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Micro Watershed Development Using GIS & Remote Sensing in the Case of Chille and Ocholo Watersheds, Duguna Fango Woreda, Wolaita Zone, Southern Nations Nationalities and Peoples Region, Ethiopia

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Abstract
This study analyses micro watershed development using the techniques of GIS and Remote Sensing in order to delineate the areas of Chille and Ocholo micro watersheds, generate their base map and development map. Watershed development is the approach best suited to address the sustainable use and management of resources. In Ethiopia, large-scale watershed development has been limited. In the country at large and the study area, Duguna Fango Werda, in particular is currently facing numerous environmental problems resulted from inappropriate agricultural practice and exploitation of natural resource base. Scarce vegetation cover associated with erosion induced factors exposing the study area to high rates of soil erosion and loss of soil fertility that initiated the researcher to conduct this study in this area.Data were collected from sources such as, SRTM-DEM and Satellite Image with row 55 and path 169 full scene of the year 2017 downloaded from USGS; Google earth image; Shape file of the SNNP Regional State; GPS reading point data from the study area and physical observation of the area studied. Materials used to effectively execute this research include Global Mapper 11, ArcGIS10.3 and ERDAS Imagine 2014. Land use/cover classifications were generated through image classification of Landsat ETM+5 satellite imagery using ERDAS Imagine 2014softwareand mapped using ArcGIS10.3. The Zonal toposheet maps of the scale 1:50,000 and 20meter spatial resolution SRTM DEM was used to produce the location map and delineate area of the watersheds. Landsat ETM+5 satellite imagery of the study area having 30meter spatial resolution was used for base map production and development map.The area of Chille Micro Watershed is 468.8 Hectares whereas that of Ocholo is 309.3 Hectares. Chille Micro Watershed covers wider extent than that of Ocholo.Major land cover of Chille watershed, constituting 27.7percent or 129.3 hectare, is degraded land followed by 22.6percent or 105.6 hectare farmland. Its least proportion is human settlement and forest land that constitute 37.3hectare or 8percent and 32.1 hectare or 6.9percent land cover respectively. The majority, 30.5percent or 94.2 hectare, of Ocholo Micro Watershed is degraded land followed by 23.5percent or 72.5 hectare farmland. This watershed has the least proportion of 19.4hectare or 6.3percent forest cover preceded by 22.7hectare or 7.3percent of human settlement. The largest land use proportion of both Chille and Ocholo Micro Watersheds is degraded land followed by farmland while their least proportion is human settlement and forest cover. For the development of both Chille and Ocholo watersheds, the proposed conservation strategies include bench terrace, deep trench, stone bund and hill side terrace for degraded land. Faniyajuu, soil bund, trench, bench terrace, and cut off drains for the farm land areas; cut & carry system, cut off drain, deep trench area closure for the grasslands; plantations of trees, SWC methods such as trench for bush land; and area closure for the protection of the limited forest coverage found in the micro watersheds.
Keywords: GIS & Remote Sensing, Micro watershed, watershed development, base map generation, development map production

1. Introduction

Degradation of natural resources is considered as the greatest constraint to sustainable agricultural development in most of the developing countries including Ethiopia, which depend on subsistence agriculture. The agricultural productivity is still low due to its subsistence rain-fed nature (FDRECSOP, 2009).

Hence, effective management through the development of appropriate approaches of watershed development and adequate policies became the pillar. The approach of Watershed development is widely accepted as the approach best suited to address the sustainable use and management of resources. In fact, watershed development aspects such as forestry, agriculture, hydrology, ecology, soils, and other sciences to provide guidelines for choosing acceptable management alternatives within social and economic aspects have been practiced (Achouri, 2002).

Planning watershed development traced back to 1980s in Ethiopia constituting 30-40 thousand hectares of large watershed as planning unit. The purpose was to implement natural resource conservation development programs. However, the large-scale ones remained mostly unsatisfactory due to lack of participation, limited sense of responsibility over asset created, and unmanageable planning units (Lakew et al, 2005). In addition, expanding human population and their increasing demands for natural resources led to exploitation and degradation of land and water resources. Expanding human demands for resources intensified watershed

degradation (Brooks and Eckman, 2000).

The country Ethiopia is currently facing a number of environmental concerns resulting directly or indirectly from inappropriate agricultural practice and exploitation of natural resource base. The study area is characterized by serious soil erosion problem. Scarcity of vegetation cover associated with erosion induced factors exposing the area to high rates of soil erosion and loss of soil fertility (Eyasu, 2003).

Due to these problems, watershed development at Chille and Ocholo micro watersheds in Duguna Fango Woreda, the study area, was needed. Therefore, this research was intended to investigate watershed development for sustainable rural development at Duguna Fango Woreda.

2. Objectives of the Study

The specific objectives of the study are to:

- delineate the areas of Chille and Ocholo micro watersheds
- generate base map of Chille and Ocholo micro watersheds in order to compare existing land-use/land-cover among these two micro watersheds
- prepare development map of Chille and Ocholo micro watersheds for suggesting suitable conservation strategies to develop these two micro watersheds

3. Method

3.1 Study Area Location

Diguna Fango is one of the Weredas in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia. It is part of Wolayita Zone located in the Great Rift Valley. Diguna Fango is bordered in the southwest by Damot Weyde Wereda, in the west by Damot Gale Wereda, in the north by Hadiya Zone, in the northeast by Oromia Region, and in the east by Sidama Zone (WZFEDD, 2015).

Chille and Ocholo micro watersheds are found in Duguna Fango Wereda. Chile micro watershed is located at $06^0$57’12’’N - $06^0$59’07’’N latitude and $38^0$02’42’’E - $38^0$04’13’’E longitude while Ocholo is found at $06^0$55’30’’N - $06^0$57’18’’N latitude and $38^0$02’28’’E - $38^0$04’12’’E longitude as it can be seen from the location map below in Figure 1

Duguna Fango Woreda is structured among 28 administrative kebeles. The wereda covers 40,150.3hectares. Farm land is the major land uses of the wereda which covers 34%, followed by degraded of 31%, grassland of 9%, grazing land of 5%, forest & bush land of 4% while the rest 17% is consisted of other land uses. Agro-ecologically, the woreda is dominated by lowland with hot climate of 73% of the total area followed by midland (moderate climate) and the rest 27% is highland (cold climate). Rugged land features with undulating slopes characterize this wereda topographically (WZFEDD, 2015).

Even if the agricultural system in Duguna Fango Woreda is of traditional subsistence type or small scale peasant farming, it is the dominant economic base of this wereda. It is largely rain-fed which is practiced in small-scale fragmented holdings of peasant farmers (CSA, 2015).

3.2. Sample and Sampling Technique

There are twelve wredas and three town administrations in Wolaita zone. Duguna Fango wereda is one of these weredas which is the most degraded and drought prone region in the zone. Chille and Ocholo micro watersheds are found under Blate watershed (the main river into which all watersheds of Duguna Fango wereda drain). From the watersheds found under this main watershed, Chille and Ocholo micro watersheds are purposively taken as they are the leading micro watersheds in the amount of annual soil loss under this main watershed in the wereda.

3.3 Data Collection

For the successful attainment of the above stated objectives, different data were collected from the study area and from different sources such as, SRTM-DEM and Satellite Image with row 55 and path 169 full scene of the year 2017 downloaded from USGS; Google earth image; Shape file of the SNNP Regional State; GPS reading point data from the study area and physical observation of the area studied. Materials used to effectively execute this research include Global Mapper 11, ArcGIS10.3 and ERDAS Imagine 2014.

3.4 Methods of Data Analysis

To produce the location map and delineate area of Chille and Ocholo micro watersheds, toposheet maps of Wolaita Zone with the scale of 1:50,000 and SRTM (Shuttle Radar Topography Mission) DEM (Digital Elevation Model) with 20 meter spatial resolution was used. Then the extracted layers were imported to Global Mapper 11 version and configured their coordinate system to UTM projection WGS_1984 datum. The projected DEM was exported to ArcGIS10.3 using ArcGIS10.3 Hydrology tools.

For base map production, image classification of Landsat ETM+5 satellite imagery of the study area having with 30meter spatial resolution was imported into ERDAS Imagine 2014 software. Accuracy assessment was

checked for the classified image by calculating the error matrix to confirm the result of classification with ground truth. Similarly, development map production was done using the image classification of Landsat ETM+5 satellite imagery by ERDAS Imagine 2014software.

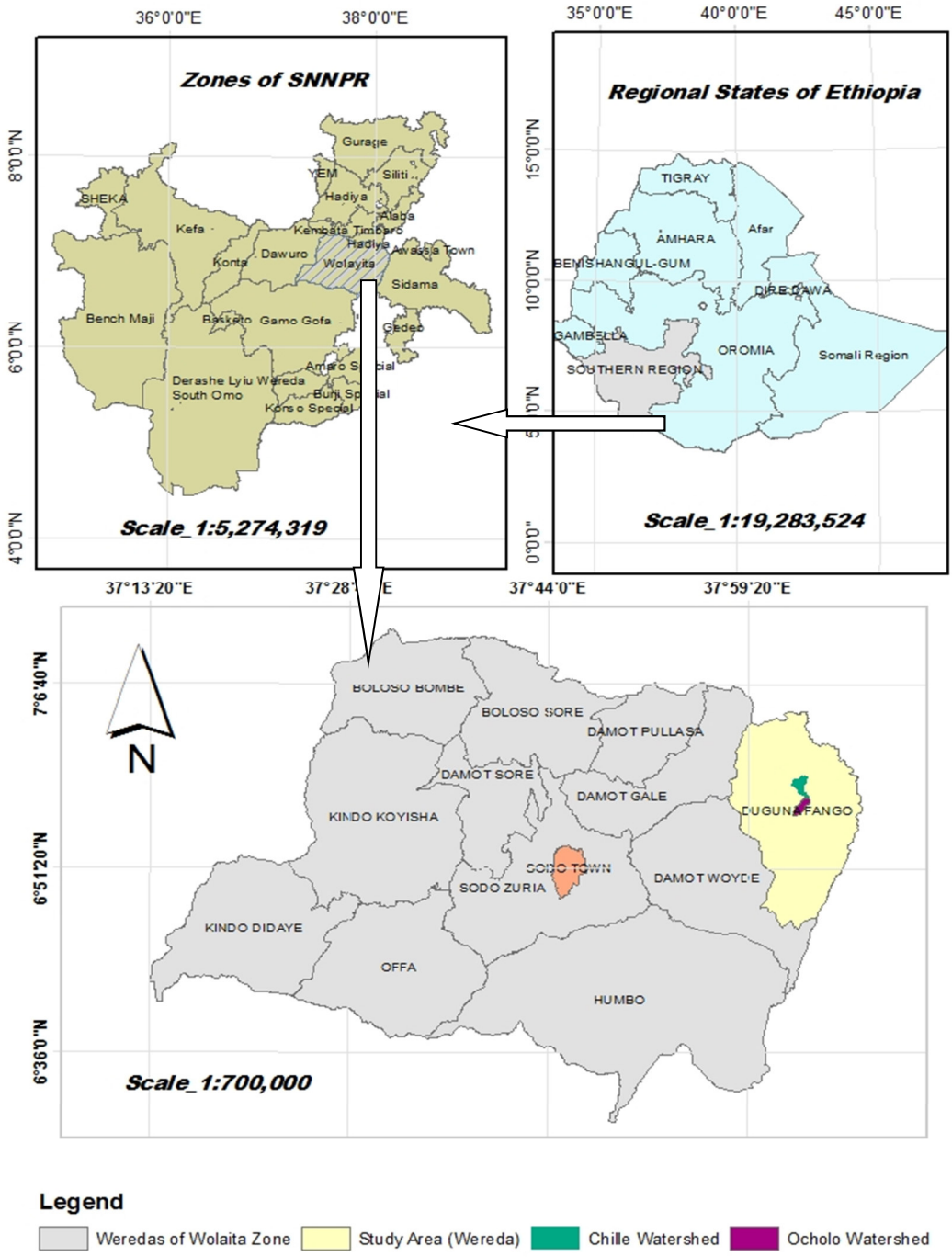


Figure 1: Location Map of Chile and Ocholo Micro Watersheds

4. Results and Discussion

4.1 Delineating Areas of Chille and Ocholo Micro Watersheds

The total area of Chille Micro Watershed is 466.9 Hectares whereas Ocholo Micro Watershed has the total area of 308.9 Hectares. This indicates that Chille Micro Watershed covers wider extent than that of Ocholo as indicated in Figure 2.

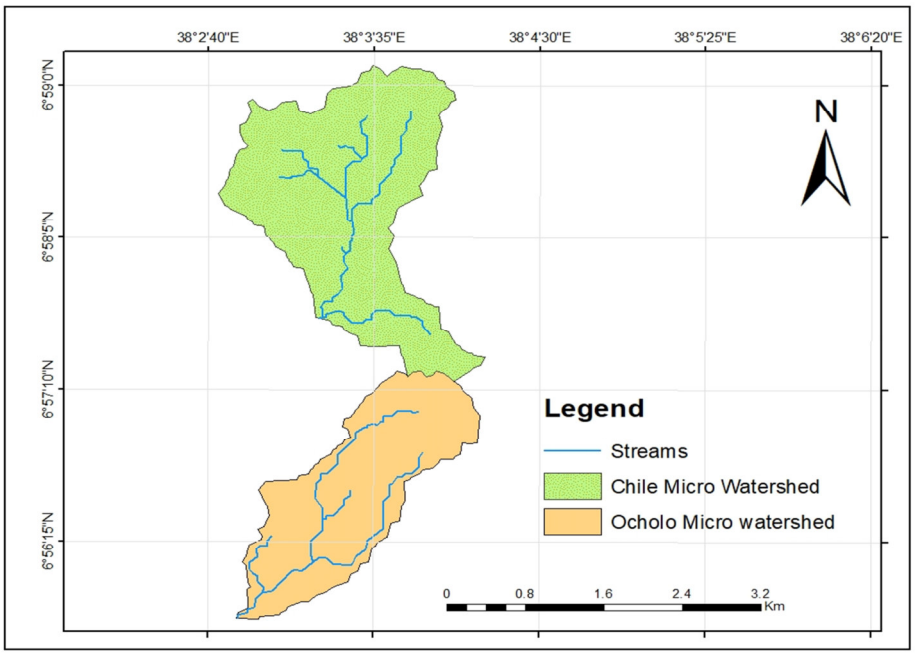
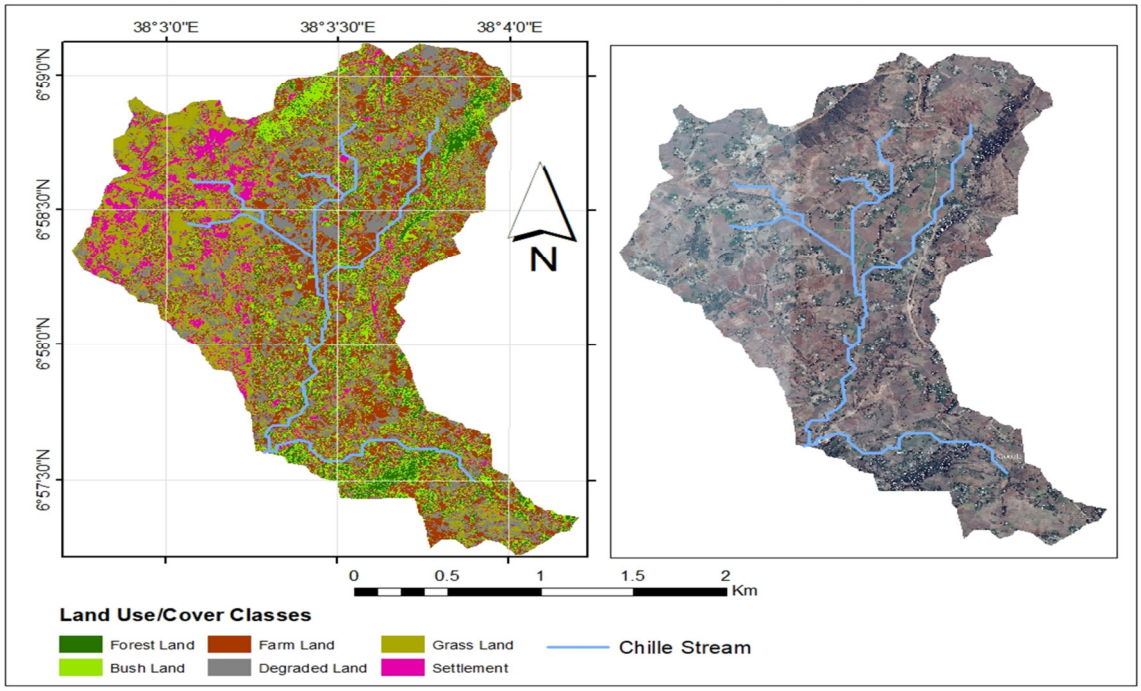


Figure 2: Area Delineation of Chille and Ocholo Micro Watersheds

4.2 Base-Map of Chille Micro Watershed

As it can be seen from the base-map of Chille Micro Watershed shown in figure 3 below, the majority of the existing land cover, constituting 27.7percent or 129.3 hectare land of the watershed, is degraded land followed by 22.6percent or 105.6 hectare of farmland. The third largest share is grassland which covers 20.2percent or 94.5 hectare and the fourth largest coverage is bush land which covers 14.6percent or 68.1 hectare. The watershed has the least proportion of human settlement and forest land that constitute only 37.3hectare or 8percent and 34 hectare or 6.9percent land cover respectively.

Geographically, degraded land of Chille Micro Watershed is found largely through north to south orientation, the forest & bush lands are found in the northern and southern margins, farm land is also through north to south orientation while grassland is largely located at the western dimension of the watershed as to the Base map of Chille Micro Watershed shown in figure 3 below.



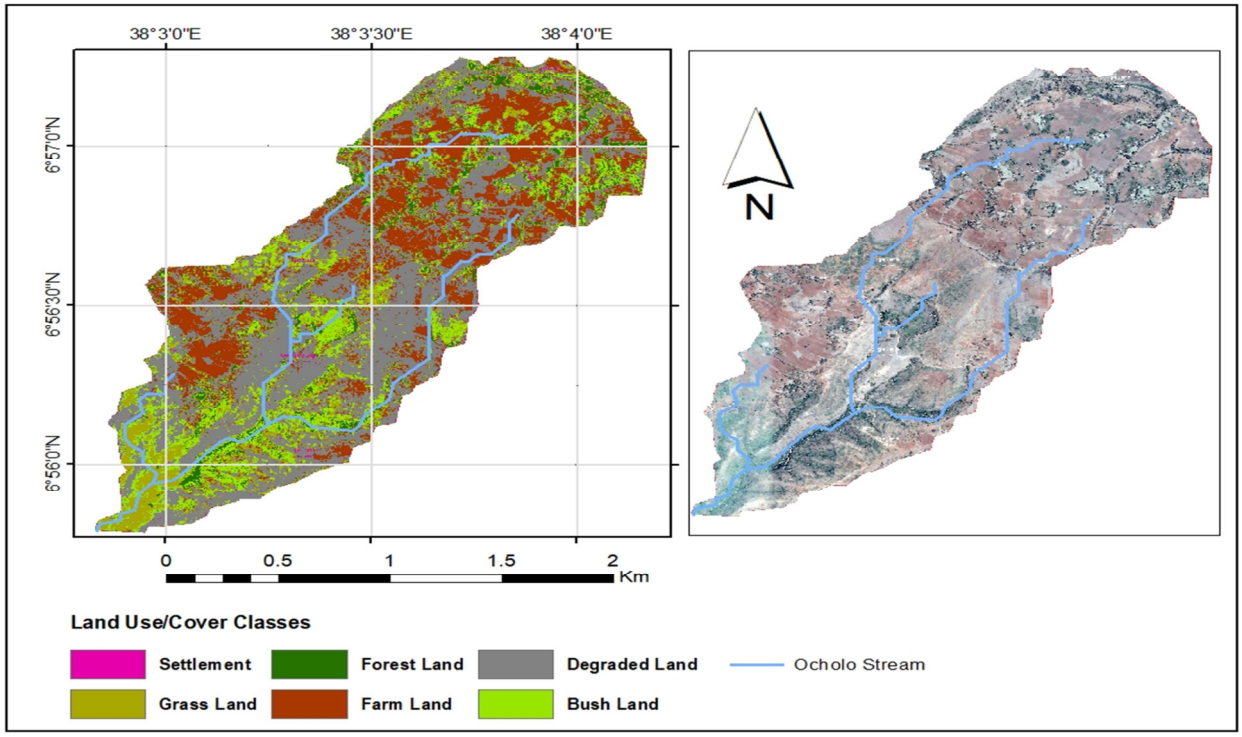
S.No.	Land Use/Cover Type	Area in Hectare	Area in Percent
	Degraded Land	**129.3**	**27.7**
	Farm Land	**105.6**	**22.6**
	Grass Land	**94.5**	**20.2**
	Bush Land	**68.1**	**14.6**
	Settlement	**37.3**	**8.0**
	Forest Land	**32.1**	**6.9**
Total Area		**466.9**	**100.0**

Figure 3: Base-Map of Chille Micro Watershed

4.4 Base-Map of Ocholo Micro Watershed

The base-map of Ocholo Micro Watershed shown in figure 4 below indicates that the majority of the existing land cover constituting 30.5percent or 94.2 hectare land of the watershed is degraded land. The second largest land use at this Micro Watershed is farmland which covers 23.5percent or 72.5 hectare. Thirdly, 18.1percent or 56 hectare land covered by grass and the fourth share is bush tree coverage constituting 14.3percent or 94.1hectare. The watershed has the least proportion of only 19.8hectare or 6.3percent forest cover preceded by only 22.7hectare or 7.3percent of human settlement.

Geographical distribution of the land covers of this Micro Watershed indicates that degraded land is found largely through the central part to south dimension, the forest & bush lands are found in the northern and southern margins, farm land is boldly found to the north orientation while grassland is largely located at the southern & northern parts of the watershed as shown in figure 4 below.



S.No.	Land Use/Cover Type	Area in Hectare	Area in Percent
	Degraded Land	94.2	30.5
	Farm Land	72.5	23.5
	Grass Land	56.0	18.1
	Bush Land	44.1	14.3
	Settlement	22.7	7.3
	Forest Land	19.4	6.3
Total Area		308.9	100.0

Figure 4: Base-Map of Ocholo Micro Watershed

4.5 Development-Map of Chille Micro Watershed

The proposed conservation strategies for the dominantly found degraded land include: bench terrace, deep trench, stone bund and hill side terrace. For the farm land areas; Faniyajuu, soil bund, trench, bench terrace, and cut off drains are suggested. For the grasslands; cut & carry system, cut off drain, deep trench area closure are proposed.

The areas where there are bushes; plantations of trees, SWC methods such as trench are the proposed development strategies. The limited forest coverage found in this micro watershed should have area closure for the protection of these resources and its rehabilitation.

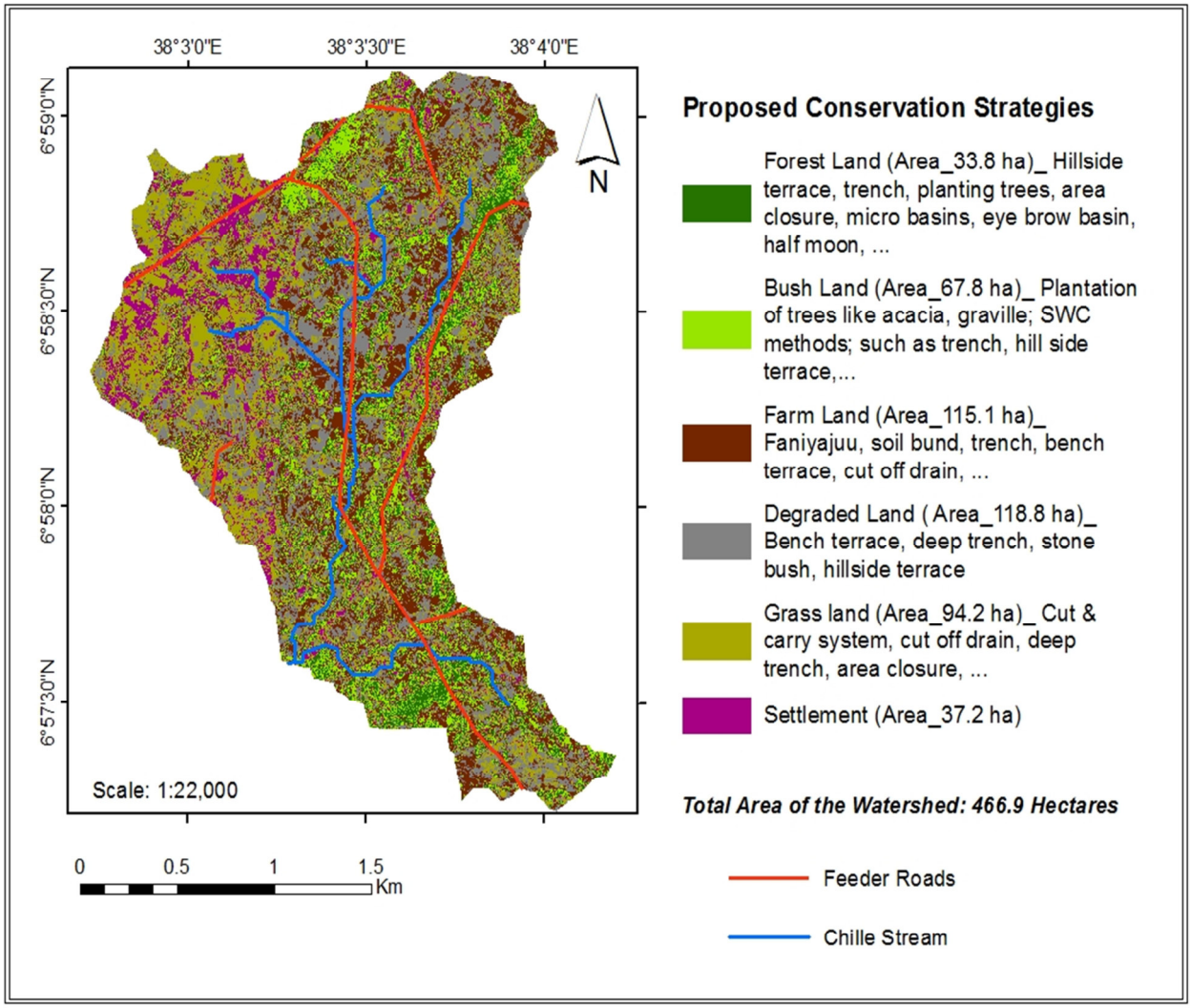


Figure 5: Development Map of Chille Micro Watershed

4.6 Development-Map of Ocholo

In the same manner to that of the Chille Micro Watershed, proposed conservation strategies for the dominantly found degraded land include: bench terrace, deep trench, stone bund and hill side terrace. For the farm land areas; Faniyajuu, soil bund, trench, bench terrace, and cut off drains are suggested. For the grasslands; cut & carry system, cut off drain, deep trench area closure are proposed.

The areas where there are bushes; plantations of trees, SWC methods such as trench are the proposed development strategies. The limited forest coverage found in this micro watershed should have area closure for the protection of these resources and its rehabilitation. The geographic dimension for each of the watersheds varies but their respective proposed conservation strategies are similar.

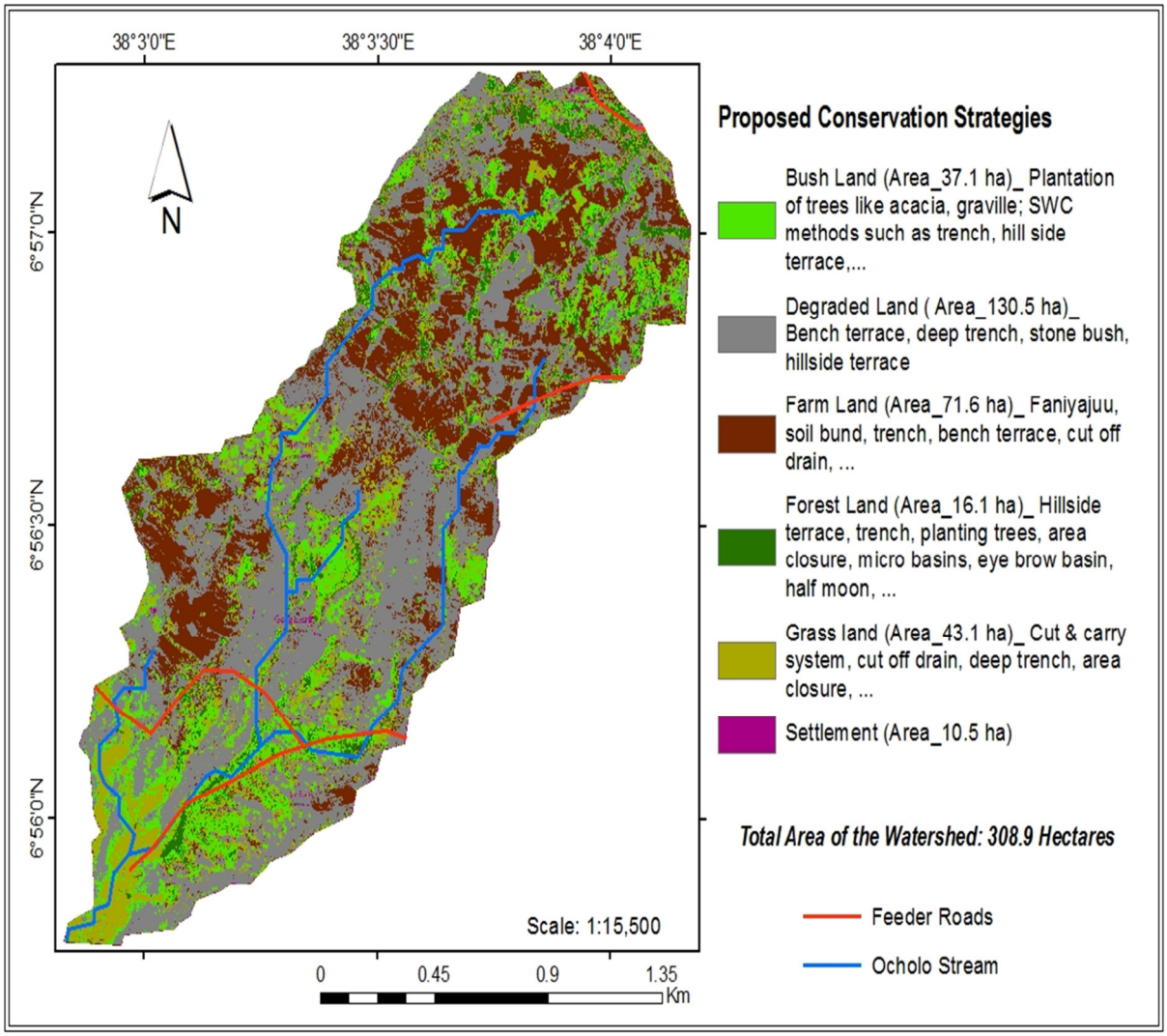


Figure 6: Development Map of Ocholo Micro Watershed

5. Summary and Possible Recommendations

The approach of Watershed development is widely accepted as the approach best suited to address the sustainable use and management of resources. Even if planning watershed development traced back to 1980s in Ethiopia, its large-scale development has been limited to conserve natural resource. In Ethiopia, the country at large and the study area, Duguna Fango Werda, specifically is currently facing a number of environmental concerns resulting directly or indirectly from inappropriate agricultural practice and exploitation of natural resource base. The study area is characterized by serious soil erosion problem. Scarce vegetation cover associated with erosion induced factors exposing the area to high rates of soil erosion and loss of soil fertility. Due to these problems, watershed development at Chille and Ocholo micro watersheds in Duguna Fango Woreda was needed.

Toposheet maps of Wolaita Zone with the scale of 1:50,000 and SRTM DEM having 20 meter spatial resolution was used to produce the location map and delineate area of Chille and Ocholo micro watersheds. Landsat ETM+5 satellite imagery of the study area having 30meter spatial resolution was imported into ERDAS Imagine 2014 software for base map production. Development map production was also done using image classification of Landsat ETM+5 satellite imagery by ERDAS Imagine 2014software.

The area of Chille Micro Watershed is 468.8 Hectares whereas that of Ocholo is 309.3 Hectares. Chille Micro Watershed covers wider extent than that of Ocholo.

The majority of the existing land cover, constituting 27.7percent or 129.3 hectare land of Chille, is degraded land followed by 22.6percent or 105.6 hectare farmland. Its least proportion is human settlement and forest land that constitute only 37.3hectare or 8percent and 32.1 hectare or 6.9percent land cover respectively. Geographically, its degraded land is found largely through north to south orientation, the forest & bush lands are in the northern and southern margins, farm land is through north to south orientation while grassland is largely at

the western dimension of the watershed.

The base-map of Ocholo Micro Watershed shows that its majority, 30.5percent or 94.2 hectare, is degraded land followed by 23.5percent or 72.5 hectare farmland. The watershed has the least proportion of 19.4hectare or 6.3percent forest cover preceded by 22.7hectare or 7.3percent of human settlement. The largest land use proportion of Micro Watersheds is degraded land followed by farmland while their least proportion is human settlement and forest cover. Geographical distribution of the land covers of this Micro Watershed indicates that degraded land is largely through the central part to south dimension, the forest & bush lands are in the northern and southern margins, farm land is boldly to the north orientation while grassland is largely at the southern & northern parts of the watershed.

To develop both Chille and Ocholo watersheds, the proposed conservation strategies include bench terrace, deep trench, stone bund and hill side terrace for the dominantly found degraded land. Faniyajuu, soil bund, trench, bench terrace, and cut off drains are suggested for the farm land areas; for the grasslands; cut & carry system, cut off drain, deep trench area closure are proposed. The areas where there are bushes; plantations of trees, SWC methods such as trench are the proposed development strategies. The limited forest coverage found in this micro watershed should have area closure for the protection of these resources and its rehabilitation.

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