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VEGETATION DYNAMICS ANALYSIS USING NORMALIZED DIFFERENCES VEGETATION INDEX AS INDICATOR OF RESTORATION OR DEGRADATION, SOUTH WOLLO ZONE, NORTHERN ETHIOPIA

BY

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This is to certify that project presented by Shewangzaw Moges entitled: *Vegetation dynamics analysis using Normalized Differences Vegetation Index as indicator of restoration or degradation, in South Wollo zone, Northern Ethiopia* and submitted in partial fulfillments of the requirements for the degree of master of arts in Geography and Environmental Studies with complies with the regulation of the university and meets the accepted standards with respect to originality and quality.

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Abstract

Ethiopia is facing rapid deforestation and degradation of land. To overcome this serious problem, the Government of Ethiopia has taken different measures such as policy interventions, conducted studies, and implemented massive soil and water conservation (SWC) and capacity building programs. The study analyzed normalized difference vegetation index as indicator of vegetation restoration/degradation, in South Wollo, Northern Ethiopia. The study analyzed inter-annual normalized difference vegetation index (NDVI) changes using MODIS data. The analysis was based on data from 2000 to 2011, by classifying in to three parts, i.e., from 2000 to 2005, 2006 to 2011, and 2000 to 2011 for the dry seasons. Between 2000 and 2005 degradation was greater than restoration but the rest two section (2006 to 2011 and 2000 to 2011) show general vegetation restoration. The statistical result indicated that in the period the area shows significant restoration and degradation at 90% and 95% confidence interval. The study also shows vegetation dynamics across the slope by using cross tabulation method. Average 2000 NDVI cross tabulation indicated that more vegetation dynamics is shown in lower (0-10^{o}) slope interval but little vegetation dynamics in higher slope interval. However, vegetation restoration is slightly greater than degradation in higher slope interval. On the other hand Average 2005 show almost balanced vegetation degradation and restoration between 0 and 10 degree slope but in higher slope interval i.e.40 degree and above vegetation restoration higher than degradation. Average 2011 cross tabulation also the same with earlier but in lower slope area vegetation degradation mach greater than restoration. Generally in higher slope area vegetation restoration greater than degradation that indicates it is not accessible for the expansion of Agriculture. On the other hand in lower slope area vegetation degradation greater than restoration which indicates the area more accessible for the expansion of agriculture.

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List of Acronyms

CSA	Central Statistics Authority
EFAP	Ethiopian Forestry Action Program
IFPI	International food policy research institution
EMR	Electromagnetic radiation
FAO	Food and Agricultural Organization
FINN IDA	Finished International Development Agency
GPS	Global positing system
GIS	Geographic information system
Ha	Hectare
HDF	Hierarchical Data Format
MOA	Ministry of Agriculture
MODIS	Moderate Resolution Imaging Spectrometer
M.a.s.l	Meters above sea level
MRT	MODIS Re-projection Tool
NIR	Near infrared
NDVI	Normalized Difference Vegetation Index
PGRC	Plant Genetic Resource Center
RS	Remote sensing
RSS	Residual
SE	Standard Error
SERI	Society for Ecological Restoration International
SWC	Soil and Water Conservation
TFYP	Transitional Five Yeas Plan
T_o	Time
UNDP	United Nation Development Program
UNEDP	United nation Environmental Development program
UNEP	United nation Environmental program
UNSO	United Nation Sudano Sahelian Office
VI	Vegetation Indices
Var	Variance
Yr	Year

1. INTRODUCTION

1.1 Background

Land degradation is happened in different part of the world, but it is severe in developing countries, particularly in africa, where resources over-exploitation and inappropriate land use such as over-grazing, deforestation, expansion of cultivation land were aggravated. Agricultural practices are considered as the major causes of land degradation. as a result of this, almost all inhabited lands in Sub-Sahara Africa (SSA) are prone to soil and environmental degradation (Nana- Sinkam, 1995 and FAO, 2004). Deforestation can be one of the factors for this land degradation.

Forest provides different benefits for human being such as for wood, food, income, and watershed protection. It is also an important and plays critical role in enabling people to secure a stable and adequate livelihood supplies. Moreover, forests have great contribution to food security, and to provide other benefits, such as fuel wood and fodder (Girma, 2001).However, they are depleted through time by different causes.

Ethiopian population has been growing at a fast rate which grew from 12 million at the beginning of the 1900s to 74 million in 2007, i.e., at a rate of <1.3% before 1950 and by 2.6% between 1994 and 2007 (Logan, 1946; CSA, 2008; Sørensen and Bekele, 2009). This is the major cause in Ethiopia for the conversion of forest and marginal lands into agriculture by using inappropriate agricultural practices. The Ethiopian highlands are most vulnerable to the land degradation problems (Shiferaw and Holden, 1999).

Degradation in Ethiopia, however, is impairing the capacity of forests and the land to contribute to food security and to provide other benefits such as fuel wood and fodder. Ethiopia is facing rapid deforestation and degradation land. To overcome this serious problem, the Government of Ethiopia has taken different measures such as policy interventions, conducted studies, and implemented massive soil and water conservation (SWC) and capacity building programs, especially after the severe drought of the failed 1974/75 and 1984/85 rainy seasons (Shiferaw and Holden, 1999; Tilahun, 2006). Soil and Water conservation measures were implemented largely in the prone areas, including in Wollo. The interventions were focused on both mechanical and biological measures. The major mechanical measures include construction of bunds, check dams, micro-basins and hillside terraces. The biological measures include enclosure of degraded land from human and animal interferences (exclosures), tree seedling production, planting of tree seedlings on farmlands (agro-forestry), afforestation, and tree plantations around the homesteads and tree plantation in exclosures as enrichment to the natural regeneration (Mekuria et al., 2011). Closed areas or exclosures are rehabilitation techniques which are implemented on degraded land. In practice, these areas are closed for grazing and most other agricultural uses and controlled by guards. Especially, in the Northern Ethiopia natural vegetation that re-growth in exclosures has a positive impact on formerly degraded commons where they constitute green spots with considerable species diversity. The ability of exclosures to recruit and sustain new species, which illustrate their contribution to biodiversity and forest conservation, is considerable (Tucker and Murphy, 1997).

GIS is mostly known tool for ecosystem management and has provided an enhanced capability for research scientists to develop and apply land use models. Because, it has the capacity to work with organizing large datasets, integrating with most image analysis and processing systems, its application in recourse monitoring is vital. It has become increasingly useful tool in many natural resource disciplines, including plant ecology. The ability to track vegetation change through time and to make predictions about future vegetation change is just two of the many possible uses of GIS (Bakker et al., 1994).

Remote sensing has indispensible role for vegetation dynamics assessment. For example, the spectral signatures of photo-synthetically and non-photo-synthetically active vegetation showed obvious difference and could be utilized to estimate forage quantity and quality of grass prairie. Over the last a few decades, numerous advances have been made in the development of remote sensors and geographic information systems (GIS) and their linkages with land use change models to assess the influence of land cover on biophysical processes and conditions. For example it used for assessment of land degradation, ecosystem vulnerability, watershed condition, and biodiversity (Guisan and Zimmermann, 2000).

1.2 Statement of the problem

Like all biological systems, plant communities are temporally and spatially dynamic; they are changed at all possible scales. Dynamism in vegetation is defined primarily as changes in species composition and/or vegetation structure (Barbour et al., 1987).

Deforestation in Ethiopia happens in different ways, among them; for fuel wood, expansion of farmland, production of charcoal and over grazing. It has been taking place unrestrained for centuries. In consequence, changes in local environment particularly, decline in natural vegetative cover is widespread in Ethiopia and the local environmental changes in turn affect livelihoods of local populations (Kahsay, 2004).

To reduce the widespread and deep socio-economic and environmental consequences of deforestation as well as land degradation, several land rehabilitation measures have been implemented in Ethiopia. Among the measures have been taken, the establishment of fast growing plantations of exotic species and area enclosures are the most prominent (Alemneh, 1992; Mulugeta, 2004). Area enclosure is simply as excluding human and livestock populations from degraded lands to activate natural succession and rehabilitation is assumed to reverse environmental degradation and loss of biodiversity and it can be used as a strategy for biodiversity conservation, reduction of soil erosion and minimizing flooding hazards. It improves soil quality and productivity by enriching soil nutrients through nutrient recycling, built soil organic matter and reducing loss of nutrients from a site (Bkele, 2001).

To afforest the degraded area, service time and difference in agro-ecological and also topographic conditions has been taken in to consederation. Furthermore, SWC structures construction demands huge resources (finance, labor, materials and equipment), and the adoption and recommendations of the SWC interventions should be justified by empirically proven evidence (Badege, 2001; Nyssen et al., 2007). The study that is conducted by Shemeles Damene (2012) both North Wollo and South Wollo show that the general vegetation dynamics between 2000 to 2010. But this Study has found that vegetation dynamics five years before the Ethiopian land use policy proclamation (2000 to 2005) and five years after the proclamation (2006 to 2011) and also differentiate among each other as well as with overall vegetation change (2000 to 2011). Because the land use proclamation give high consideration forest resource management. As Federeral *Negarit Gazeta* of the federal democratic republic Ethiopia (2005), displayed that, any types rural land where soil and water conservation works have been under taken a system of free grazing shall be prohibited and a system of cut and carry feeding shall be introduced step by step. The slope is less than 30% shall follow the strategy of soil and water harvesting. The slope which is 31 to 60% may be allowed only through making bench terraces. The slope which is more than

60% shall not be used for farming free grazing. They shall be used for development of trees, perennial plants and forage production. Rural land of any slope which is highly degraded shall be closed from human. The overall and animal interference from a given period of time to let it recover, and shall be put use when ascertained that it has recovered. Unless the degradation is caused by the negligence of the peasant farmers, semi-pastoralist and pastoralist the users shall be given compensation or other alternatives for the interim period (FNG-FDRE,2005). It clearly shows that the Soil and Water conservation activates has been improving the vegetation cover of the area. also Understanding the direction of Soil and Water Conservation, and its implications on vegetation regeneration is important to plan for a sustainable land management and local economic development. To address this objective, it needs to combine data from remote sensing and ground serving.

1.3. OBJECTIVE OF THE STUDY

1.3.1. General Objective:

The overall objective of the research is to assess implication of soil and water conservation (SWC) intervention, particularly the biological measures (i.e., exclosure, afforestation, and reforestation) on vegetation cover dynamics using NDVI.

1.3.2. Specific objectives

- to analyze the spatio-temporal vegetation dynamics processes using Normalized Deference Vegetation Index (NDVI) by dividing in to three period (i.e., 2000 to 2005, 2006 to 2011 and overall change from 2000 to 2011) for the dry periods
- to analyze spatio-temporal green vegetation dynamics across the slope

1.4. Significance of the study

In the Ethiopian context without technological and economic advancement of the rural people's livelihood mostly depends on local natural resources. These natural resources determine every activity of the people. At present, due to natural and anthropogenic forces, natural resources have been declining and modifying. This study can show the vegetation dynamics from 2000 to 2011 in South Wollo Zone of the Amhara region, Ethiopia. At the end of the analysis, this research can show the relationship of vegetation dynamics to soil and water conservation Intervention. As the result of this, the policy makers can use this decision making in regarding to vegetation dynamics, soil and water conservation intervention.

1.5. Scope and Limitation of the study

This study is delimited vegetation dynamics analysis by using normalized deference vegetation index in relation to soil and water conservation intervention in south Wello zone of the Amhara National Regional State. Therefore, it does not cover other aspects of land use and land cover change and related biophysical and livelihood change.

Generally, the study has some limitations. First, it lacks information about irrigated areas in south Wello. This can affect the clear vegetation covered area by making simulation. Second, the study is limited by financial constraints and absence of transport access in order to collect sufficient ground control points. It was so difficult to sufficiently physically investigate area particularly exclosure and afforested areas in the study area.

1.7. Project outline

This project work consists of five chapters. In the first chapter, a general introduction about vegetation dynamics and soil and water conservation is presented. The problem statement, objectives, significance and scope of the study are also discussed in this chapter. The second chapter is about literature review. The literature review includes topics about capabilities and applications of GIS and RS for vegetation detection, concepts and positive impacts of water and soil conservation on vegetation improvement, deforestation, vegetation regeneration. The third chapter consists of background to the study area and materials and methods used in the study. The fourth chapter presents the results and discussions of the study. The last chapter presents the conclusions and recommendations

2. REVIEW OF RELATED LITERATURE

This chapter reviews topics and studies that directly related to the current study. As the study tries to detect vegetation dynamics, first it presents the capability and application of GIS and RS technology for NDVI vegetation dynamics detection. Secondly, it reviews both local and global literature on vegetation dynamics (deforestation or restoration). Thirdly; it reviews the impacts of soil and water conservation including enclosures on vegetation dynamics.

2.1. The role of geographical information system and Remote Sensing in Vegetation Dynamics Assessment

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. It is a tool that allows users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. The idea of the geographical information systems emerged during the 1960s and 1970s as new trends arose in the means in which maps were being produced and used for resource assessment, land evaluation and planning. Essentially, this concept focuses on the ability to develop a powerful set of tools for collecting, storing, retrieving, transforming, and displaying spatial data from the real world for specific analysis and inquiry (Clarke, 1986).

Geographic Information System (GIS) is an emerging technology encompassing many disciplines namely: geography, cartography, remote sensing, surveying, global positioning system (GPS) technology, statistics and other disciplines concerned with handling and analyzing spatially referenced data (Heywood et al, 2002).

GIS is mainly comprised of data handling tools for storage, retrieval, management and analysis of spatial data as well as solving complex geographical problems and the application of such data to decision making. GIS can also be used for the generation of new information by the user-defined combination of several existing information. Because of the various distinguishing features of GIS, it is considered as an indispensable tool for conducting spatial searches as well as overlays and association of the spatial data with the non-spatial attribute data to eventually generate useful information. The distinguishing feature of GIS is its capability to perform an integrated analysis of spatial and attribute data, and it can be used not only for automatically producing maps, but also it is unique in its capacity for integration and spatial analysis of multisource datasets (Malczewski et al, 2003). GIS is a widely accepted tool for ecosystem management and has provided an enhanced capability for research scientists to develop and apply land use models because of the capacity to work with and organize large datasets in addition to the ability to integrate with most image analysis and processing systems. It become increasingly useful tools in many natural resource disciplines, including plant ecology. The ability to track vegetation change through time and to make predictions about future vegetation change is just two of the many possible uses of GIS (Bakker et al., 1994).

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans (Campbell, 2002).

A remote sensing sensor is a key device that captures data about an object or scene remotely. Since objects (including vegetation) have their unique spectral features (reflectance or emission regions), they can be identified from remote sensing imagery according to their unique spectral characteristics. A good case in vegetation mapping by using remote sensing technology is the spectral radiances in the red and near-infrared regions, in addition to others. The radiances in these regions could be incorporated into the spectral vegetation indices (VI) that are directly related to the intercepted fraction of photo-synthetically active radiation (Asrar et al., 1984). The spectral signatures of photo-synthetically and non-photo-synthetically active vegetation show obvious difference and could be utilized to estimate forage quantity and quality of grass prairie (Beeri et al., 2007). Over the last a few decades, numerous advances have been made in the development of remote sensors and geographic information systems and their linkages with land use change models to assess the influence of land cover on biophysical processes and conditions. For example it is in use to asses land degradation, ecosystem vulnerability, watershed condition, and biodiversity (Guisan and Zimmermann, 2000).

Today, remotely sensed data in the form of classified land cover are used to derive input variables for a wide variety of environmental models. For example for hydrologic-response and habitat models with the increasingly widespread combined implementation of remote sensing and GIS technologies, more natural resource professionals have been provided with efficient and accurate tools for mapping and maintaining management information on forests and other natural resources in regional areas (Miller et al., 2007).

Analyses of forest degradation and change in land use are major examples of applications of remote sensing. In remote sensing, images from different years can be compared. These images must be captured during the same time of year so as to minimize the expression of variations in such factors as light quality, the geometry of the observation and differences in the behavior of a community over the course of the year, in the case of plant ecosystems (Singh, 1986).

2.2. Capabilities and application NDVI on vegetation dynamics

In remote sensing, information transfer is accomplished by the use of electromagnetic radiation (EMR), which is the form of energy that reveals its presence by observable effects, it is produced when it strike the matter (Gonzales, 2007)

Digital image processing of satellite data provides tools for analyzing the image through different algorithms and mathematical indices. Based on reflectance characteristics, indices have been devised to highlight features of interest on the image. There are several indices for highlighting vegetation bearing areas on a remote sensing scene. Normalized Difference Vegetation Index (NDVI) is a common and widely used index (Chuvieco, 1998).

Ecosystem changes can be detected and quantified using multi-temporal satellite observations of the land surface. Different states of the land surface can be measured by satellite-derived biophysical parameters (Jonckheere, 2004). The Normalized Difference Vegetation Index (NDVI) is a remotely-sensed measure of vegetation greenness and is related to structural properties of plants like leaf area index and green biomass and also to properties of vegetation productivity like absorbed photosynthetic active radiation and foliar nitrogen (Fensholt, 2004).

NDVI is an indicator of vegetation health, because degradation of ecosystem vegetation or a decrease in green would be reflected in a decrease in NDVI value. Therefore, if a relationship between the quantity of an indicator – aerial biomass – in various forest ecosystems and the NDVI can be identified, processes of degradation and regeneration can be monitored (Tovar, 2011).

There are various methodologies for studying seasonal changes in vegetation through satellite images, one method of which is to apply vegetation indices relating to the quantity of greenness (Chuvieco, 1998). The NDVI is a measurement of the balance between energy received and energy emitted by objects on Earth. When applied to plant communities, this index establishes a value for how the green area is the quantity of vegetation present in a given area and its state of health or Vigor of growth.

Variations in the reflectivity of surface materials across different spectral bands provide a fundamental mechanism for understanding features in remotely-sensed multispectral imagery. Chlorophyll is the key factor in reflectivity of vegetation. It absorbs strongly in red, giving rise to our visible observation that healthy vegetation is green. But chlorophyll reflects most strongly in very near-infrared (VNIR) just beyond the visible and NDVI is a dimensionless index and its values range from –1 to +1. In a practical sense, the values that are below 0.1 correspond to bodies of water and bare ground, while higher values are indicators of high photosynthetic activity linked to scrub land, temperate forest, rain forest and agricultural activity. It can be calculated using $\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{Red})\,/(\mathrm{NIR} + \mathrm{Red})$(Bradley, 2007).

2.3. Vegetation dynamics in Ethiopia

Vegetation dynamics could be positive or negative changes through elapsed time. Under this, deforestation, vegetation regeneration and area of enclosures in Ethiopia have been reviewed.

2.3.1. De-vegetation and Deforestation in Ethiopia

Deforestation is the removal or damage of vegetation in the forest to the extent that it no more supports its natural flora and fauna (FAO, 2004). In the same way which is explained by AGI (2007), deforestation is here taken to mean the large-scale removal or partial removal of trees from forested areas, which may be done deliberately by human being or due to natural causes.

The Ethiopian forests are being depleted at an alarming rate. At the turn of the last century, around the year 1900 the forest cover in Ethiopia was 40 %, and in 1989 estimated put it at only 2.3% of the land mass (EFAP, 1994). This deforestation has been carried out in many parts of the country. However, deforestation is rapidly becoming the most serious problems in rural Ethiopia where the majority of the population live and depend on the forest products for energy, Forest fulfill central role in rural livelihoods, providing a wide range of products and services for subsistence use, cash income, and safety nets in times of need. Particularly, rural households depend on forest and wood land resources to meet their energy needs, to provide construction and roofing materials, and to provide fodder for livestock (Tumbe et al., 2005, Schereckenberg, et al., 2007). In addition, wild fruits ensure healthy diet as well as a supply of medicinal plants.

Many factors are responsible for vegetation deforestation in Ethiopia, such as the increasing population of Ethiopia has resulted in excessive forest clearing for agricultural use, overgrazing and exploitation of the existing forests for fuel wood, fodder and construction materials have been reduced the forest areas of the country (Badege, 2001).

Rural peoples and a significant number of urban dwellers depend solely on biomass energy for cooking and in some cases even for lighting. Therefore, wood is vital sources of domestic energy, besides the need for construction and production of farm implementation and household furniture. Especially, the energy sector remains heavily dependent on wood for fuel. Wood provides 78% of the energy required, while livestock dung and crop residues provide 16% (Bekele, 2001).

In relation with the forest is lost due to the subsistence-oriented farmers' unsustainable resource-use practices including clearing up of steep lands of vegetative cover in the quest of fuel wood and croplands. On the other hand, introducing more animals create conditions which are likely to lead to deforestation and land degradation (Berry, 2003).

Deforestation has many comprehensive impacts in different parts of the country. Deforestation reduces biological diversity, it increases soil erosion and the siltation of rivers and streams can endanger hydroelectric schemed (Karkee, 2004). It is possible to say that deforestation is another form of land degradation that affects the life of people in general and the rural population in particular. The disappearance of natural forests in developing countries is a major problem because it negatively affects the livelihoods of people dependent on forest products and services (Brosius, 2005). Additionally, deforestation has impacts of economic activity, which threatens the livelihood and cultural integrity of forest-dependent people at local level because it reduces the supply of forest products which leads to siltation, flooding and soil degradation. Clearing forests and the subsequent agricultural development has a detrimental effect on every element of local ecosystems such as microclimate, soil and aquatic conditions, and most significantly, the ecology of local plants and animals including human disease factors (Claus, 2006)

2.3.2. Vegetation Restoration in Ethiopia

Forest restoration in passive or active processes can be a primary component of conservation and sustainable development programs, which provide people with the opportunities not only to repairing the damaged ecology, but also it is directly related to improve the human conditions by creating livelihood diversifications and renew economic opportunities, restore traditional and cultural practices, and growth the work habit with confidence of local communities (SERI, 2004). Restoration evolves returning native species to an area, stabilizing soil and reducing soil erosion. The influence of trees in soil physical properties is also very important in augmenting the overall capacity of the land to be productive. In this regard enclosures played an important role in conserving remaining soil resources and improving soil fertility. They improved soil fertility by adding soil nutrients from decomposed plant remains. Enclosures also reduced nutrient loss from a site by controlling runoff (vegetation acting as a physical barrier to soil erosion) (kibret, 2008). Proper conservation of genetic resources in country like Ethiopia can only be achieved through a well established system, under which biological resources are sustainably exploited for immediate use and species continue to evolve with the dynamic force of their habitat. Despite limitation in resources to achieve immediate solutions for minimizing the rate of the loss of biological resources, Ethiopia is making efforts to conserve soil and water, and rehabilitating degraded lands by natural means (enclosure) and human intervention (tree planting on degraded land that lost its productivity). Strategies are designed to effect conservation for domesticated and wild flora and fauna within natural and human managed ecosystems to conserve the genetic variation within and among species. Forest landscape restoration incorporates both biophysical and socioeconomic values; that is, ecosystem restoration as well as the changes in human well-being associated with it. The main focus of forest restoration considers the social and economic impacts of forest restoration initiatives, particularly the effects on people living in or near the restored areas (PGRC, 1995).

The Ethiopian forest plantations have long historical background that started by the turn of the 19th century when Emperor Menelik requested his advisor to get him a fast growing tree species to overcome the fuel wood shortage he faced at the time. During the early 19th centuries, it was reported most of Addis Ababa was covered by forests and there were about 13,500 hectares of Eucalyptus plantation in 1964. However, the rapid expansion large scale and community plantation occurred during the Derg regime, which resulted in the establishment of large scale plantation activities. During this time, several fuel wood project funded by UNSO,UNDP and FINN IDA spread throughout the country with marked concentration around the big cities such as Bahir Dar, Dessie, Gonder, Nazerate, Adiss Abeba and Debre Brehan (FAO, 1985). The extent of conservation activities through the use of food aid escalated tremendously and the conservation continued to grow arithmetically though the implementation, which could not keep pace with the plan. Up to 1986, food aid used for payment of conservation and related works as food-for-work payment accounted for approximately 29% of total food aid (71% of the food aid was distributed as emergency food). With this, Ethiopia became the largest food–for-work program beneficiary in Africa and the second largest country in the world following India (Campbell, 1991). Between 1976 and 1988, some 800,000 km of soil and stone bunds were constructed on 350,000 ha of cultivated land for terrace formation, and 600,000 ha of steep slopes were closed for regeneration (Menfesse, 1992). Ethiopia's forest resource conservation, development and utilization today is not the product of a long evolving process in which different land-use planning measures have been devised and used to meet changing needs and various ecological conditions of the country. The absence of sound and comprehensive land-use policies encompassing the identification, selection and appropriation of suitable areas for forestry development based on production and environmental protection is the outstanding forestry problems in Ethiopia. But know the state has given high consideration and by grate mobilization of the community in the rural part of the country, there is appreciated plantation activity has been carried on (MOA, 1991).

2.4. The positive impacts of soil and water conservation on vegetation restoration

Soil and water conservation activity is most crucial for highland country like Ethiopia with increasing soil moisture and reduce soil erosion. The activity has been conducted vegetating grass trips constructing contour leveling and it incorporating tree or hedgerows, to reduce runoff velocity and allow water to infiltrate and also trap sediments (EFPI, 2009).

The Ethiopia land configuration is mostly dominated by the high land. In the Ethiopian highlands case, the decline of soil fertility and severs most soil erosion is due to water outflow on steep and fragile land that has been under intensive farming (Amsalu and de Graaff, 2006). In 1986, estimations of the erosion damage were as followed: regarding the highlands, 50% were significantly eroded, of which 25% are seriously eroded and 4% of those are impossible to regenerate (FAO, 1986). In order to improve agricultural productivity and rural livelihoods, Promotion of SWC measures have been suggested by the scientific literature as a key adaptation strategy for developing countries and more particularly in Sub Share Africa. It may be carried on in different way, but compared with the dramatic increase of soil erosion problems in Ethiopia. Traditional soil conservation practices were limited to ´´few" areas and rendered ineffective due to reduced vegetative cover and inappropriate land use systems such as overgrazing and destructive farm management practices (Hurni, 1988)

Historically soil conservation activity in Ethiopia was very localized and insignificant before the mid seventies. Polices related to land, the most important resource for the rural poor and of the national governments at different time played an important role in land management in Ethiopia. During the feudal regime, prior to 1974 revolution, land tenure system made tenants to be subject to insecure land tenure, and expropriation of large portion of their product and labor by landlords. This created disincentive for adoption of soil conservation (Wagayehu, 2003). Furthermore, the agricultural sector in general and the peasant agriculture in particular did not get the policy attention it deserved due to the focus of the country's development plan on industrial development agenda. According to Dejene (1990), the first two five year plans (1957-62 and 1962-1967) gave priority to large scale commercial farms and exportable crops. The third five year plan (1968-1973) put much emphasis on high input package programs to be implemented in few high potential agro-ecological areas where quick return was expected (Dejene, 1990). Small farmers that cultivate almost all-agricultural land and who are complained to be agents of soil degradation, and areas that did not promise return in short term but susceptible to soil degradation, failed to get policy attention. Therefore, policy attention towards industry combined with complex system of land tenure variously dominated by absentee landlords, local administrators, church estates and forms of private and freehold tenure hindered the effort to conserve land (Campbell, 1991).

The military regime that took over in 1974 proclaimed land reform. The reform abolished feudal land tenure system and eliminated large holding, landlessness and absentee landlordism. Although this was expected to improve the situation and provide incentive for investing in soil and water conservation, it could not succeed triggering adoption of conservation practices. This was because, these reforms were later liquidated by misguided policies and ardent socialist orientation. The Transitional Five Year Plan (TFYP) Ministry of Agriculture (MOA, 1969) specially recommended the establishment of soil and water conservation division within the Ministry of Agriculture after identifying the problems of soil erosion in the North and Eastern part of the country. The major difficulties in the highlands were erosion on steep slopes and poor drainage. Study by Lund University Geography Group (Helden, 1987) showed that land cover is the most important factor controlling soil erosion.

As Ethiopia Development Research Institute stated that , all soil and water conservation technologies considered stone and soil bunds, grass strips, waterways, trees, and contours show positive and highly significant impacts on crop output in the low-rainfall areas, but only waterways and trees show strong and significant positive effects in high-rainfall areas. Grass strips show the largest effect on crop yields among the technologies used in low-rainfall areas (EDRI, 2006).

In the case of South Wollo, there was soil erosion like the other parts of the country. To combat the negative consequences of soil erosion in this area, the government of Ethiopia implemented various mechanical and biological soil and water conservation measures in various parts of the country where, farmland terracing is widely implemented practice. The primary objectives of the government-initiated SWC interventions are to reduce soil erosion, improve environmental conditions and stabilize or improve agricultural productivity (Lal, 2003). Despite the long history of terracing in very few parts of the country and the current efforts to extend it, some farmers oppose terracing stating that it is labor intensive, harbors rodents, decreases the size of cultivable land, and leads to soil fertility and crop production gradients within a terrace (Nyssen, 2007) .

2.4.1. Advantages of Area of Enclosure on Vegetation Regeneration

Area of enclosure is the proper method to perform the water and soil conservation in Ethiopia. According to experimental research, enclosures are units or plots in which living things are confined, for instance to reveal competitive relationships between different animal species (Manor and Saltz, 2008). In the enclosures, vegetation recovery typically starts with a rapid increase in diversity and cover of the herbaceous layer. After three to five years, shrub and tree species gain importance and start to suppress the herb layer (Asefa et al., 2003). But in the case of exclosures, unwanted animals and plants are excluded and their main purpose is to keep things out of a given area. Some other common terms are related to the concept of ‘‘exclosure’’ but not with that of ‘‘enclosure’’. The term ‘‘closed area’’ is primarily used in marine and freshwater biology where it usually refers to areas where fishing is forbidden or suspended (Hunter et al., 2006; Moustakas et al., 2006). ‘‘Protected area’’ has a similar, but broader meaning, and usually refers to more formal conservation areas (Grech and Marsh, 2008).

Experimental exclosures have been widely used as treatments to exclude (or statistically control for) the effects of predation or herb ivory on species richness and recruitment in plant and animal communities. Fence is the typical example of exclosures that prevent animals from entering, to increase experimental control, and it is possible to only exclude targeted species from the fenced area while allowing other animals to move freely (Vercauteren et al., 2007). Fencing off areas in this way is a common practice in forest management throughout the world because high tree seedling mortality is often related to high browsing pressure by large or small herbivores (Coop and Givnish, 2008).

This activity performed in different parts of the Ethiopia region, especially in the northern parts of Ethiopia. Natural vegetation that re-growth in exclosures has a positive impact on formerly degraded land where they constitute green spots with considerable species diversity (Tefera, 2001). The ability of exclosures to recruit and sustain new species illustrates their contribution to biodiversity and forest conservation. Generally, it is assumed that exclosures lead to restoration of natural resources such as soil fertility, vegetation biomass and composition, fauna, and water storage (Tucker and Murphy, 1997).Some pastoralist and agro pastoralist communities such as the Gogo and Maasai in Tanzania, the Himba in Namibia, and the Borana in Ethiopia, traditionally set aside some of their grazing land during the rainy season so that it can be grazed during the dry season. The primary goal these temporary range exclosures is to recover palatable species which are also known as feed, fodder or forage reserves (Muller et al., 2007; Tefera et al., 2007).

3. METHODOLOGY

3.1. Description of the study area

3.1.1. Location

The study was conducted in South Wollo. South Wollo is one of 10 Zones in the Amhara National Region State of Ethiopia. It is located between 10°05´ and 11°45´ North latitude 38°35´ and 40°50´ East Longitude (Figure 1). The elevation of this area is ranging from 900 to 4220 meters above sea level. South Wollo is bordered by Northe Shewa and Oromia Region on the south, by West Gojjam on the west, by South Gondar on the northwest, by North Wollo on the north by Afar Region on the northeast, and by the Oromia Zone and Argobba special Woreda on the east. Its highest point is Mount Amba ferit. Dessie is the capital of South Wollo, which is located 410 km far from Addis Ababa.

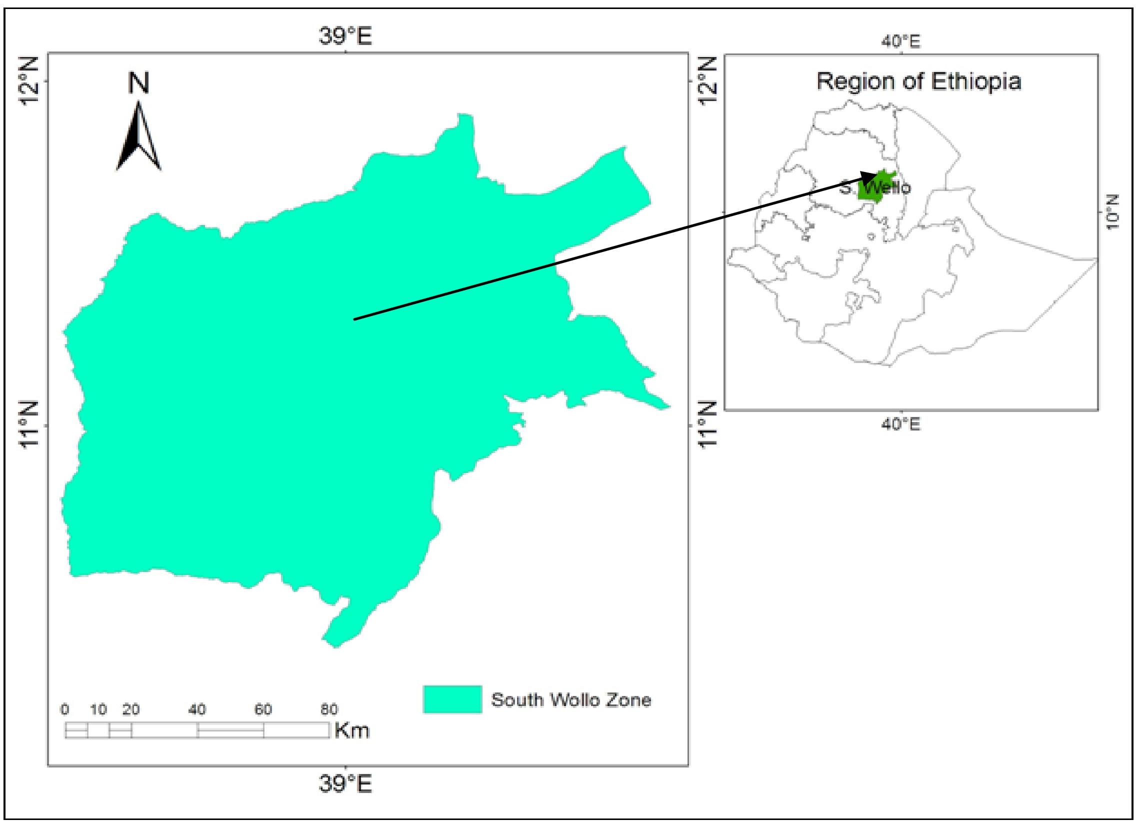

Figure 1: Location of Study Area

Source: Ethio-GIS, 2008

3.1.2. Topography

South Wollo is characterized by rugged topography that consist very high mountains, deeply incised canyons and gorges, valleys and plateaus (FAO, 1984 and Coltorti et al., 2007). Due to the strong relief differences, anthropogenic activities have led to extensive degradation. South Wollo altitude ranges from 900 to 4220 meter above m.a.s.l (Damene, 2012).

3.1.3. Climate

South Wello is characterized by both wet and dry seasons. The distribution of rainfall mostly occur from June to September (big rain season), locally known as "*Kiremt*", and February to May is the small rain season, which is locally known as "*Belg*". The small rainy season is erratic and highly variable. There is a long dry period from the end of September to February, and a short dry spell in June (Abate, 2003). Altitude has a decisive influence on temperature and rainfall. Rainfall generally increases and temperature decreases with altitude (Abebe, 1977). The mean annual temperature and mean annual rainfall ranges from 14°C to 20°C and 680 mm to 1200 mm, respectively (Gonfa, 1996).

3.1.4. Geology

Wello is covered mainly by Cenozoic volcanic rocks, and some sedimentary rocks. The Cenozoic volcanic rocks have developed from tertiary flood basalt sequences with intercalation of felsic lava and pyroclastic rocks up to 3 km thick. The Cenozoic volcanic rocks and the associated sedimentary rocks are further subdivided in various formations. The major formations are Ashangi, Tarmaber-Megezez, Alajae, Aiba basalts and Amba-Aradom formations (Tefera et al. 1996).

3.1.5. Demography

Based on the Census, the Zone has a total population of 2,518,862, which increased by 18.60% over the 1994 census of whom 1,248,698 are males and 1,270,164 are females; with an area of 17,067.45 square kilometers (CSA,2008). South Wollo has a population density of 147.58 per square kilometer. A total of 598,447 households which were counted in this Zone, results in an average of 4.21 people to a household, and 574,378 housing units. The largest ethnic group of South Wollo is the Amhara (99.33%). All other ethnic groups account only for 0.67% of the population. Amharic is spoken as a first language by 98.65%; the remaining 1.35% spoke other primary languages. According to the census, 70.89% are Muslims, and 28.8% of the population follows Ethiopian Orthodox Christianity (CSA, 2008).

3.1.6. Land Use/Land Cover of South Wollo

South Wollo zone has different types of land use/Land cover. Most parts of the land which is covered by plantation forests that share 35% of the total land. Next Afro- Alpine (19%), grass land (15.5%) and Cultivated Land (10.8%) are the main land uses. The rest Shrub land, Natural forest, Swamp area, Wood Land and others land use share 7.9%, 3.5%, 0.9%, 0.5% and 26.8% respectively(ANRS-BFED,2008).

3.1.7. Soil and water conservation

The broken and rugged nature of topography together with adverse interference of humans on the environment has brought about severe soil erosion in South Wello. As natural balance is disturbed by human activities especially for fuel wood and for more cultivated lands, the process of erosion is speeded up many folds. In the past decades, it has been observed that most part of the natural vegetation has been depleted to the maximum because of the reasons mentioned above. As a result, South Wello zone currently is not rich in forest resources (Abate, 2003). Based on Ethiopian Forestry Action Program (EFAP, 1994) the total forest cover (natural vegetation) of the region is estimated as 597,460 ha. On the other hand, volume of wood to be harvested from this vegetation (i.e. woodland, bush/shrub land below 50% slope) is estimated about 639,409.6 m^3/yr, where wood and bush/shrub land above 50% slope and natural forests left for conservation.

3.2. Materials and Methods used

3.2.1. Normalized Difference Vegetation Index (NDVI) data acquisition

The Normalized Differences Vegetation Index (NDVI) data for the period from 2000 to 2011 was acquired from Moderate Resolution Imaging Spectrometer (MODIS). To assess the impact of soil and water conservation (SWC) interventions, particularly the biological measures on land restoration, inter-annual NDVI changes analysis is used. MODIS NDVI data are composited every 16 days and delivered in approximately 10-degree blocks in sinusoidal grid mapping projection for free. For current analysis, the data, which are available in hierarchical data format (HDF), was processed by MODIS re-projection tool (MRT) into Geo TIFF data. The resolution of the MODES NDVI data used in this analysis has 431 m by 431 m resolution. In order to discriminate the effect of crop cover (mainly C4 crops), the analysis period was purposefully selected, where there is no such cover which might confuse with the required vegetation analysis. Moreover, the influence of cloud cover on the data was also reduced by avoiding the rainy season data. Therefore, data captured from January to June and November to December were found appropriate for this analysis. The time after crop harvest was selected to avoid the effect of sorghum and maize signatures, which may confuse with bushes and shrubs (Damene , 2012).

After the collection of necessary materials, prepare the Data for further analysis using Arc GIS 10 Software. The NDVI has always been taken values between -1 and 1, with values nearer to 1 indicating dense vegetation and values <0 indicating no vegetation. NDVI has proved to have an extremely wide (and growing) range of applications. NDVI data is calculated from satellite imagery as NDVI = (NIR – RED/ (NIR+ RED), where NIR is reflectivity of plant materials in the near-infrared and RED is the chlorophyll pigment absorption in the red band (Demene, 2012).

3.2.2. Preparing and pre-processing NDVI data

a) Adjusting NDVI values

The NDVI MODES data obtained for free from internet starting from 2000 has 18 to 23 observations. From these data the above mentioned period data were selected and the data was converted in required NDVI values, i.e., between -1 and 1 just simply multiplying the value by 0.0001. The data has 18 to 23 observations per year so the analysis has been begun by taking the mean calculation of every year for the selected period and adjusting NDVI value. (This means changing the NDVI value between -1 and 1 by multiplying by 0.0001). Then, using the adjusted NDVI result, value below ´´0´´ NDVI was removed for all selected data.

In addition to the MODIS NDVI data, digital elevation model data are also used for this project work.

b) Removing below zero NDVI values

In order to avoid confusion of the negative NDVI with negative values (declining tread) resulted from the modeling, the negative NDVI values were removed before applying the analysis model. Value below zero is removed in raster calculator by the following way, i.e., [input data <=1] & [input data >=0] then define the output new value as ´´NoData’’ for ‘’0’’ and ´´1´´ for all others, then reclassify and multiply the original data with reclassified data, then make the data permanent.

3.3. Field Work

The field data was collected to gain sufficient information of the study area and compare the NDVI analysis output with actual covering existing forest/vegetation, which is due to the soil and water conservation. Global positioning system (GPS) was used for the field data collection. These points used to check the area weather it has vegetation (forest) cover or not. The GPS reading of the ground control points are given in the annex.

3.4. Data Analysis

The analysis used linear relationships of year (X) and NDVI (Y) to determine inter-annual change using Arc GIS adopted from (Shimeles, 2012). The model is given as:

$$Y = AX + B + \varepsilon$$

Where A = slope, B = intercept, ε = random error

The detail data analysis is given below.

3.4.1. Time analysis

The time used in this analysis is between 2000 and 2011. Thus, this time is statistically analyzed as

$$\text{Sxx} = \sum_{i=2000}^{2011} (Xi - \bar{X})^2$$

Where Xi is each year that represent, 2000, 2002,… 2011.

Table 1: Statistical Analysis of the time change (SXX)

Xi (Year)	$Xi - \bar{X}$	$(Xi - \bar{X})^2$
2000	-5.5	30.25
2001	-4.5	20.25
2002	-3.5	12.25
2003	-2.5	6.25
2004	-1.5	2.25
2005	-0.5	0.25
2006	0.5	0.25
2007	1.5	2.25
2008	2.5	6.25
2009	3.5	12.25
2010	4.5	20.25
2011	5.5	30.25
$\bar{X}$= 2005.5	**5.5**	**143**

Therefore, $Sxx = \sum_{i=2000}^{2011} (Xi - \bar{X})^2 = 143$

3.4.2. Yearly dry months average NDVI

The yearly average dry month NDVI (Yi) is calculated by dividing the sum of NDVI value of the selected data of the year (i.e., average of January to end of June and November to December) in consideration by the number of observation (n). This calculation is done for all year.

$$Yi = [\sum_{\substack{k=January \\ November}}^{\substack{December \\ June}} (Yk)]/n$$

Where, Y_i = the yearly mean NDVI, for each year, i = 2000 to 2011

Y_k = k^{th} observation NDVI

n = number of observations in a year

3.4.3. Overall average NDVI (2000 to 2011) of dry months

The overall mean NDVI (Y) is calculating by dividing the sum of the average of each year by total number of years (N) in consideration

$$\mathrm{Y} = [\sum_{i=2000}^{2011} (Yi)]/N$$

Yi = the yearly mean NDVI

Y = Overall mean NDVI of the dry period (January to April), i.e., average of 2000 to 2011.

N = total years, i.e., 12 years (2000 to 2011)

NDVI slope (calculate slope [Acal] = A) will statistically test by using t-test.

3.4.4. NDVI change across year

The NDVI change across the year (Sxy) is calculated using the following model

$$\mathrm{Sxy} = \sum_{i=2000}^{2011} (Xi - \bar{X})(Yi - \bar{Y})$$

3.4.5. NDVI change modeling

The vegetation dynamics across time is modeled using the following linear statistical model

a) NDVI change slope (A_{cal}): NDVI change slope or the NDVI gradient, i.e., an increase NDVI (vegetation restoration) or NDVI decrease (vegetation degradation) over time is calculated as

$$\mathrm{Acal} = \frac{\mathrm{Sxy}}{\mathrm{Sxx}}$$

b) Coefficient determination (R^2) is given by

$$\mathrm{R}^2 = \frac{\mathrm{Sxy}^2}{\mathrm{Sxx.Syy}}$$

Where R=random error

c) The residual sum of square (RSS) is also very important which is given by

$$\mathrm{RSS} = \mathrm{Syy}\ (1 - \mathrm{R}^2)$$

d) Variances (Var [ε] is calculated as

$$\text{Var}\ [\square] = \frac{\text{RSS}}{\text{n} - 2}$$

Where var = variance

ε = error

n = is the number of year that has been taken.

e) The standard error of the slope coefficient is calculated as

$$SE = \sqrt{\text{var}(\square)/S\text{xx}}$$

Where SE= the standard error the slope coefficient

f) The T- test (statistically significance) is calculated as

$$T\text{o} = \frac{\text{Acal}}{\text{SE(a)}}$$

Where T_o = T- test (statistically significance).

Acal=calculated slope

3.4.6. Accuracy Assessment

Accuracy is very important to cross check the last result of the project. The main objective of this assessment is to check whether the places are really forested/vegetated or irrigated. Consequently, this project has been accurately assessed in the exact place where the research has been conducted. To make this project reliable, 100 global positioning points were collected from Hyke, Mahibure, and Kutaber. These points were collected with a distance gap of every 5km of the above listed places. Some of the points which were collected are found in the area of exclosure. Whereas, the remains points were collected in areas where forests were planted and owned by the local community. This place can be used either for agricultural activities or for the sake of grazing land. After the collection of the significant GPS points, it has been properly recorded in the excel sheet. Then after, the data has been exported in to shape files by exporting and projecting in the ARC GIS soft ware. Finally, it has been overlaid on NDVI processed data between 2006 and 2011 in the dry season. The above mentioned activities are closely related with the water and soil conservation program. As a result, south wollo zone is actively exercising the water and soil conservation activities.

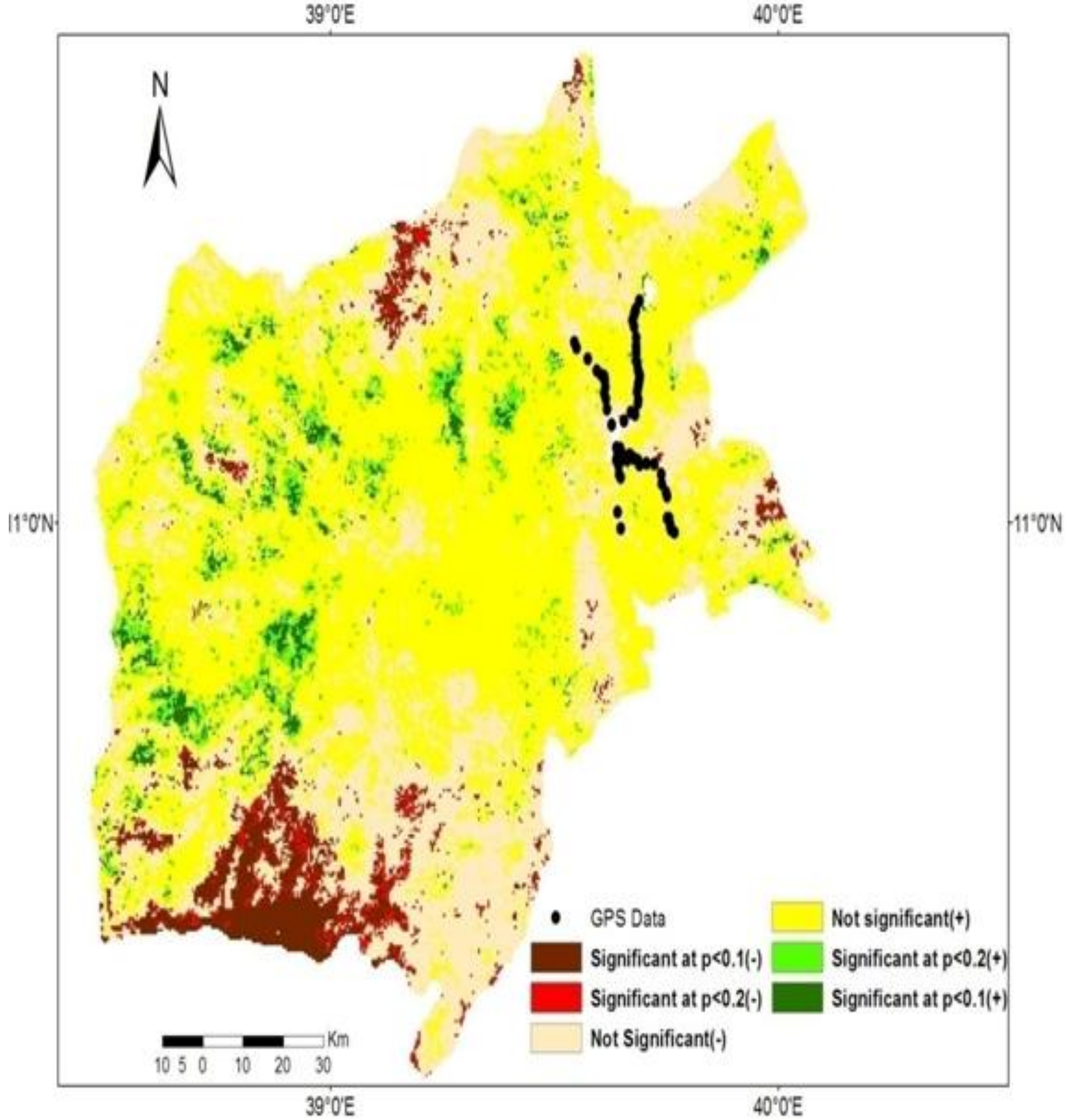

Figure 2: Accuracy Assessment of South Wollo Zone between 2006 and 2011

4. RESULT AND DISCUSSION

4.1. Vegetation dynamics trend Analysis in South Wollo zone

This analysis shows that, there is a significant vegetation change in the study area within the year from 2000 to 2011.The analysis is made in three parts, the first analysis is for the vegetation analysis (NDVI) change that covered the period from 2000 to 2005, the second is from 2006 to 2011, and the third category of the analysis is the overall dynamics, i.e., between 2000 and 2011. In every section, there were both positive and negative changes.

4.1.1. Spatio-temporal Vegetation dynamics between 2000 and 2005

The Spatio-temporal NDVI analysis has been conducted to check whether the area has brought vegetation improvement or declination and indicate area of vegetation improvement and declination (Figure 3) between 2000 and 2005.

a) Areas that show vegetation restoration between 2000 and 2005

As shown on Figure 3, considerable part of South Wollo zone shows vegetation improvement i.e. most Tehuledere, Kutaber, Dessie Zuria, Legambo show vegetation restoration. In addition North , East , South and South Eastern parts of Ambasel ; South and South West Werebabu ; central , Southern , Western and Eastern parts of Tenta; North and North Eastern parts of Albuko; North , North West , South parts of Kala; North West, West, and some South West parts of Were-Illu; South and some South Eastern Parts of Jama; some South West, North And Northeast parts of Kelela; little Northeastern and South western parts of Wegde; very small North Eastern parts of Debresina; some north ,South and Eastern parts of Mekdela and also little East ,Southeast and southern Sayint Districts show vegetation restoration between 2000 and 2011.

b) Areas that show vegetation degradation between 2000 and 2005

Most part of Wegde, Kelela, Debresina, Saint, Mekdela and Jama Woredas/Districts show vegetation degradation. In addition North, South, West and Southeast Tenta; West, southwest, central and some Western parts of Ambasel; North, South Kutaber; North, Northwest and South Dessie Zuria; South, West, Some North parts of Kalu; South and Southwestern parts of Albuko; central, western, South and South western WereIllu; Western, some north, central and south Western Legambo Districts show vegetation degradation between 2000 and 2005 (Figure 3).

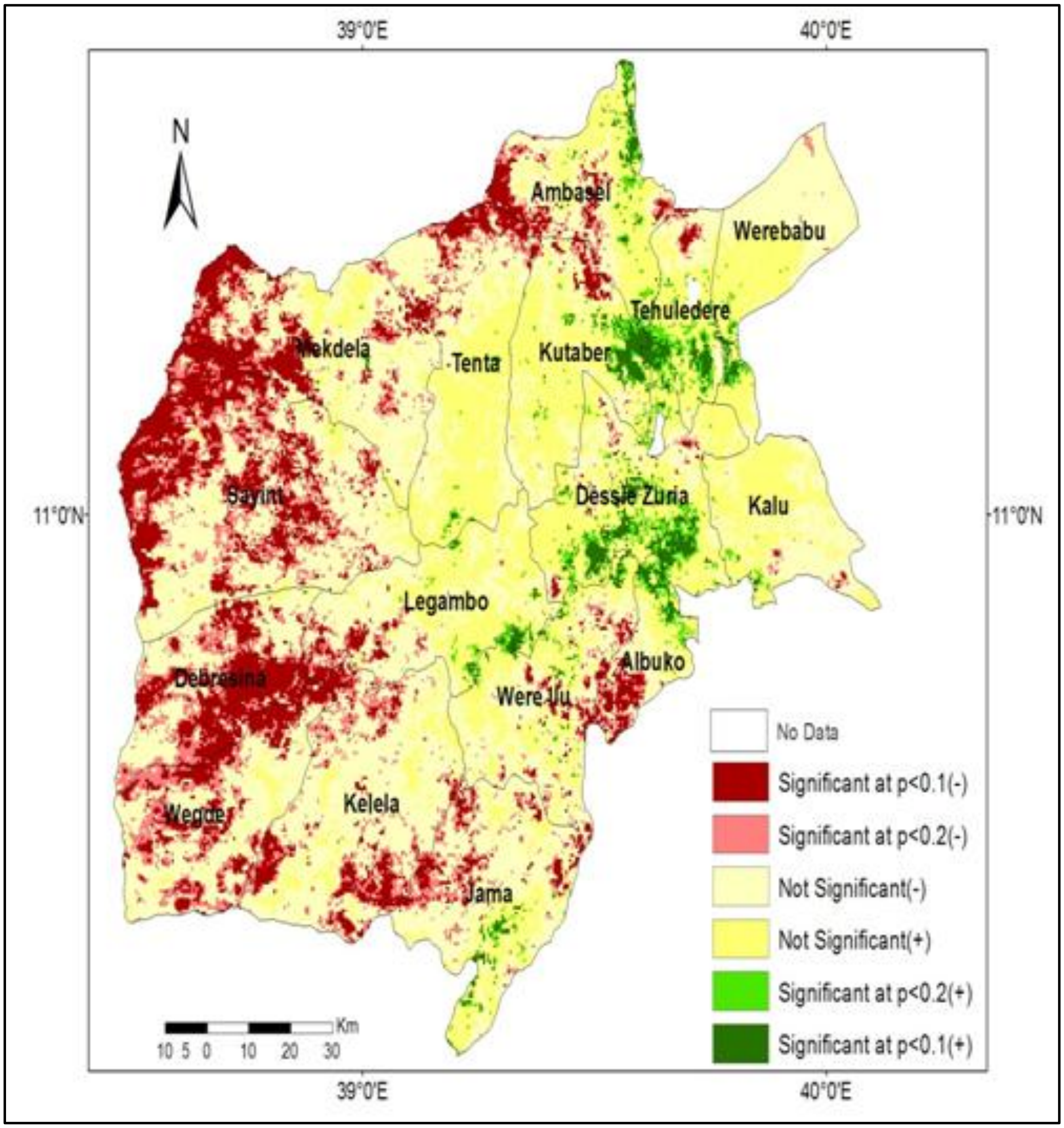

Figure 3: Inter- annual NDVI change across the district between 2000 and 2005

C) General NDVI change trend between 2000 and 2005

The analysis shows the general vegetation gradient/change in the positive and negative direction. As shown on Figure 4, Central, Eastern, Southeastern, some Northern and Southern, little Northwestern parts and Southwestern parts of south Wollo Zone show vegetation restoration. On the other hand Western, Northern, Southern, Northwestern, Southwestern and some central and Eastern parts show vegetation degradation. As shown on Table 2, about 32% (452668.2 hare of land) show restoration whiles the area which show vegetation degradation account for 68% (cover 968818.2 hare of land).

Table 2: general NDVI change trend between 2000 and 2005

Vegetation change	Pixel count	In hectare	In percent (%)
Decreasing	52087	968818.2	68.16
Increasing	24337	452668.2	31.84

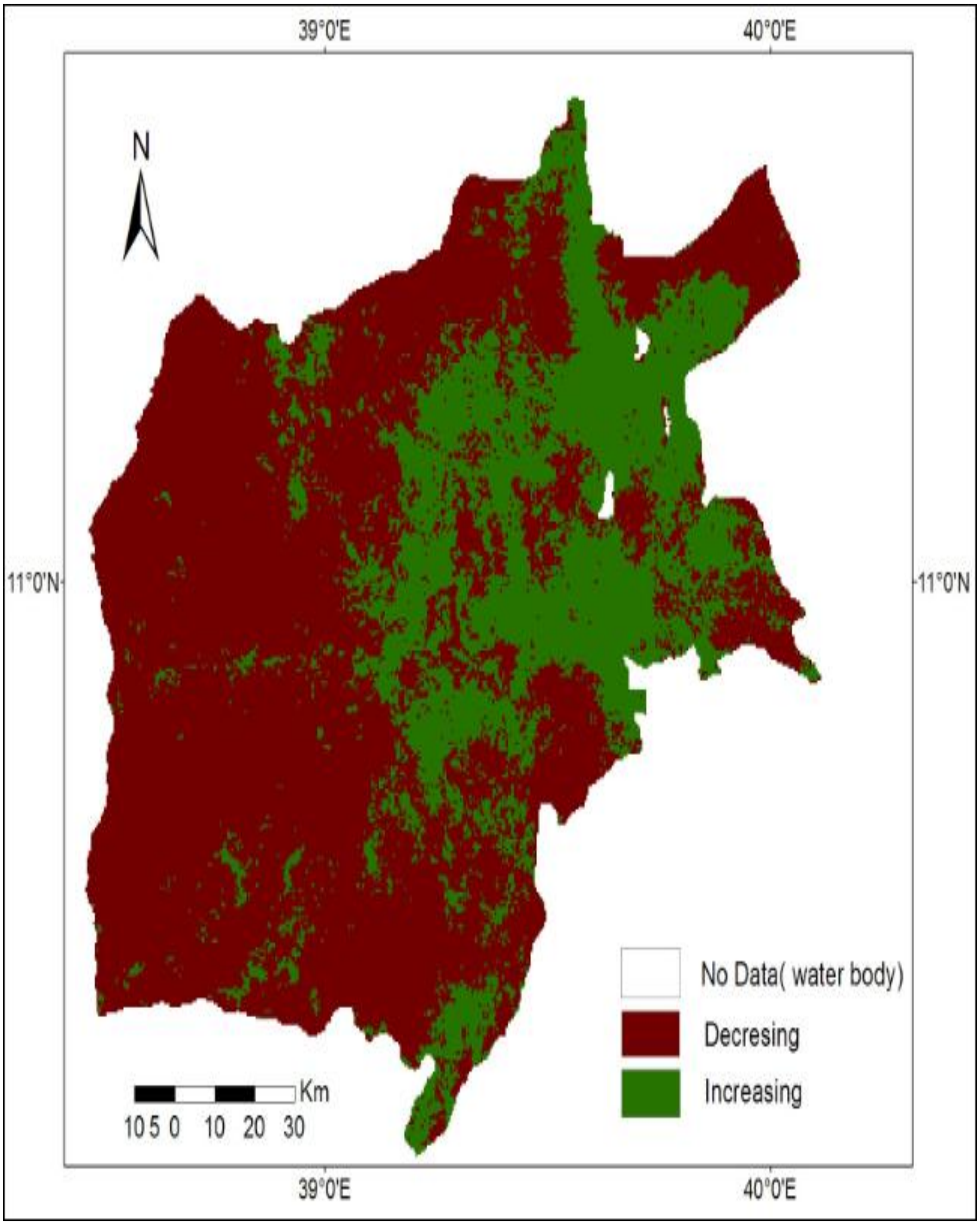

Figure 4: General NDVI change trend between 2000 and 2005

4.2.1. NDVI dynamics by significance level between 2000 and 2005

The vegetation change is not at the same statistical significance level in all parts South Wollo zone. Statistical significance level used to show the strength of vegetation restoration and deforestation. In some parts of the area show vegetation restoration and degradation in higher confidence level. In some other area show vegetation dynamics in lower confidence level. The rest show restoration and degradation but not statistically significant. Based on table 2, at 95%, 90% confidence interval was 181889.4 ha (12.8%) and 156742.2 ha (11.03%) vegetation degradation, respectively. Whereas 30485.4 ha (2.14%) and 2.42% (34447.2 ha) vegetation improvement in the same confidence interval to above. There are also 630186.6 ha (44.33%) and 387735.6 ha (27.28%) show degradation and restoration, respectively but not statistically significant.

Table 3 show vegetation restoration and degradation in different statistically significance level. The range of confidence interval manipulated in Arc GIS Soft ware by using 90% and 95% confidence interval. The negative sign indicate degradation and positive sign restoration.

Table 3: NDVI dynamics in significance level between 2000 and 2005

Range of confidence level	Statistical significance at p_value	Pixel count	Area (hectares)	Percent (%)
-19.219 to -2.132	P<0.1(-)	9779	181889.4	12.8
-2.132 to -1.533	P<0.2(-)	8427	156742.2	11.03
-1.533 to 0	Not significant (-)	33881	630186.6	44.33
0 to 1.533	Not significant (+)	20846	387735.6	27.28
1.533 to 2.132	P<0.2(+)	1852	34447.2	2.42
2.132 to 14.635	P<0.1(+)	1639	30485.4	2.14
Sub-Total		76424	1421486.4	100

4.2.2. Spatio-temporal Vegetation dynamics from 2006 to 2011

The second parts of NDVI analysis covered the time period between 2006 and 2011. In this part both vegetation restoration and degradation also analyzed and compared across the districts.

a) Areas that show vegetation restoration in South Wollo Zone

As shown on Figure 6, most districts show vegetation restoration. The field survey also verified the analysis (Figure 5). Central, Eastern, and Northwest Ambasel; South, Southwestern, some North and Eastern parts of Werebabu; South, Southwestern, central, Eastern and some northern Tehuledere; Eastern, Northeastern, Southeastern and some South west Albuko; North, East, some West and North WereIllu; Some central, North, Northwest, and Northeast Kelela; Northeast, some western, central Wegde; Most part of Legambo, Sayint and debresina; central, Southwest and Southeast Tenta show vegetation improvement.

b) Areas that show vegetation declination in South Wollo Zone

Generally, considerable parts of South Wollo show vegetation degradation between 2006 and 2011. Most part of Kelela and Jama; Northwest, some central, Eastern, southern, and some Western part of Wegde; some central, Western, southern, and southeastern Syint; some South and west Debresina; Northeast, some North and Northwest Mekdela; Northern and some Southern Tenta; little Southwestern Legambo; some central, Southern, Southwestern, northeastern WereIllu; central, Northwest and South Albuko; some central, Northeast, East and some Dessie zuria; Central, eastern, some Southeast and North Kalu; North and Northeast Tehuledere; Northwestern, Northeast and some South part of Werebabu Woredas of the South Wollo zone show vegetation declination between 2006 and 2011.

Figure 5: Area of Exclosure at Harego Mountain (A) and Tossa Mountain (B) in 2013

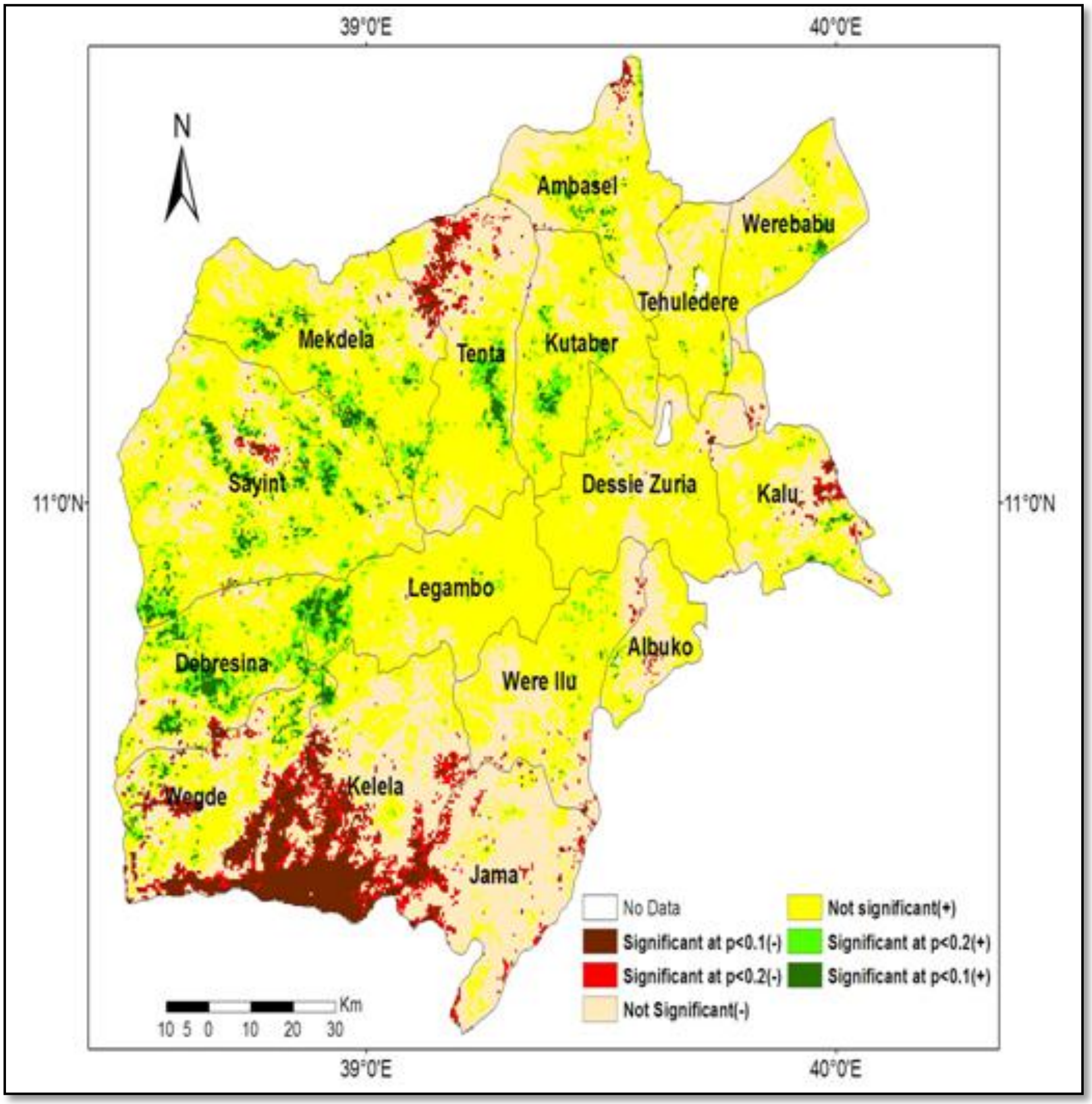

Figure 6:Inter-annual NDVI change across the district between 2006 and 2011

c) Crude NDVI change between 2006 and 2011

In the second part of analysis, the general vegetation dynamics /change assessed in South Wollo Zone show considerable improvement (Figure 7). Based on the Figure, Central, Western, some Northern, Eastern and Southeastern areas show vegetation restoration. On the other hand Southern, some Northern, Eastern, Southeastern and also little Western parts show vegetation degradation. As shown on Table 3, 893376.6 ha (62.84%), 528240 ha (37.16%) show vegetation restoration and degradation, respectively. When it is compared with the first analysis, i.e., between 2000 and 2005, the area shows greater vegetation restoration and less degradation. Between 2006 and 2011 there may be some irrigation mixed with the vegetation because irrigation activity widen up recently in the country.

Table 4: Crude NDVI change between 2006 and 2011

Vegetation change	Pixel count	Area In hectare	In percent (%)
Decreasing	28400	528240	37.16
Increasing	48031	893376.6	62.84

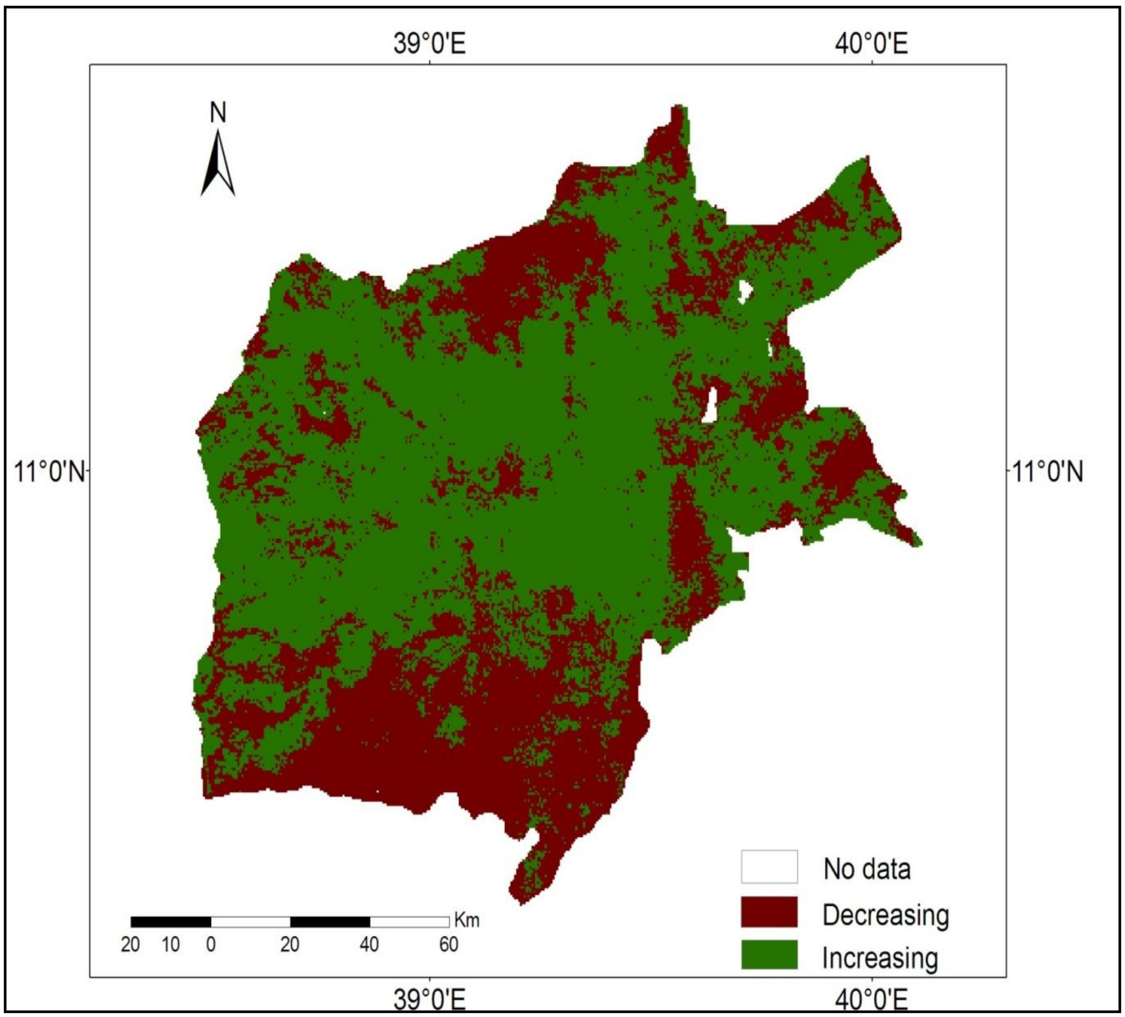

Figure 7: General NDVI change trend between 2006 and 2011

4.2.3. NDVI dynamics by significance level between 2006 and 2011

Western and some central parts of South Wollo Zone show significant vegetation restoration at 90% and 95% confidence level and Southern and some Northern parts show vegetation degradation. The statistics that is provided in the Table 5, indicate, 32531 ha (2.29%), 64430.4 ha (4.53%) areas show vegetation restoration at 95% and 90% confidence interval, respectively. On the other hand 4274.8 ha (3.82%), 41217.6 ha (2.9%) areas show vegetation degradation at 95% and 90% confidence intervals, respectively. The rest 432747.6 ha (30.44%) show restoration but not statistically significant and 796414.8h (56.02%) show degradation but not significant.

Table 5: Vegetation dynamics by statistical significance level between 2006 and 2011

Range of Confidence interval	Statistical significance at p_value	Pixel count	Area In hectare	In percent (%)
-38.065 to -2.132	P<0.1(-)	2918	54274.8	3.82
-2.132 to -1.533	P<0.2(-)	2216	41217.6	2.9
-1.533 to 0	Not significant (-)	23266	432747.6	30.44
0 to 1.533	Not significant (-)	42818	796414.8	56.02
1.533 to 2.132	P<0.2(+)	3464	64430.4	4.53
2.132 to 10.243	P<0.1(+)	1749	32531.4	2.29
Sub-Total		76431	1421616.6	100

4.2.4. Spatio-temporal Vegetation dynamics from 2000 to 2011 in South Wollo

In the period, there is a positive and negative change. The vegetation a forestation (positive change), this analysis helps to assess the general vegetation change by using dry season NDVI MODIS data. The overall vegetation dynamics model using the NDVI data between 2000 and 2011 show both positive and negative changes. The trend is discussed in the following subsections.

a) Area that show vegetation restoration between 2000 and 2011

According to Figure 8, some North and central parts of Ambasel; some southwest part of Werebabu; central, southwest and southeast Tehuledere; some Northern Kalu; central, South, Southwest Dessie Zuria; Northwest Albuko; Northwestern, central, and some Southern WereIllu; some central, Southern and North Jama; central, Western, Southern, Southeast and Northeast Legambo; Northwest, some central, and North Kelela; most central part of Tenta; central, Southwest Mekdela; Southeast, some Western, little Northern part of Sayint, central Debresina; central, Northeast and Southwest parts of Wegde Districts show vegetation restoration. Generally, Legambo, Mekdela, Tenta, Ambasel, Jama, Tehuledere, WereIllu Districts show more vegetation restoration between 2000 and 2011 in South Wollo Zone.

b) Area that show vegetation declination between 2000 and 2011

As shown on Figure 8, most part of Saint, Kalu, Werebabu, and Albuko Districts show vegetation declination/degradation. In addition, North and some west part of Tehuledare; North, West, East, Southeastern, and Southwestern part of Dessie Zuria; Central, Southern, And Northeastern WereIllu; Western, Eastern, central and some Southern parts of Jama; North, Western, Northwestern, Eastern and Southeastern part of Wegde; Eastern, Southern, Western and Northwestern Debresina; central, Southwest, Northeast, Southern, and some Northwest Mekdela; Western, Southern, Southeastern and some Northern part of Ambasel; North, South, Western, central parts of Kutaber District show vegetation degradation.

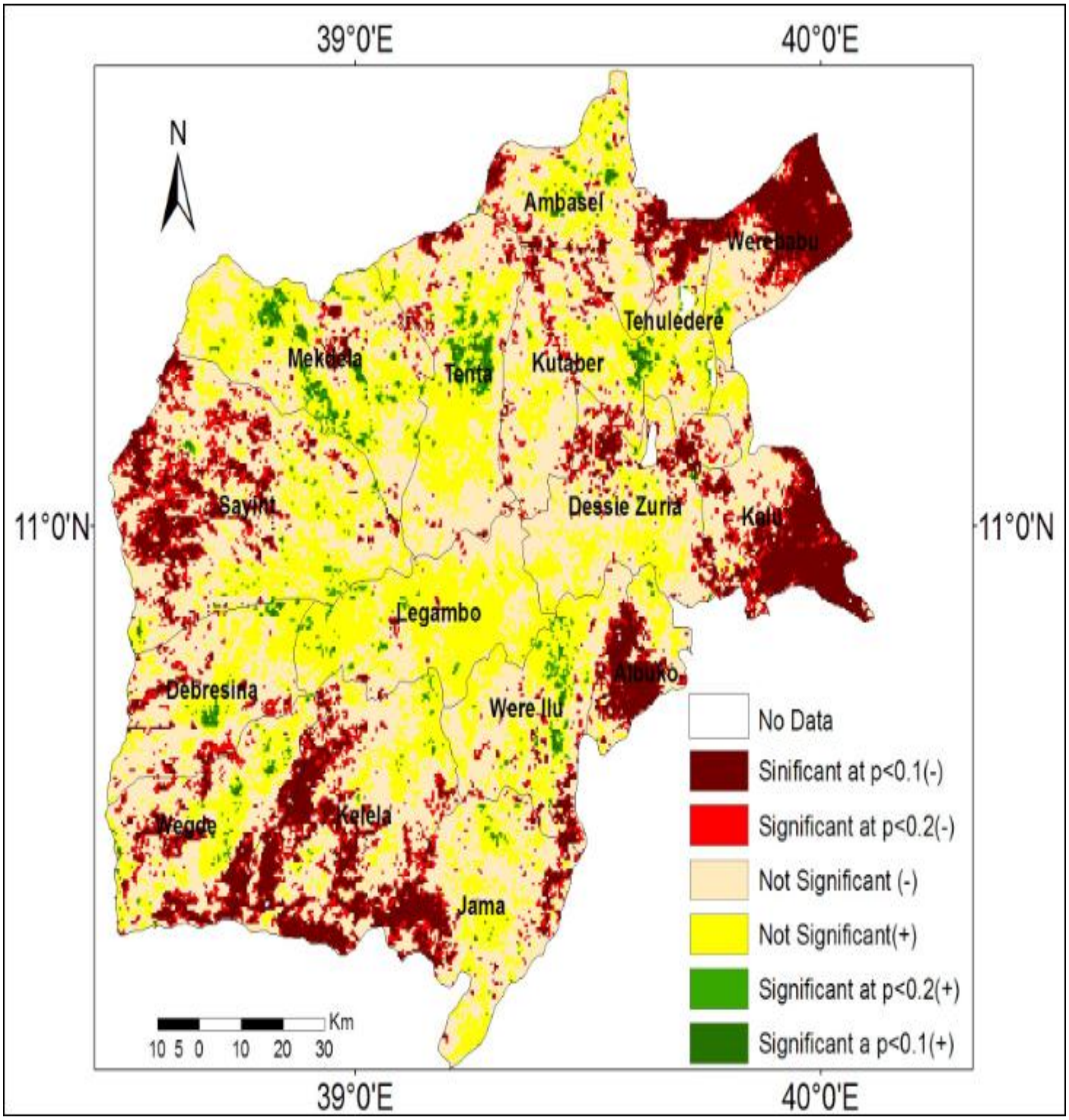

Figure 8: Inter-annual NDVI changes across the district between 2000 and 2011

c) Crude vegetation dynamics between 2000 and 2011

General vegetation dynamics assessed in over all analysis, i.e., 2000 to 2011. According to Figure 9, central, Northwestern, some Northern, Western and Southern parts show vegetation restoration and most western, Northern, Eastern, and Southern parts vegetation degradation. As the statistics provided in the Table 6, 456444 ha (32.11%), 9649866 ha (67.89%) show vegetation restoration and degradation, respectively between 2000 and 2011.

Table 6: General NDVI change between 2000 and 2011

Vegetation change	Pixel count	In hectare	In percent (%)
Decreasing	51881	964986.6	67.89
Increasing	24540	456444	32.11
Sub-Total	76421	1421430.6	100

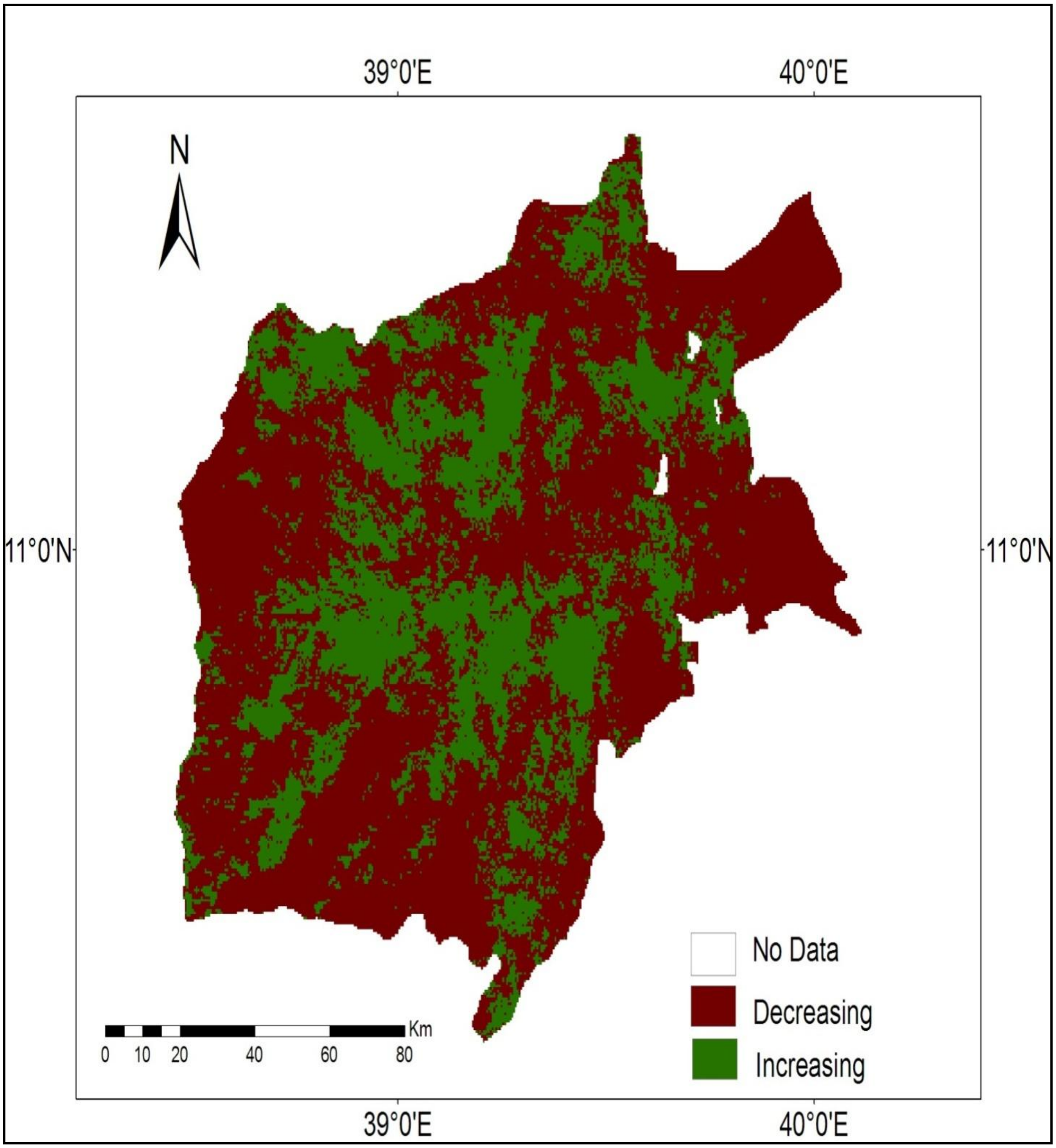

Figure 9: Crude NDVI change between 2000 and 2011

a) NDVI change by significant level between 2000 to 2011

Central, Northwestern, Eastern, Southern parts of the study area show vegetation restoration at 95% and 90% confidence level and Northeastern, Southeastern, some Western and Southern show vegetation degradation in the same confidence level. According to Table 7, 15214.8 ha

(1.07%), 24068.4 ha (1.7%) show restoration at 95% and 90% confidence level, respectively. The rest 417160.8 ha (29.37%) show restoration but not significant and 654348 ha (46.03%) show degradation but statistically significant.

Table 7: NDVI change in significant level between 2000 and 2011

Range of confidence interval	Statistical significance at p_value	Pixel count	Area In hectares	In percent (%)
-7.904 to -1.812	P<0.1(-)	10322	191989.2	13.5
-1.812 to -1.372	P<0.2(-)	6379	118649.4	8.35
-1.372 to 0	Not significant(-)	35180	654348	46.03
0 to 1.372	Not significant(+)	22428	417160.8	29.35
1.372 to 1.812	P<0.2(+)	1294	24068.4	1.7
1.812 to 6.823	P<0.1(+)	818	15214.8	1.07
Sub-Total		76421	1421430.6	100

Figure 10, is histogram of vegetation dynamics by cells that display confidence interval which show vegetation restoration and degradation. The middle section (“0”) is a cut point. It is neither negative nor positive. In the positive (right direction) show vegetation restorations while the negative or left side show vegetation degradation.

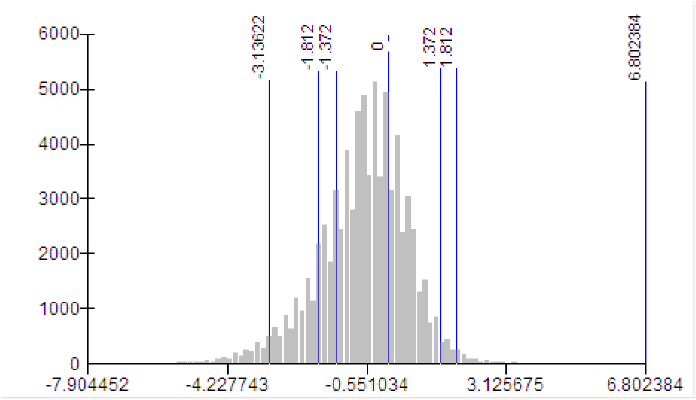

Figure 10: Arc Map generated histogram that show NDVI gradient at different confidence interval in significance level

4.4.5. Average NDVI change that show vegetation dynamics in 2000, 2005, 2011 and over all average

As shown on Figure 11, different vegetation restoration and degradation pattern in different period of time. In 2000 Eastern, Northeastern, central and western parts show vegetation restoration. According to table 9, 840180 ha (59.1%), 581250 ha (40.9%) show vegetation degradation and restoration, respectively. In 2005 restoration increase in the Eastern part but decrease in the Western part. During this time, restoration decrease but degradation increase. Totally, 936045 ha (65.5%) land show degradation while 485385.6 ha (34.1%) show restoration. In 2011, Western and central parts show vegetation restoration but no considerable change in the Eastern parts. During this time, restoration increase as compared with 2005. Generally, 858873.6 ha (60.4%), 562557 ha (39.6%) land show degradation and restoration, respectively. The overall average shows restoration in the Eastern and central parts of South Wollo Zone.

Table 8: Average NDVI change in 2000, 2005, 2011 and overall (2000 to 2011)

Average 2000	Pixel count	Area In hectare	In percent (%)
Decreasing	45171	840180.6	59.1
Increasing	31250	581250	40.9
Sub Total	76421	1421430.6	100
Average 2005	Pixel count	Area In hectare	In percent (%)
Decreasing	50325	936045	65.9
Increasing	26096	485385.6	34.1
Sub Total	76421	1421430.6	100
Average 2011	Pixel count	Area In hectare	In percent (%)
Decreasing	46176	858873.6	60.4
Increasing	30245	562557	39.6
Sub Total	76421	1421430.6	100
Overall average	Pixel count	Area In hectare	In percent (%)
Decreasing	51591	959592.6	67.5
Increasing	24830	461838	32.5
Sub Total	76421	1421430.6	100

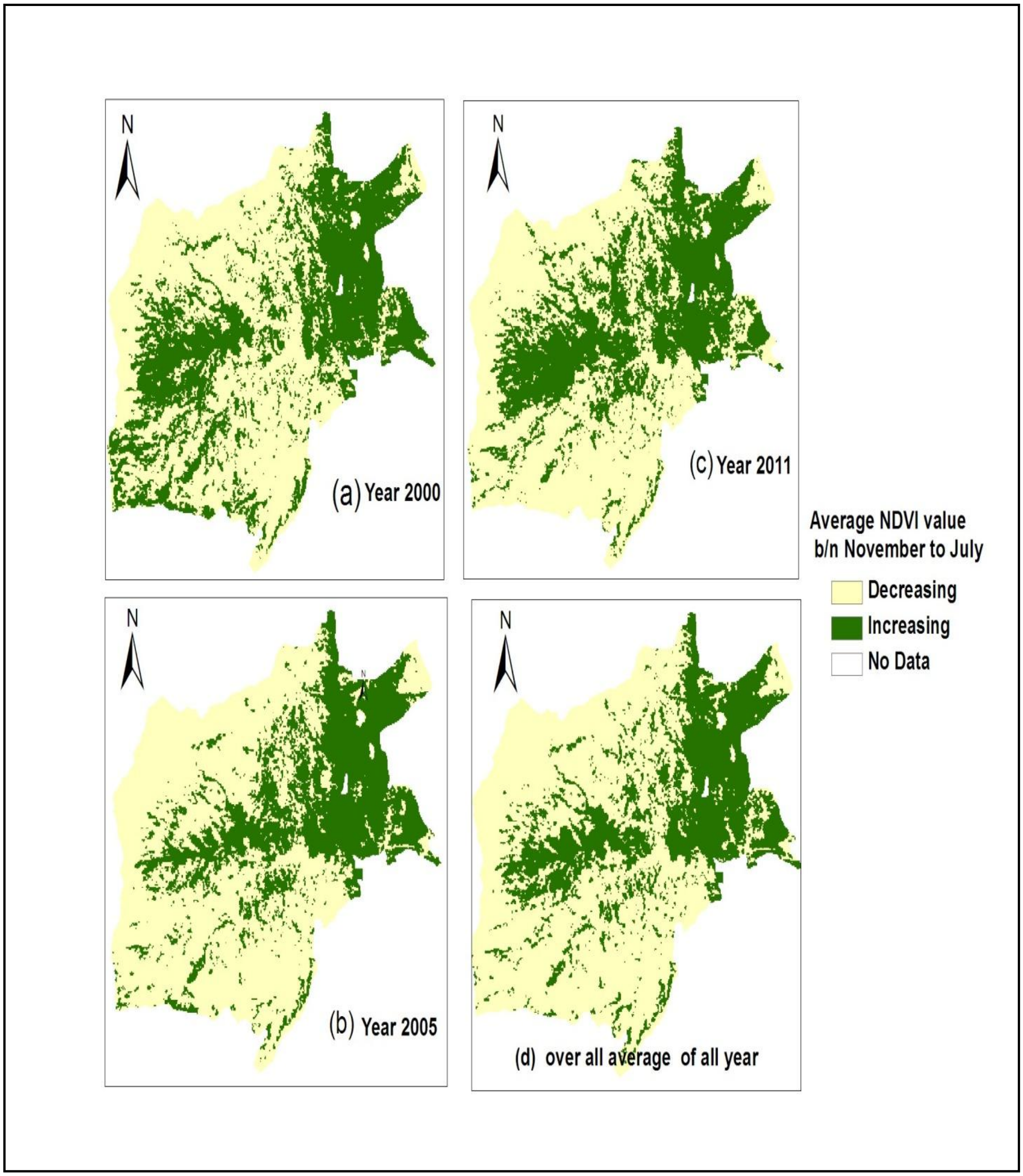

Figure 11: Average NDVI change show vegetation dynamics in 2000, 2005, 2011 and overall average

4.3. Implication of topography on Vegetation dynamics

4.3.1 Spatial-temporal vegetation change across the slope in (2000-2005, 2006-2011 and 2000-2011)

Vegetation change is varying in different topography in South Wollo Zone. According to Figure 14, The DEM shows that different slope categories in percentage. Contour lines are also generated and overlaid on NDVI analysis between 2000 and 2005, 2006 and 2011 and overall vegetation change between 2000 and 2011.As it is known, closed contour show that steep and nearly steep slope where as the contour is wide apart show gentle and nearly gentle slope.

Between 2000 and 2005 (Figure 13), North, Central, little Northwestern are the area that show vegetation restoration in steep and nearly steep slope. While some Central, Northeast, Southeast, and some Southern parts show vegetation restoration with in relatively gentle slope. On the other hand most Western, Northern, some Central parts show vegetation degradation with in steep slope and most Southern, some Central, Northeast show degradation with in relatively gentle slope.

Between 2006 and 2011 (Figure 14), most Western, Central, Northern, some Eastern and Southeastern parts show vegetation restoration in relatively steep slope area of South Wollo zone. While Central, some Eastern and Western Parts show restoration is in relatively gentle slope area. On the other hand some Northern, Southern, Eastern parts show vegetation degradation with in nearly steep slope and Southern, Eastern and little Northern show restoration relatively in gentle slope.

In overall vegetation dynamics between 2000 and 2011 (Figure 15), some Central, Northwest, little Northern, Southern tip, and little Eastern parts show restoration with in relatively steep parts. While some Central, Southern, Western and Southeast show vegetation restoration with in relatively gentle slope parts of South Wollo. On the other hand most Western, Northern, south and some Eastern parts show degradation .While most Southern, Central, Eastern and Northeastern parts show vegetation degradation in South Wollo zone.

4.3.2 Cross Tabulation of 2000, 2005 and 2011 Average NDVI with slope classification

a) Vegetation change in 2000 across the slope

As the cross tabulation indicated in Table 9, the average 2000 NDVI value show that there is both degradation and restoration in different slope interval. Between 0 and 10 degree slope interval 526510.2(62.7%), 323565.6(55.7%) area show degradation and restoration respectively. In this slope interval large amount of vegetation change has been conducted. There is also little vegetation dynamics has been observed in higher slope interval. i.e. 40 and above degree slope interval 4836h (0.6%), 10360.2h (1.8%) area show vegetation degradation and restoration. However, the restoration is slightly greater than vegetation degradation in this slope interval.

Table 9. Cross tabulation of 2000 average NDVI and slope classification

Slope interval (□)	Vegetation Degradation			Vegetation Restoration		
	Pixel size	Area (hectare)	%	Pixel size	Area (hectare)	%
0-10	28307	526510.2	62.7	17396	323565.6	55.7
11-20	9855	183303	21.8	10668	198424.8	34.1
21-30	6019	111953.4	13.3	1420	26412	4.5
31-40	730	13578	1.6	1209	22487.4	3.9
>40	260	4836	0.6	557	10360.2	1.8
Sub-Total	45171	840180.6	100	31250	581250	100

b) Vegetation change in 2005 across the slope

Based on Table 10, there is Vegetation Dynamics in South Wollo during this time. The NDVI value show that ,between 0 and10 degree 510235.2h(54.5%), 248440.2(51.2%) area show vegetation degradation and restoration respectively. In this slope interval higher vegetation change has been shown. Generally, 0-10 and 21-30 degree slope degradation is greater than restoration in south wollo zone. Whereas 11-20, 31-40 and 40 degree and above show vegetation restoration slightly greater than vegetation degradation.

Table10. Cross tabulation of 2005 average NDVI and slope classification

Slope interval (□)	Vegetation Degradation			Vegetation Restoration		
	Pixel size	Area (hectare)	%	Pixel size	Area (hectare)	%
0-10	27432	510235.2	54.5	13357	248440.2	51.2
11-20	14127	262762.2	28.1	9202	171157.2	35.3
21-30	7349	136691.4	14.6	1486	27639.6	5.7
31-40	1069	19883.4	2.1	1362	25333.2	5.2
>40	348	6472.8	0.7	689	12815.4	2.6
Sub-Total	50325	936045	100	26096	485385.6	100

C) Vegetation change in 2011 across the slope

In the same with way with the above vegetation dynamic has been shown in 2011.As Table 11, show between 0 and 10 degree 448632 (52.3%), 224520.6(39.9%) and also within 11-20 degree slope 286272.6 (33.3%), 182763.6 (32.5%) show degradation and restoration. In higher slope interval vegetation restoration is relatively greater than degradation.

Table 11. Cross tabulation of 2011 average NDVI and slope classification

Slope interval (□)	Vegetation Degradation			Vegetation Restoration		
	Pixel size	Area (hectare)	%	Pixel size	Area (hectare)	%
0-10	24120	448632	52.3	12071	224520.6	39.9
11-20	15391	286272.6	33.3	9826	182763.6	32.5
21-30	5022	93409.2	10.9	6781	126126.6	22.4
31-40	1298	24142.8	2.8	894	16628.4	3
>40	345	6174	0.7	673	12517.8	2.2
Sub-Total	46176	858873.6	100	30245	562557	100

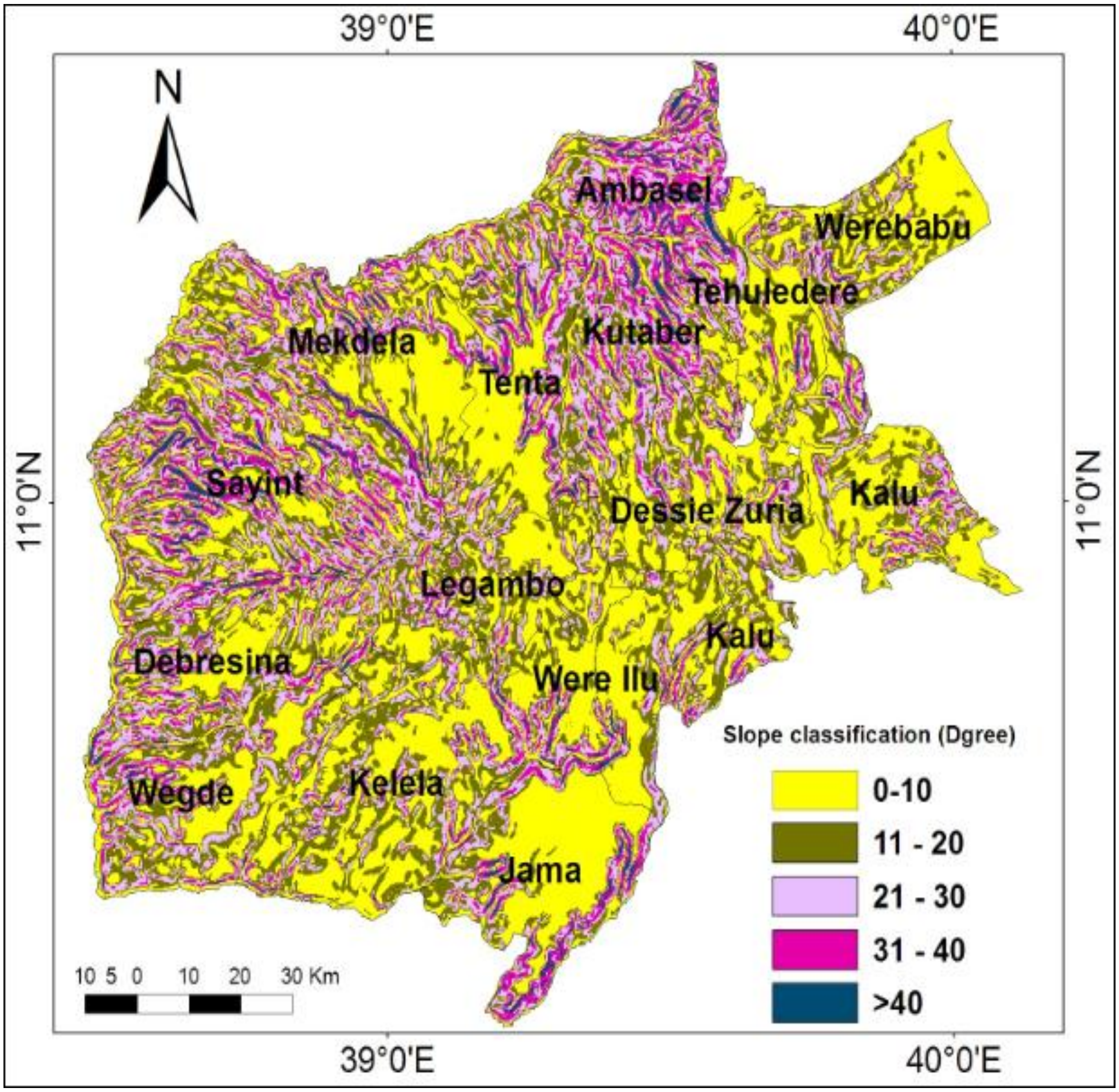

Figure 12: Digital Elevation Models of South Wollo Zone

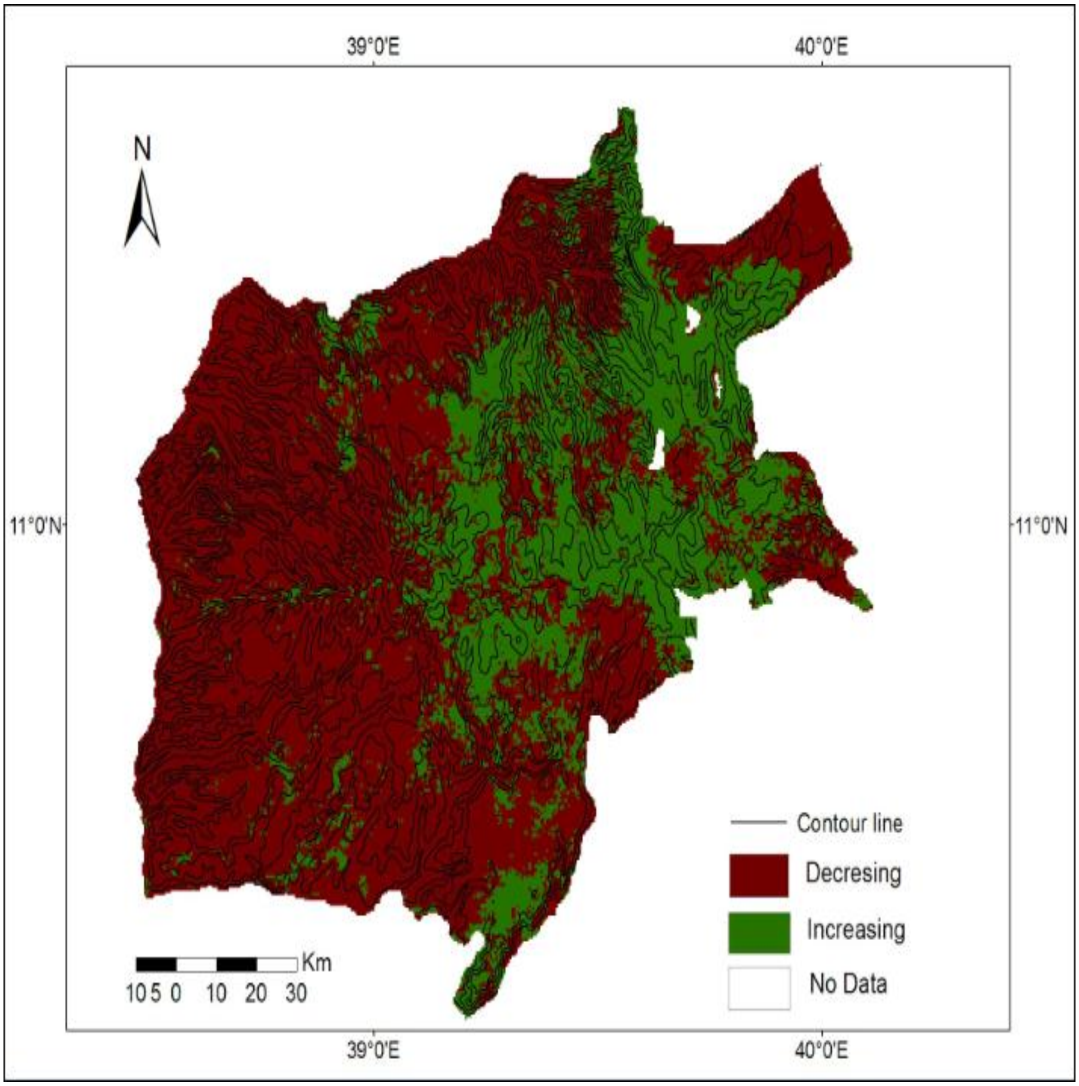

Figure 13: Crude NDVI from 2000 to 2005 and contour line overlay

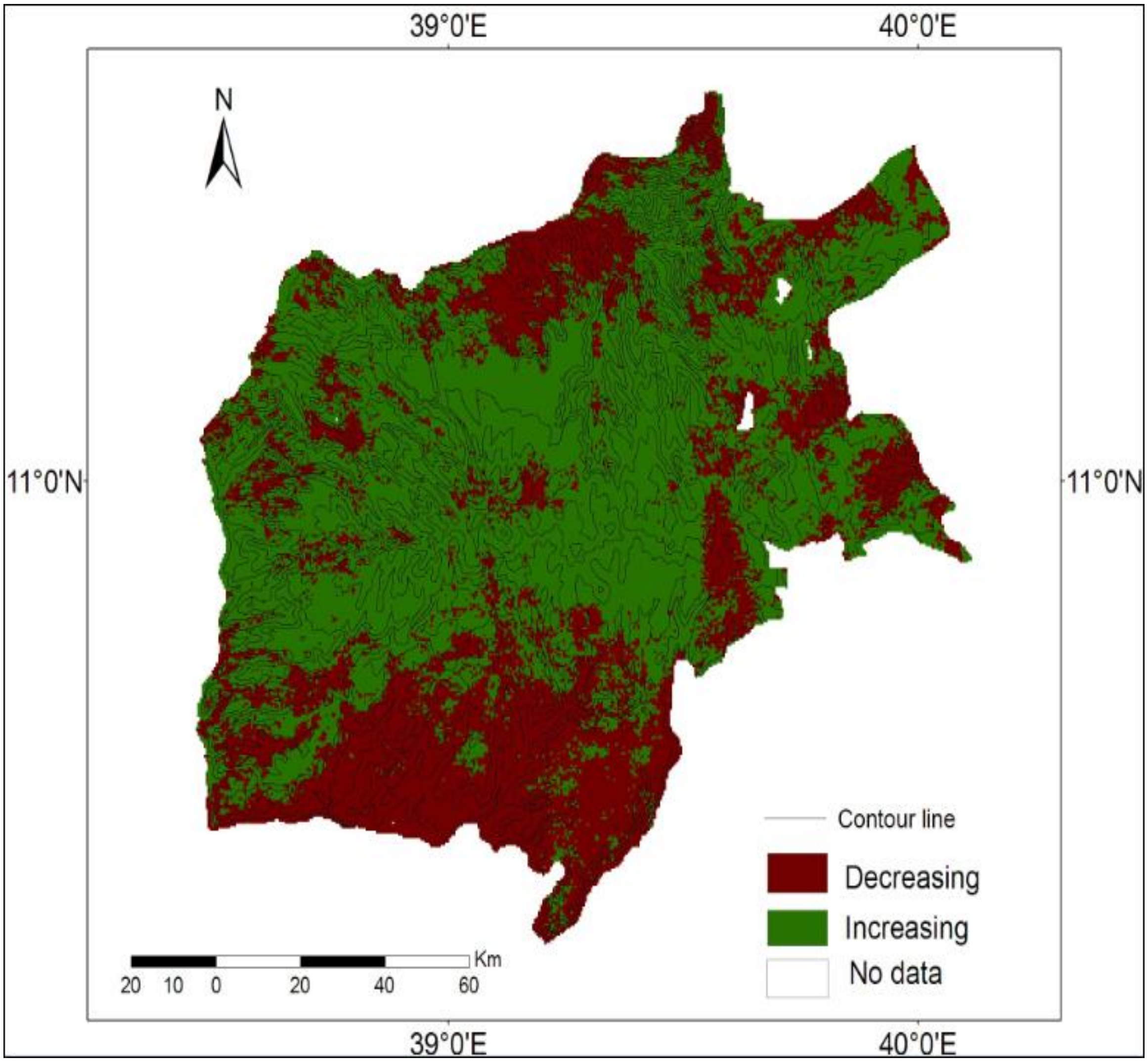

Figure 14: Crude NDVI from 2006 to 2011 and contour line overlay

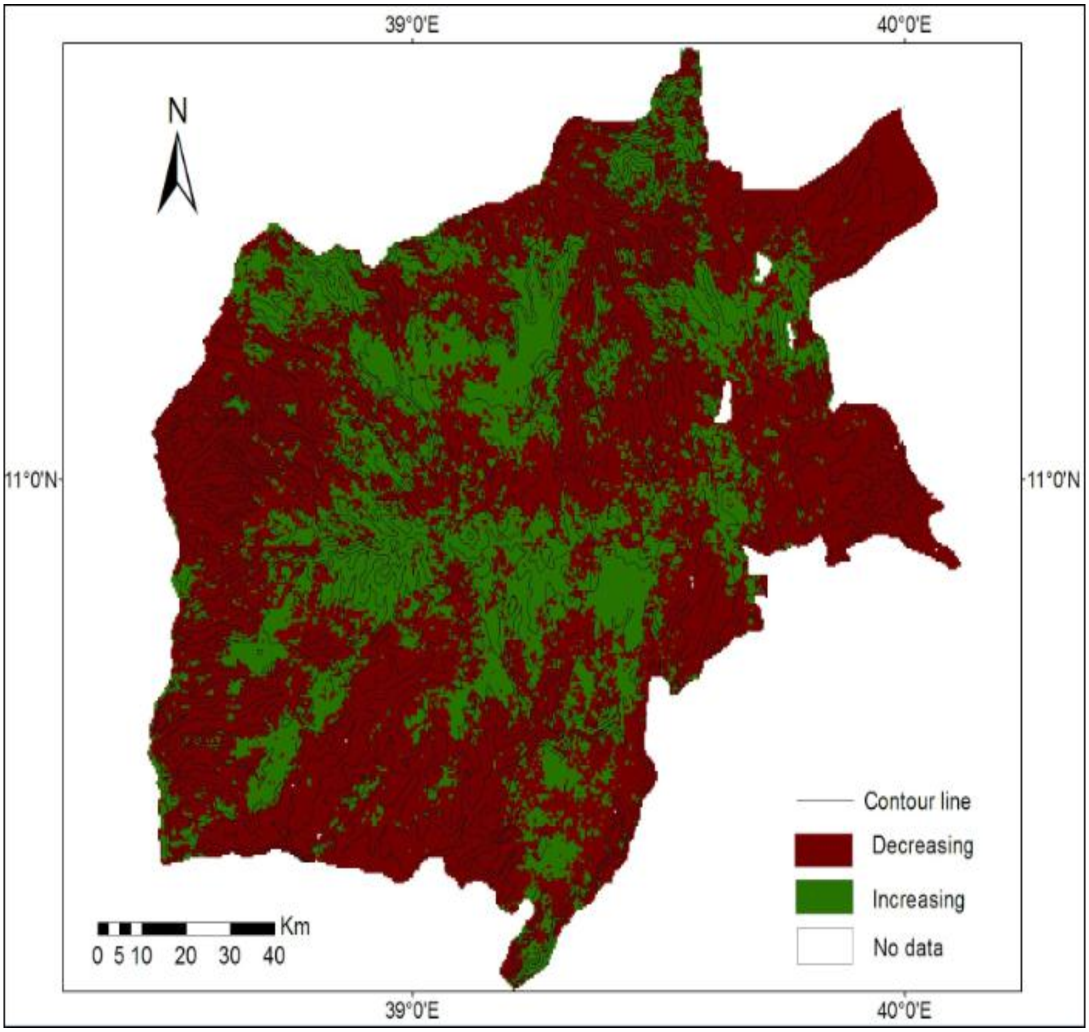

Figure 15: Crude NDVI from 2000 to 2011 and contour line overlay

5. SUMMARY, CONCLUSION and RECOMMENDATION

5.1. Summary

The NDVI analysis between 2000 and 2005 shows the general vegetation gradient/change in the positive and negative direction. According to Figure 2, central, Eastern, Southeastern, some Northern and Southern, little Northwestern and Southwestern Parts of south wollo Zone show vegetation restoration. On the other hand Western, Northern, Southern, Northwestern, Southwestern and some central and Eastern parts show vegetation degradation. Generally, 452668.2 ha land which account 31.84% show vegetation restoration while 968818.2 ha (68.16%) show vegetation declination.

In the second part of analysis (i.e., the period cover from 2006 to 2011) general vegetation dynamics assessed in South Wollo Zone shows that Central, Western, some Northern, Eastern and Southeastern areas show vegetation restoration. On the other hand, Southern, some Northern, Eastern, Southeastern and also little Western parts show vegetation degradation. The areas which show vegetation restoration account for 62.8% and cover 893376.6 ha of land while the area show vegetation degradation were 528240 ha that account 37.16%. The vegetation restoration trend between the two periods, i.e., 2000 to 2005 and 2006 to 2011, revealed that higher/better restoration in the later period. Beside the vegetation restoration due to soil and water conservation, the higher vegetation could also partly attribute to irrigation development. Between 2006 and 2011 there may be some irrigation mixed with the vegetation because irrigation activity widen up recently in the country.

General vegetation dynamics is assessed in over all analysis i.e., 2000 to 2011. Accordingly, Northwestern, some Northern, Western and Southern parts show vegetation restoration and most western, Northern, Eastern, and Southern parts vegetation degradation. As the statistics indicate that 456444 ha (32.11%) show vegetation restoration and 9649866 ha (67.89%) show vegetation degradation between 2000 and 2011.

Vegetation dynamics is different in various slope categories. Contour lines are the one of the methods to show vegetation change across the steep slope and gentle slope area in SouthWollo. Between 2000 and 2005 North, Central, little Northwestern are the area that show vegetation restoration in steep and nearly steep slope. While some Central, Northeast, Southeast, and some

Southern parts show vegetation restoration with in relatively gentle slope. On the other hand most Western, Northern, some Central parts show vegetation degradation with in steep slope and most Southern, some Central, Northeast show degradation with in relatively gentle slope.

Between 2006 and 2011 most Western, Central, Northern, some Eastern and Southeastern parts show vegetation restoration in relatively steep slope area of South Wollo zone. While Central, some Eastern and Western Parts show restoration is relatively gentle slope. On the other hand some Northern, Southern, Eastern parts show vegetation degradation with in nearly steep slope and Southern, Eastern and little Northern show restoration relatively in gentle slope.

In overall vegetation dynamics between 2000 and 2011, some Central, Northwest, little Northern, Southern tip, and little Eastern parts show restoration with in relatively steep parts. While some Central, Southern, Western and Southeast show vegetation restoration with in relatively gentle slope parts of South Wollo. On the other hand most Western, Northern, south and some Eastern parts show degradation .While most Southern, Central, Eastern and Northeastern parts show vegetation degradation in South Wollo zone.

Cross tabulation method is the second method to show vegetation dynamics across the slope. the average 2000 NDVI value show that there is both degradation and restoration in different slope interval. Between 0 and 10 degree slope interval 526510.2(62.7%), 323565.6(55.7%) area show degradation and restoration respectively. In this slope interval large amount of vegetation change has been conducted. There is also little vegetation dynamics has been observed in higher slope interval. i.e. 40 and above degree slope interval 4836h (0.6%), 10360.2h (1.8%) area show vegetation degradation and restoration. However, the restoration is slightly greater than vegetation degradation in this slope interval.

There is Vegetation Dynamics in South Wollo during this time. The NDVI value show that ,between 0 and10 degree 510235.2h(54.5%), 248440.2(51.2%) area show vegetation degradation and restoration respectively. In this slope interval higher vegetation change has been shown. Generally, 0-10 and 21-30 degree slope degradation is greater than restoration in south wollo zone. Whereas 11-20, 31-40 and 40 degree and above show vegetation restoration slightly greater than vegetation degradation.

Between 0 and 10 degree 448632 (52.3%), 224520.6(39.9%) and also within 11-20 degree slope 286272.6 (33.3%), 182763.6 (32.5%) show degradation and restoration. In higher slope interval, restoration is relatively greater than degradation.

5.2 Conclusion

The aim of this project work was to assess implication of soil and water conservation (SWC) intervention, particularly the biological measures (i.e., exclosure, afforestation, and reforestation) on the vegetation cover dynamics.

The analysis has been taken place by dividing in to three parts, i.e., the first part between 2000 and 2005 which shows less vegetation restoration and higher vegetation degradation. This indicates although water and soil conservation interventions were started in the time, it didn't develop properly. But between 2006 and 2011 most of the area shows vegetation restoration and less declination. This indicates Rural Land use policy proclamation has brought significant vegetation restoration. The overall analysis, which covers the period from 2000 to 2011, shows that there is more area show vegetation degradation which is shadowed by the result of the previous year (i.e., 2000 to 2005)

Generally, the vegetation dynamics from 2000 to 2011, varied spatially. Accordingly, most parts of Sayint, Debresina, Mekdela, Kutaber, Ambasel, Dessie zuria and WereIllu shows vegetation restoration, while most northern parts of Kelela; northern parts Tenta; some west parts of Jama and Kala; northern parts of Alboku districts show vegetation declination. It implied that water and soil conservation has not evenly distributed throughout south wollo zone. Therefore, zonal and regional authorities need to alert lagging Wored as Soil and Water conservation is concerned so that the areas can also rehabilitate as the others.

The study shows vegetation dynamics across the slope by using cross tabulation method. Average 2000 NDVI cross tabulation indicated that more vegetation dynamics is shown in lower (0-10^{o}) slope interval but little vegetation dynamics in higher slope interval. However, vegetation restoration is slightly greater than degradation in higher slope interval. On the other hand Average 2005 cross tabulation show almost balanced vegetation degradation and restoration between 0 and 10 degree slope but in higher slope interval i.e.40 degree and above vegetation restoration higher than degradation. Average 2011 cross tabulation also the same with earlier but in lower slope area vegetation degradation mach greater than restoration. Generally in higher slope area vegetation restoration greater than degradation that indicates it is not accessible for the expansion of Agriculture. On the other hand in lower slope area vegetation degradation greater than restoration which indicates the area more accessible for the expansion of agriculture.

5.3 **Recommendation**

- Vegetation restoration has been improved through time but it is not optimum and not evenly distributed so government should strength water and soil conservation program throughout the area.
- Government should expand Area of enclosure where the area is not used for Agricultural activity.
- Give awareness about the soil and water conservation for the local community to reduce vegetation degradation.
- Give awareness for the people to limit the number of animals and use well mechanized grazing techniques so that the pressure on communal land particularly on bush/forest land for grazing purpose.

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APPENDICES

This x and y co ordinate were collected from south Wollo Zone by using GPS instrument.particularly, form Dessie zuria (Kutaber, Hayke, Alboku, and from Dessie up to Kemise).

x	y
568,540	1232459
567120	1236813
566781	1237706
566985	1238808
566809	1239957
567405	1235069
566773	1240653
566073	1240810
564898	1241564
562665	1243578
559910	1245333
559445	1246285
571537	1233152
573192	1234638
574990	1236752
575166	1239534
574908	1241922
574497	1245757
573947	1248969
573613	1249952
573943	1250826
574113	1251313
574329	1251572
575322	1253345
574372	1251829
574527	1247144
574501	1245647
574517	1244833
574564	1244345
574542	1243322
574813	1242913
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574839	1237878
574919	1236013
574299	1234152
570416	1228471
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570339	1228432
574860	1238546
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570240	1225609
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569946	1226812
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570151	1227634
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570049	1228056
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573266	1227199
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574037	1226866
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577067	1226046
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582884	1215242
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583993	1214558