachana Gau, Ward 7: west part of khadka gaun, Ward no 9-East part of Kot & Khagena Gaun (Ward 6, 4, 7, 9 - (Up) Ward 4: South part of Kuna & Pachana Village, Southwest part of Jantekot Village, (Up) 7: East/south part of Khadkagaun, (UP) 9: East part of Kot village, (down)ward no 6: Along the river course/arable valley cultivation land). **Paganath:** (Ward 3 – Pokharidanda, Majgau, Pagnath; Ward 1 – Sano Pagnath, Ward 1-Amare and Chitmola gau, Sahutada, Ward 5 Northeast of Simal pokhari, Ward 4-Simalpokhari and Thulo Ganma, Ward 7 South-west part, Ward 7 Kurmigau, Ward 8 Sano Ganma, Ward 9 (Ward 2- Grassland near Khalga (Up) & Ward 1- Forest (Down), Ward 5- Northeast of Simalpokhari (Up) & Ward 6- West of Simal Pokhari (Down), Ward 6 (Up) & Ward 7-(Down), Ward 8- Near Khaule gau (Up) and Ward 7- South of Khaule gau). **Rum:**(Ward 3: Katiya Gaun, Ward 4: North part of Simaltakura, Ward 5: West upper site of Linche Village, Ward 6: West upper site of Bajeda Village, Ward 9: West upper site of Loda & Guyaldadim Village-North part of Nagaun, Ward 8: North part of Arsina village, Ward 7: North part of Saltage Village, Ward 4: North part of Simal Takura near the border with ward no 7, Ward 3: Katiya & Mauladanda west). (Ward: 3,4,5,6,7,8,9, Upstream: Ward 3,5,6,9-Upper part of Linche, Bajeda, Lode & Guyaldadim, Downstream: Ward 4,7,8- Arsina, Saltage & Simaltakura). **Katti:** (Ward 2: Berama village upper side, Ward 1: upper site, Ward 6: upper site, Ward 5: Dudhila and Sera site, Maluka village site, Ward 9,7: Lower Katti Village near the	

		katti river site, ward no 4: Upper site of chipin Village, west part of chipin village, Lower site around the Timalsina village, Ward no: 8, Upper site of Jotinge village and down ward chipin danda village). (Ward 7, 2, 6-(Up) Ward: 5 2,6, (down)ward no: 7- Ward 1, 5- (Up) Ward: 1-(down) ward no: 5)	
SOIL EROSION	▪ Conservation education and extension activities to create awareness on erosion problems ▪ Water resources protection ▪ Monsoon run-off management ▪ Terrace farming ▪ Runoff control ▪ Windbreaks ▪ Cover crops/ rotation crop ▪ Soil conservation farming ▪ Agroforestry ▪ Gully treatment ▪ Torrent control Stream bank protection	**Lakuri:** (Ward no 2,4,5, 6-Ward no 2: North aspect slope of village near the Khada khola, Ward no 4: west aspect slope near the Khada khola, east side of the mathillo lakuri village. Ward no 6: Different site of streams networks of Baitadi Khola near the different villages such as Palta, Uma & Sirseni, ward no 7: Along the river side of Bijetkot khola, sim khola & Paryachaur Khola, Ward no 7: Near the Dumri village & along the stream networks of Paryachaur Khola). (Ward 5,4-Up: ward no 5-North part of Trikule Village down: ward no 4: Near the mathillo Lankuri Village) **Badabhairab:** (Ward no 2,3,4, 5, 6,7, 8-Ward no 2: Pallo khor, Jastala village, ward no 3: Northwest part of Khor gaun, ward no 4: west part of Duni/near the Gaiaut village/Pachana/Barsana village along the Bada Khola, ward no 5: East/west part of Khagena Village, ward no 6: Along the Bada khola river site, Ward no 7: East/west part of Khadkagaun). (Up: ward no 4, 5, 6, 7-Ward no 4: West part of Duni Village, East Part of Duni Village along the Bada khola, West part of Pachana Village, Northwest of Barsana Village, North part of Gaiaut Village, ward no 5: west/east part of Khagena village, Ward No 7: west part of Khadka gaun Village & North Part of Kot Village, down: ward no 6, Along the river course/arable valley cultivation land) **Paganath:** (Ward no 5, 6,7). (Up: ward no 5, 6, down: ward no 7, up: ward no 2, down: ward no 3) **Rum:** (Ward no: 2,3,4,7,8,9-Along almost all streams). Ward no: 8,9- Upstream: 9, Lower part of Guyaldadim & Jogimara Khola, D-stream: 8 Arsina village, Ward no: 2,4-Upstream: 2, Around the Dandagaun streams, Downstream: Around the Simal Takura streams **Katti:** (Ward no: 2,3,6,7). Ward no: 3,6,7-Up Ward no: 3,6 Down ward no: 7, Ward no: 6- Jhegada & Panchtola, Sanigaun, ward no: 3-Sanigaun Village, ward no :7 -Base & Paiyagaun Village, ward no: 2 Barama Village, Ward no: 1,5 Up Ward no : 1, Down ward no: 5 - Mayabas Village, Down ward no: 5 - Maisthan village, Chakhla & Jaina	

LANDSLIDE	▪ Landslide treatment ▪ Conservation pond construction ▪ Run-off harvesting dam construction ▪ Agroforestry ▪ Bio-engineering ▪ Check dam ▪ Retention wall ▪ Amriso/Grass plantation	**Lakuri:** Ward no 2,3,4,7-Ward no :3-South Part of Tallo Lankuri,Ward no:4-West part of Majgaun village near the khada khola **Badabhairab:** Badabhairab 4 and 3-Ward no 4: mid part of Jantekot & Duni village, Ward no 3: North west part of Khor village. Badabhairab 4,6-Impact: Land use, Settlement & Road, Upstream: ward no 4, Jantekot Village, Duni Village, Downstream: ward 6-Arable Valley cultivation **Paganath:** Paganath 4,6, 9 and 7 Paganath 4,6-Impact: Land use, Road, Upstream: ward no 4, Downstream: ward 6, Paganath 4,6-Impact: Land use, Road Infrastructure & Human Settlement. Upstream: ward no 9 **Rum:** Ward no: 2,3,4,6,9 Ward no: 3,4-Upstream: ward no3, Downstream: ward no 4,Wardno: 3-Mauladanda, Thantichaur & Rum Gaun, Ward no :4-Agriculture area **Katti:** Ward no: 1,3,5,6,7 Ward no: 3,6,7-Up Ward no: 3,6-Down ward no:7, Ward no: 6- Jhegada & Panchtola Village Ward no: 3-Sanigaun Village, ward no:7 -Base & Paiyagaun Village, Ward no: 1,5-Up Ward no : 1, Mayabas Village ,Down ward no:5, Maisthan village, Chakhla & Jaina Village	

LAND OVER USE	▪ Agroforestry ▪ Stream bank protection ▪ Terrace farming ▪ Runoff control ▪ Cover crops/ rotation crop	**Lakuri:** ward no 2: Atrauli, ward no 3: Tallo Lankuri, ward no 4: Manjgaun, ward :5-Majgaun side, ward no 6: middle part of sirsenni and Palta village, ward no 7: Simkhola gaun, Deurikharka & Rowati, Ward no 8/9: Madkeni, Paiyachaur, Gairigaun, Dumri & Asureni **Badabhairab:** Ward no 5: Dandagaun, Bhairabisthan & Khagena, ward no 2: Near Baitadi Khola, ward no 5: Barsana, Kuna & Pachana, ward no :6,7-Northwest part & downstream Part of Bada khola, ward no 8: Mahadev kuna Village, ward no 9: Kot Village east part, Olkedanda & Balchipin Village **Paganath:** ward no 1: Pokharidanda, Majgau & Sano Paganath, ward no 2: Khagla, ward no 3: Pokharidanda, Majgau & Pagnath, ward no 4: thulo ganma, ward no 5: Simalpokhari, ward no 7: Kumri khola, ward no 8: Khaule & Ganma, ward no 9: Kumri, land capability IV (more than 20 cm deep, well to imperfectly drained) & river bed, ward no 1: Amara, sahutada & Bestada, ward no 2: Maulesal, ward no 3: Maulesal, Barne,Ward no 7: Hulak Takura **Land cap. IV (more 30^0 degree slope) & Shrub**. ward no 1: Sano Paganath, Chim tole, ward no 2: Khagla, ward no 5: Simalpokhari, Ganma,ward no 6: Simalpokhari west, ward no 8: Khaule east part **Rum:** Ward no 3: Lower part of Thantichaur & mauladanda, ward no 4: lower part of Simaltakura Village, ward no 7: Lower part of Chiura & Saltage Gaun, ward no 8: Upper part of Bajeda Village, Ward no 9: Upper part of Guyaldadim & Na Gaun Village **Katti:** ward no 7,9: Around katti village, ward no 5: Sera, Dudhila, Jaina & Maluka, ward no 4: Chipin Village upper / west site / down site near the timaisina village, Ward no 8: Upper site of Jotinge village & Chipin danda village site	

OVER AND UNSUSTAINABLE HARVEST OF FOREST PRODUCTS	▪ Renewal energy technologies ▪ Agroforestry and private forestry ▪ Bio-briquette ▪ improved stoves ▪ Skill-development training to poor and marginalized local people; ▪ Establishment of multipurpose private nurseries (including forest trees, NTFPs, horticulture sp).	**Lakuri:** (Ward 2-Deuli, Atrauli & Sermakot, Ward 4-Mathillo Lankuri, Ward 3-Tallo lakuri, Gurjedanda, ward no 5-Geuli, goganpani, Trikule, ward no 6-Palta, Uma, Sirseni, ward no 7-Pipalpata, Simkhola, Rowati, ward no 8-Dumri, Ward no 8-Dumri, Ward 9-Paiyachaur, Gairigau **Badabhairab:** (Ward 1, 2 & 3- Mid transition part of forest and cultivation, Ward 5- North & East parts of Dandagaun, East part of Bhairavisthan & Khagena Village, Ward 4: South of Gaiaut & Pachana Gau, Ward 7: west part of khadka gaun, Ward no 9-East part of Kot & Khagena Gaun **Paganath:** (Ward 3 – Pokharidanda, Majgau, Pagnath; Ward 1 – Sano Pagnath, Ward 1- Amare and Chitmola gau, Sahutada, Ward 5 Northeast of Simalpokhari, Ward 4- Simalpokhari and Thulo Ganma, Ward 7 South-west part, Ward 7 Kurmigau, Ward 8 Sano Ganma, Ward 9 **Rum:**(Ward 3: Katiya Gaun, Ward 4: North part of Simaltakura, Ward 5: West upper site of Linche Village, Ward 6: West upper site of Bajeda Village, Ward 9: West upper site of Loda & Guyaldadim Village-North part of Nagaun, Ward 8: North part of Arsina village, Ward 7: North part of Saltage Village, Ward 4: North part of Simal Takura near the border with ward no 7, Ward 3: Katiya & Mauladanda west). **Katti:** (Ward 2: Berama village upper side, Ward 1: upper site, Ward 6: upper site, Ward 5: Dudhila and Sera site, Maluka village site, Ward 9,7: Lower katti Village near the katti river site, ward no 4: Upper site of chipin Village, west part of chipin village, Lower site around the timalsina village, Ward no: 8, Upper site of Jotinge village and down ward chipin danda village).	

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ANNEXES:

FIELD PHOTOGRAPHS

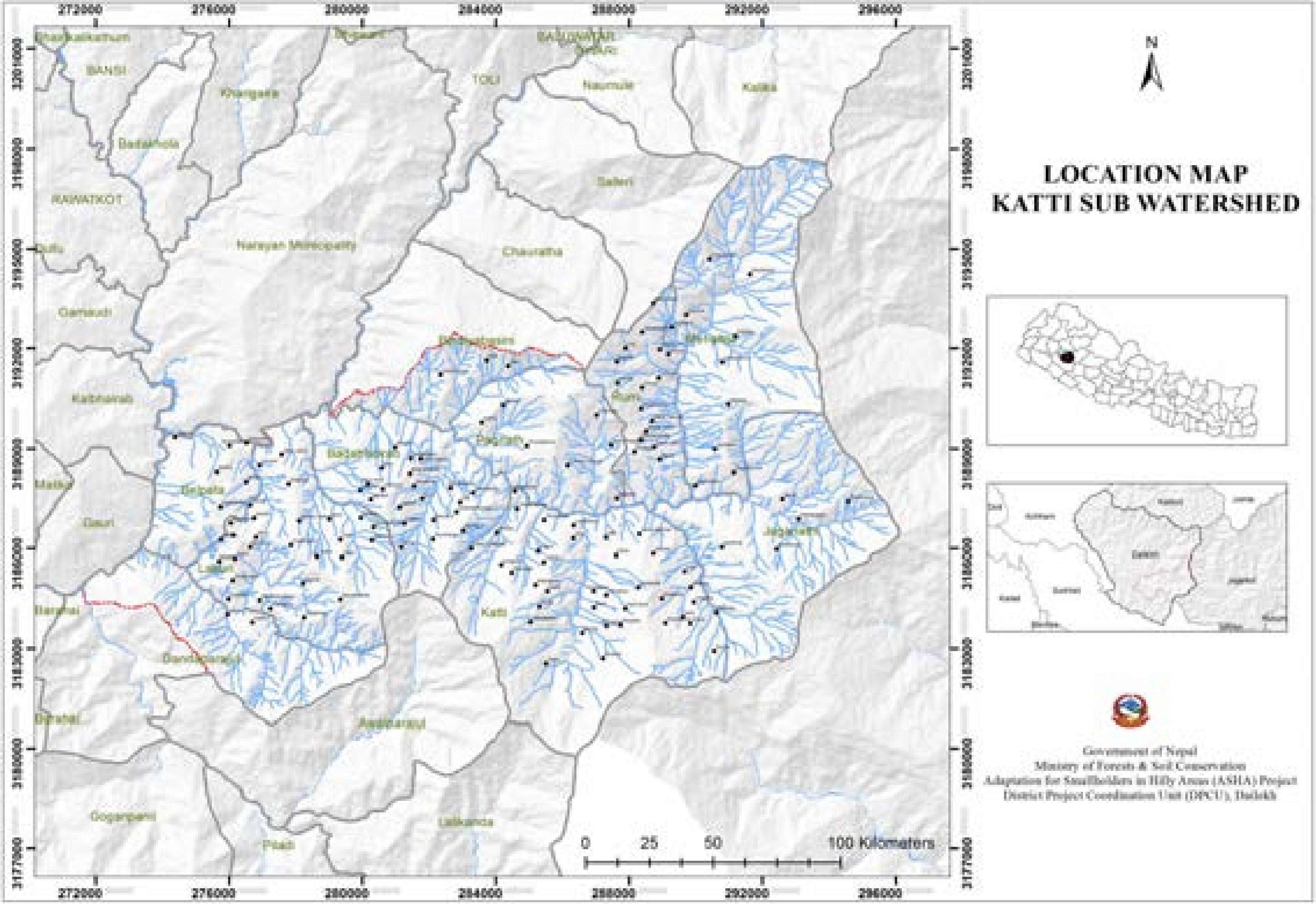
A glance of forest degradation and Land use change at Katti Vdc, Badabhairab Vdc and Paganath Vdc

Landslide at Badabhirab Vdc

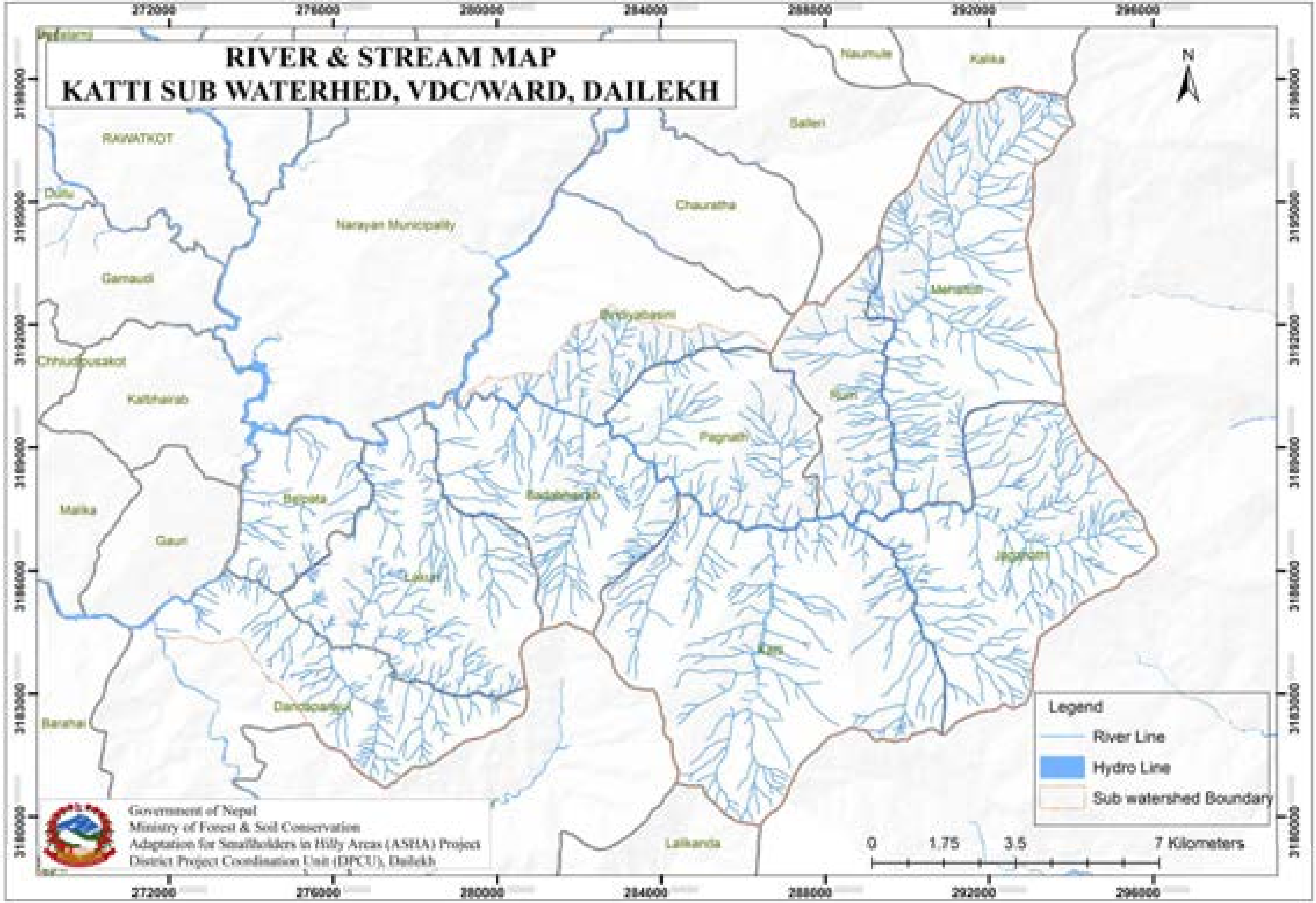
Landslide and forest degradation at Rum Vdc

Discussion on LAPA preparation and application of GIS based maps with local stakeholders

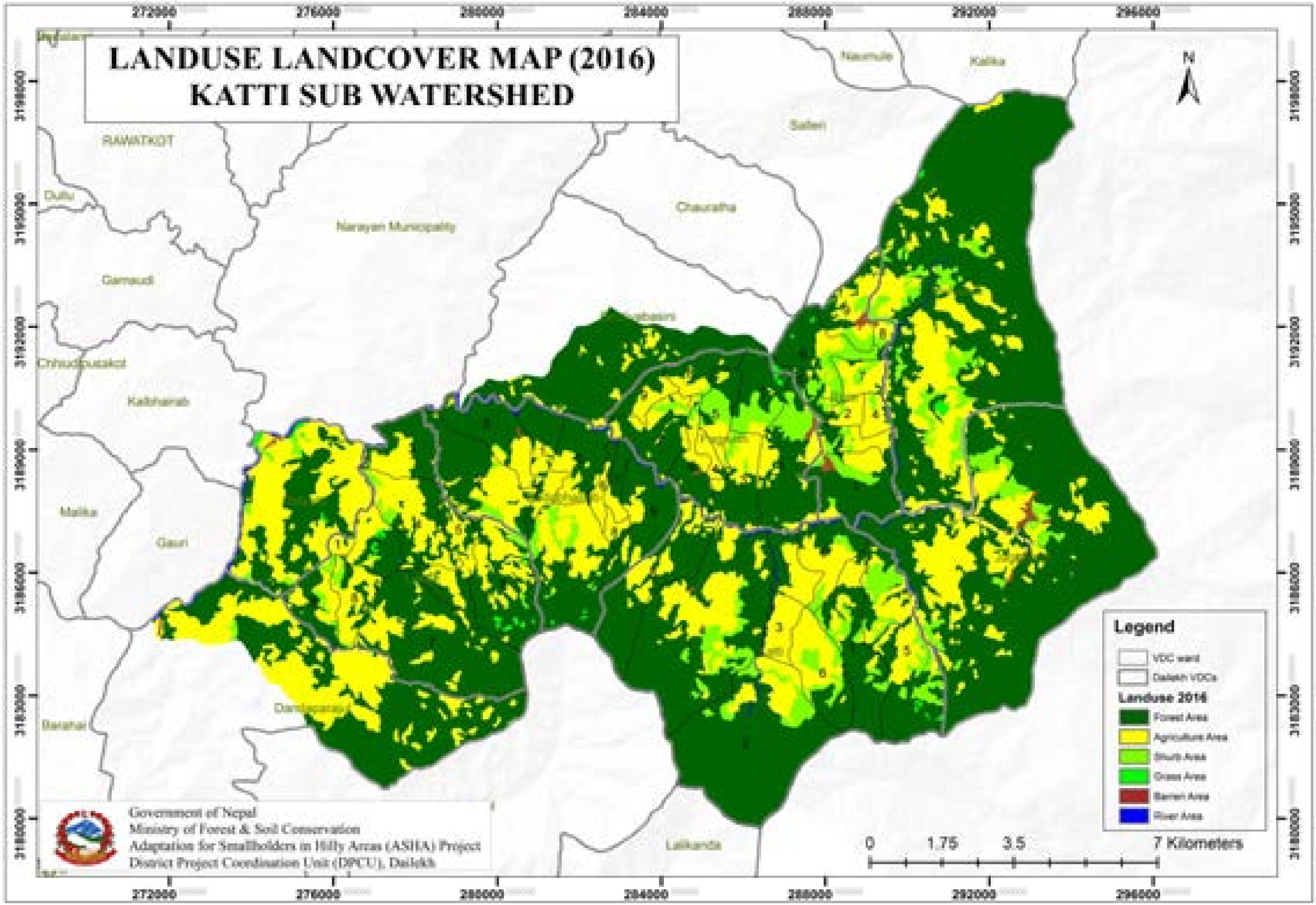
LIST OF MAPS



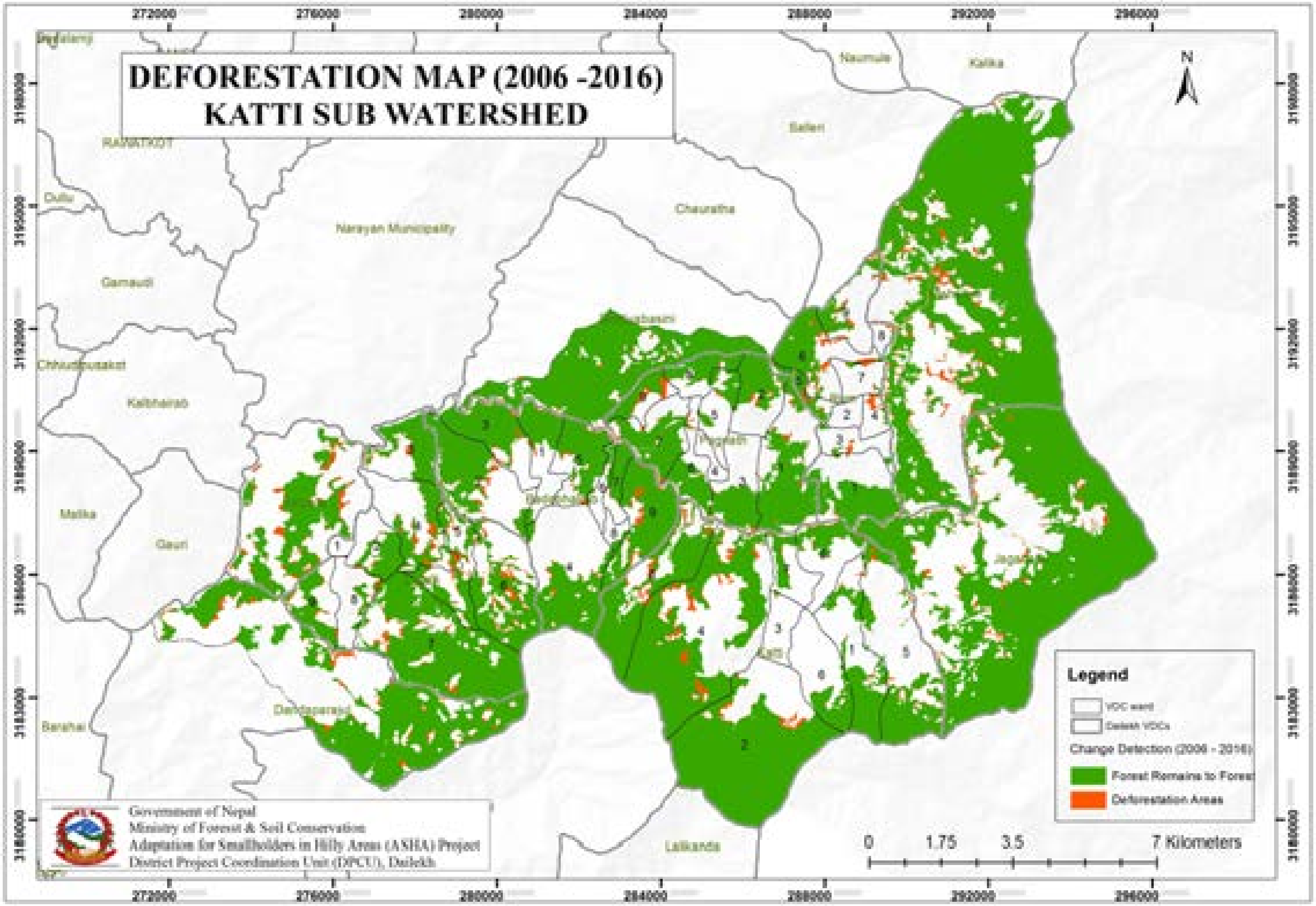
LOCATION MAP
KATTI SUB WATERSHED
N
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh
0
25
50
100 Kilometers
272000
276000
280000
284000
288000
292000
296000
BANSI
Kharigaira
TOLI
Naumule
Kalika
Salleri
RAWATKOT
Narayan Municipality
Chauratha
Dullu
Gamaudi
Kalbhairab
Jagannath
Katti
Aaalaparani
Goganpani
Lalikanda
Piladi

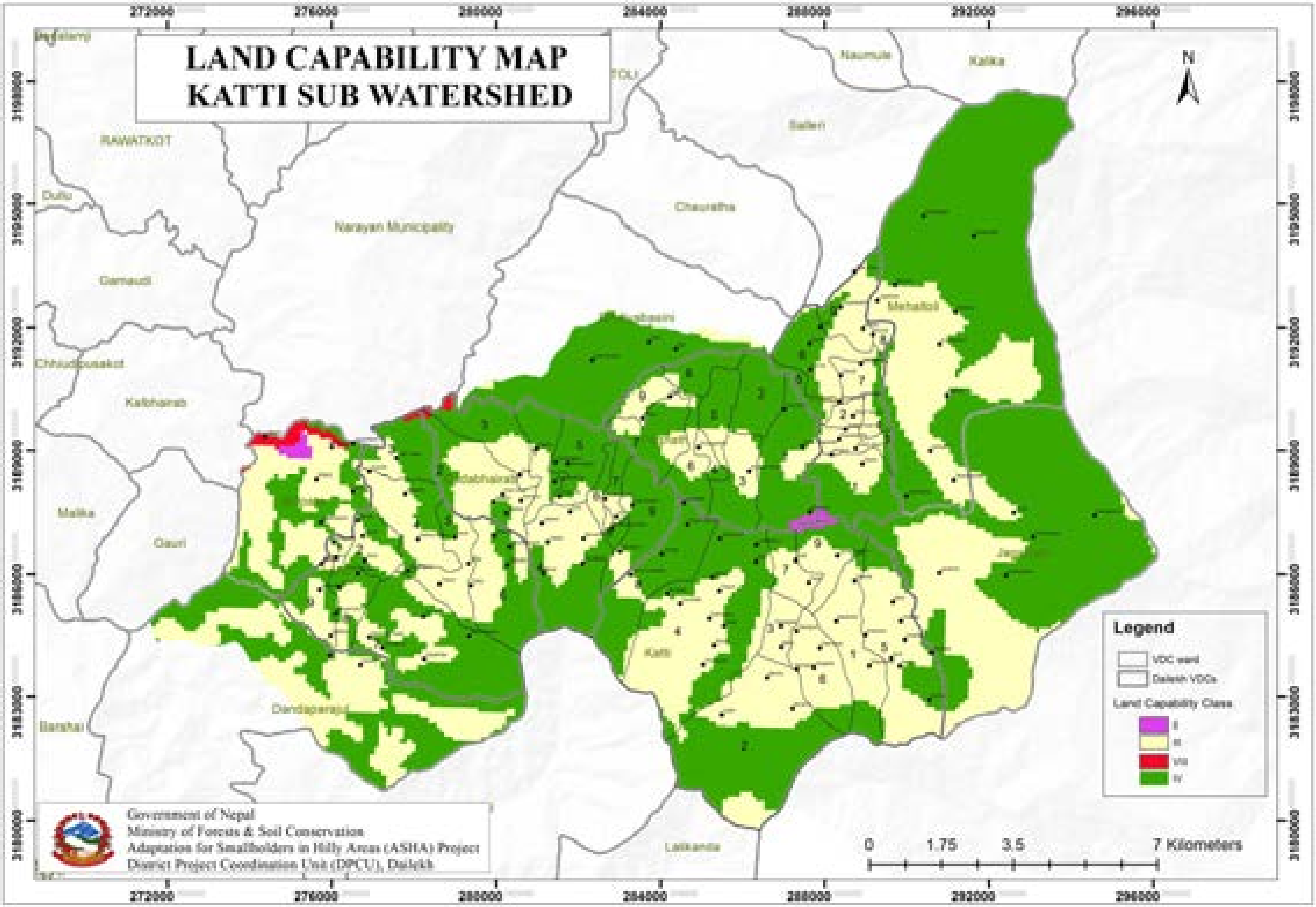


RIVER & STREAM MAP
KATTI SUB WATERHED, VDC/WARD, DAILEKH
N
272000
276000
280000
284000
288000
292000
296000
RAWATKOT
Dullu
Narayan Municipality
Chauratha
Naumule
Kalika
Salleri
Gamaudi
Chhiudipusakot
Kalbhairab
Bindyabasini
Mahatah
Rum
Pagnath
Malika
Gaun
Baluwatar
Badalamji
Lakuri
Jaganath
Kasi
Dandiparajul
Baraha
Lalikanda
Legend
River Line
Hydro Line
Sub watershed Boundary
0 1.75 3.5 7 Kilometers
Government of Nepal
Ministry of Forest & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh

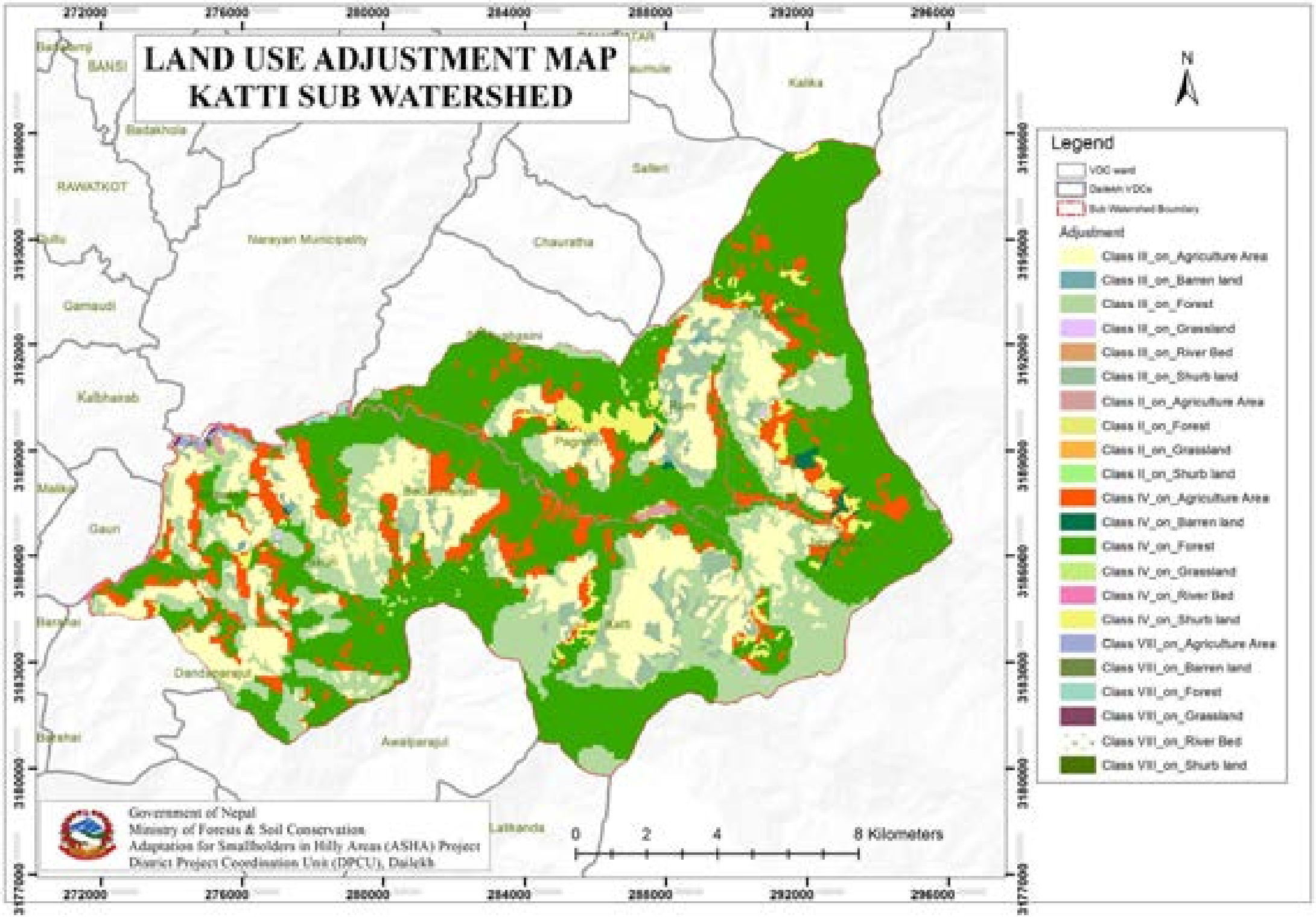


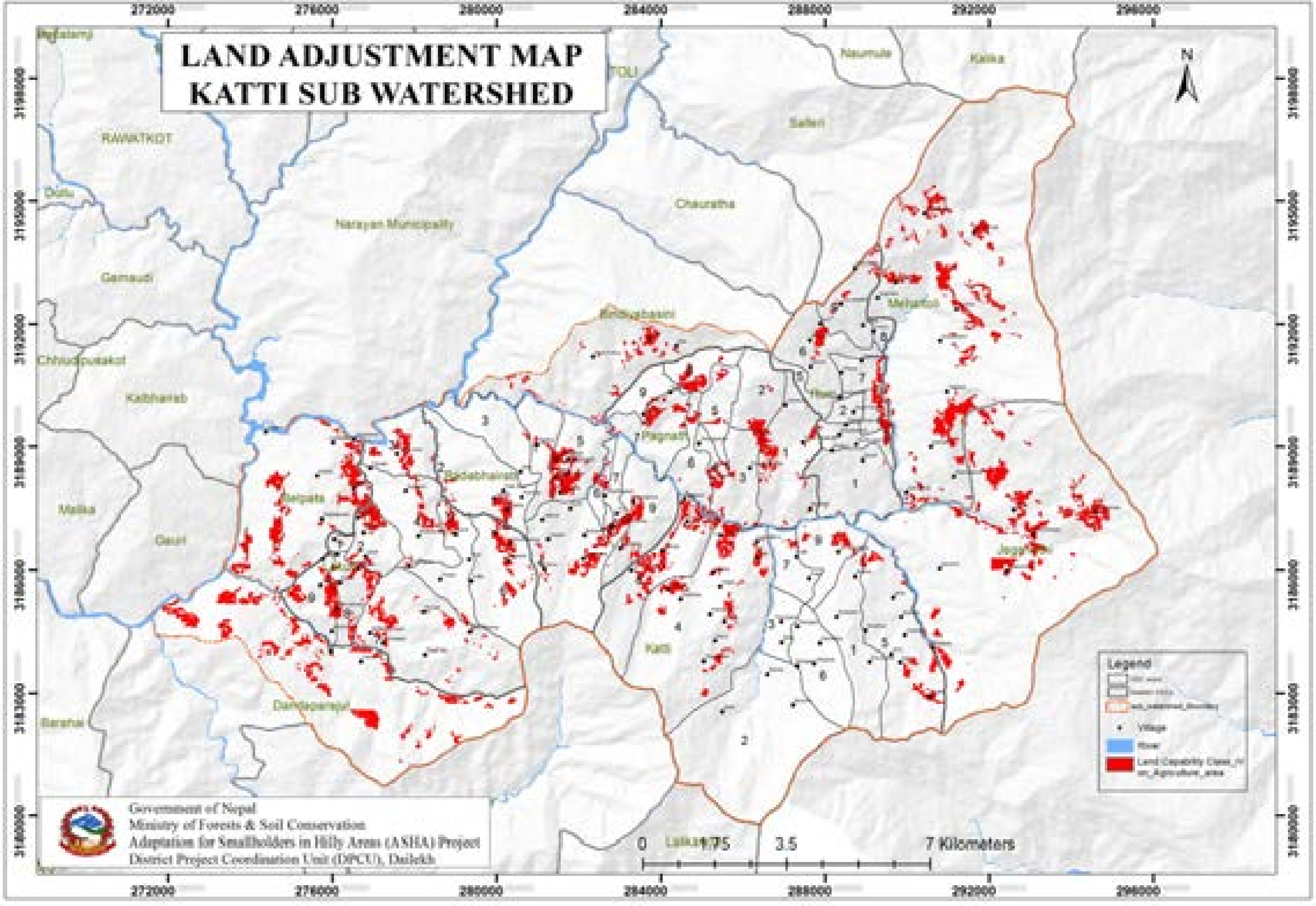
LANDUSE LANDCOVER MAP (2016)
KATTI SUB WATERSHED
272000
276000
280000
284000
288000
292000
296000
N
Naumule
Kalika
Salleri
RAWATKOT
Dullu
Chauratha
Narayan Municipality
Gamaudi
Kalbhairab
Malika
Gauri
Baraha
Dandaparajul
Lalikanda
Legend
VDC ward
Dailekh VDCs
Landuse 2016
Forest Area
Agriculture Area
Shrub Area
Grass Area
Barren Area
River Area
0
1.75
3.5
7 Kilometers
Government of Nepal
Ministry of Forest & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh

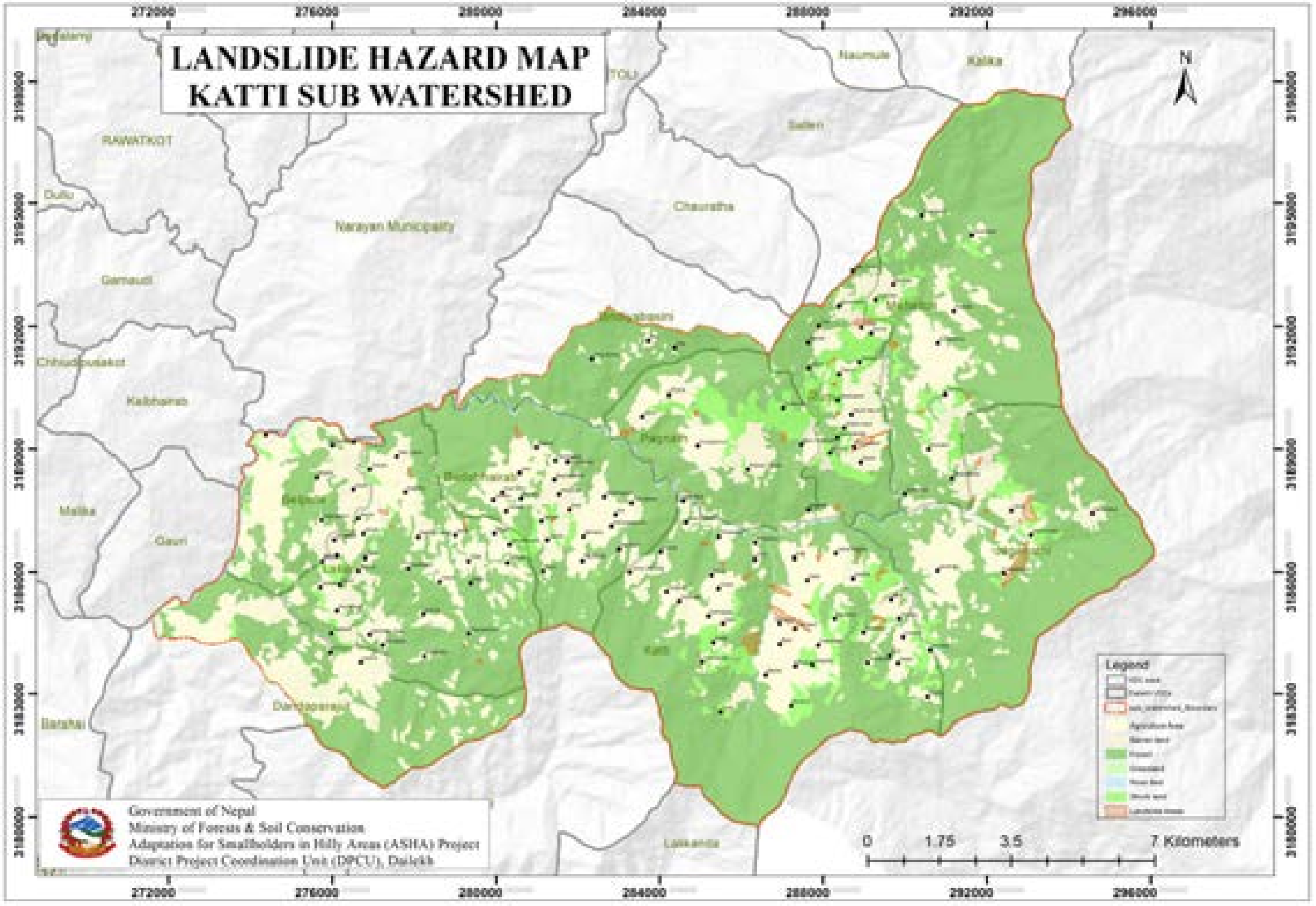

DEFORESTATION MAP (2006 -2016)
KATTI SUB WATERSHED
272000
276000
280000
284000
288000
292000
296000
Naumule
Kalika
Salleri
Chauratha
Narayan Municipality
Dullu
Gamaudi
Kalbhairab
Malika
Gauri
Dandaparajul
Lalikanda
Katti
Legend
VDC ward
Dailekh VDCs
Change Detection (2006 - 2016)
Forest Remains to Forest
Deforestation Areas
0 1.75 3.5 7 Kilometers
Government of Nepal
Ministry of Forest & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh

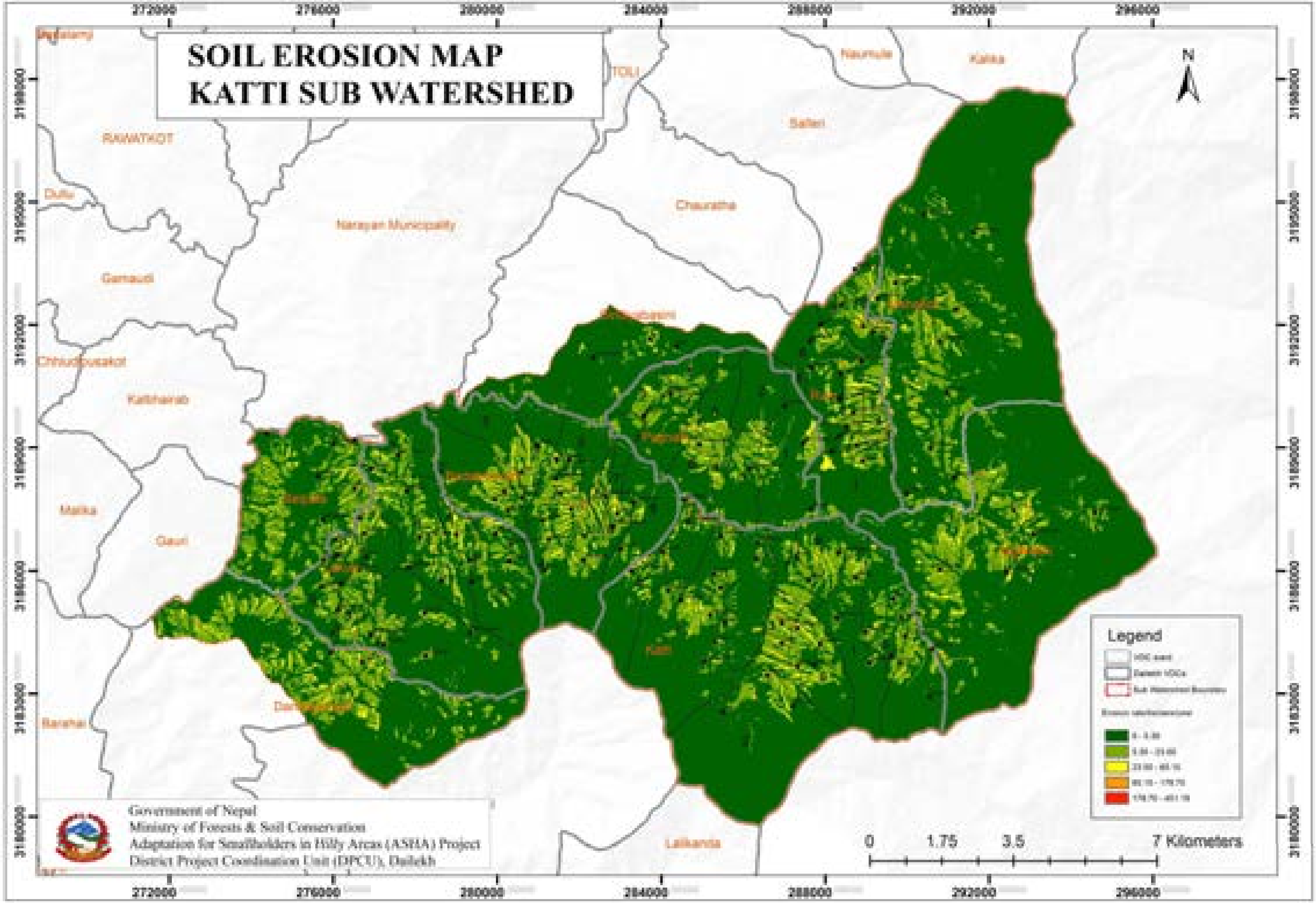


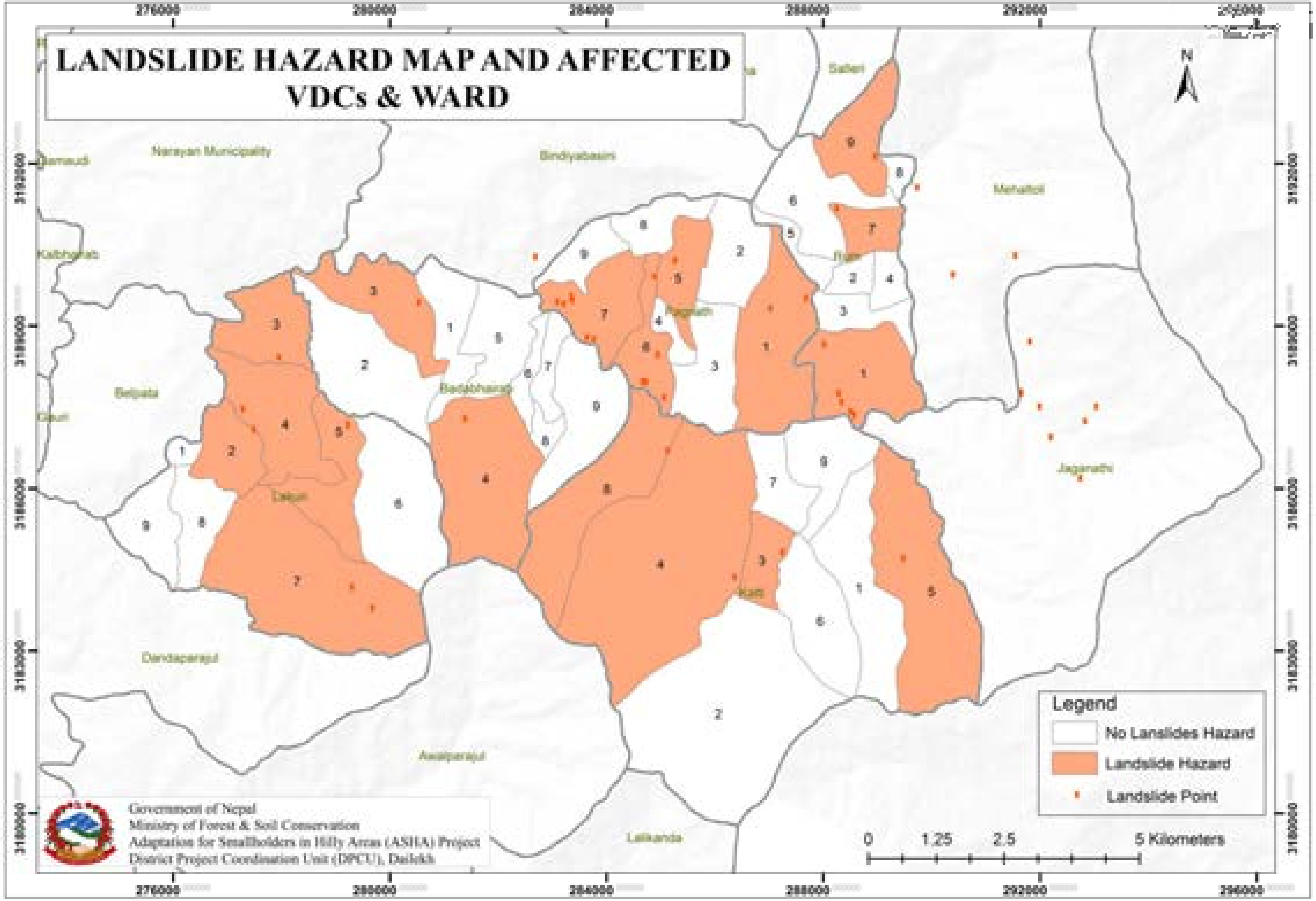
LAND CAPABILITY MAP
KATTI SUB WATERSHED
RAWATKOT
Dullu
Narayan Municipality
Chauratha
Salleri
Naumule
Kalika
Gamaudi
Chhiudipusakot
Kalbhairab
Malika
Gauri
Mehalkoli
Katti
Dandaparajul
Baraha
Lalikanda
Legend
VDC ward
Dailekh VDCs
Land Capability Class
VIII
IV
0
1.75
3.5
7 Kilometers
272000
276000
280000
284000
288000
292000
296000
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh


LAND USE ADJUSTMENT MAP
KATTI SUB WATERSHED
N
Legend
VDC ward
Dailekh VDCs
Sub Watershed Boundary
Adjustment
Class III_on_Agriculture Area
Class III_on_Barren land
Class III_on_Forest
Class III_on_Grassland
Class III_on_River Bed
Class III_on_Shurb land
Class II_on_Agriculture Area
Class II_on_Forest
Class II_on_Grassland
Class II_on_Shurb land
Class IV_on_Agriculture Area
Class IV_on_Barren land
Class IV_on_Forest
Class IV_on_Grassland
Class IV_on_River Bed
Class IV_on_Shurb land
Class VII_on_Agriculture Area
Class VII_on_Barren land
Class VII_on_Forest
Class VII_on_Grassland
Class VII_on_River Bed
Class VII_on_Shurb land
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh
0 2 4 8 Kilometers
272000 276000 280000 284000 288000 292000 296000
3177000 3180000 3183000 3186000 3189000 3192000 3195000 3198000
BANKE
Kalika
Badakhola
RAWATKOT
Narayan Municipality
Chaurasha
Salleri
Gamaudi
Kalbhairab
Mallika
Gaun
Barahtal
Dandagaraput
Awalgaraput
Latikanda


LAND ADJUSTMENT MAP
KATTI SUB WATERSHED
N
Naumule
Kalika
Salleri
RAWATKOT
Chauratha
Narayan Municipality
Gamaudi
Mehalkot
Kabhairab
Pagnath
Belpata
Malika
Gauri
Jagannath
Katti
Dandaparajul
Barahi
Legend
Village
River
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh
0
1.75
3.5
7 Kilometers
272000
276000
280000
284000
288000
292000
296000


LANDSLIDE HAZARD MAP
KATTI SUB WATERSHED
N
RAWATKOT
Narayan Municipality
Chaurasha
Salleri
Naumule
Kalika
Dullu
Dailekh
Chhedagad
Kalikasthan
Malika
Gauri
Barahi
Lakaanda
Legend
0 1.75 3.5 7 Kilometers
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh


SOIL EROSION MAP
KATTI SUB WATERSHED
272000
276000
280000
284000
288000
292000
296000
N
RAWATKOT
Dullu
Narayan Municipality
Gamaudi
Malika
Gauri
Baraha
TOLI
Naumule
Kalika
Salleri
Chauratha
Katti
Lalikanda
Legend
Government of Nepal
Ministry of Forests & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh
0 1.75 3.5 7 Kilometers



LANDSLIDE HAZARD MAP AND AFFECTED VDCs & WARD
Narayan Municipality
Bindyabasini
Mehaltoli
Belpata
Dandaparajul
Awalparajul
Lalikanda
Jaganath
Badabhairab
Legend
No Lanslides Hazard
Landslide Hazard
Landslide Point
0 1.25 2.5 5 Kilometers
Government of Nepal
Ministry of Forest & Soil Conservation
Adaptation for Smallholders in Hilly Areas (ASHA) Project
District Project Coordination Unit (DPCU), Dailekh