ASSESSING THE IMPACT OF LAND USE LAND COVER CHANGE ON CROP PRODUCTION: THE CASE OF DAMOT PULLASA WOREDA, WOLAITA ZONE, SOUTHWEST ETHIOPIA

Eyasu Bashe Duresa

A Thesis Submitted to the Department of Geomatics Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Geo informatics Engineering

Office of Graduate Studies

Adama Science and Technology University

July, 2021

Adama, Ethiopia

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APPROVAL SHEET

We, the advisors of the thesis entitled "**Assessing the Impact of Land Use Land Cover Change on Crop Production: The case of Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia**" and developed by **EYASU BASHE DURESA** hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by **EYASU BASHE DURESA** have read and evaluated the thesis entitled "**Assessing the Impact of Land Use Land Cover Changes on Crop Production: The case of Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia**" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geo informatics Engineering.

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of Postgraduate Studies, Dean	Signature	Date

DECLARATION

I hereby declare that this Master Thesis entitled "**Assessing the Impact of Land Use Land Cover Change on Crop Production: The case of Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia**'' is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

______________________	____________	__________
Name of the student	Signature	Date

RECOMMENDATION

We the advisors of this thesis, hereby certify that we have read the revised version of the thesis entitled “**Assessing the Impact of Land Use Land Cover Changes on Crop Production: The case of Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia**” prepared under our guidance by **EYASU BASHE DURESA** submitted in partial fulfillment of the requirements for the degree of Mater’s of Science in Geo informatics Engineering.

Therefore, we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

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LIST OF ACRONYMS AND ABBREVIATIONS

CP	Crop Production
DPW	Damot Pullasa Woreda
ECSA	Ethiopian Central Statistical Agency
EGSI	Ethiopian Geospatial Institute
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GIS	Geographic Information System
LU/LC	Land Use Land Cover
MLHSC	Maximum Likelihood Supervised Classification
NDVI	Normal Difference Vegetation Index
OLI/TIRS	Operational Land Imager/Thermal Infrareds
PCT	Post Classification Techniques
RS	Remote Sensing
TM	Thematic Mapper
UN	United Nation
UNEP	United Nation Environmental Program
USGS	United State Geological Survey
WAI	Woreda Agricultural Institute

ABSTRACT

Land use and land cover change is one of the challenges which strongly influence the process of crop production. Land use land cover change analysis has been conducted to assess land use land cover change and its impact on crop production in Damot Pullasa Woreda,Wolaita Zone, Southwest Ethiopia between 2008, 2014 and 2020. Landsat images, vector data from Google Earth, coordinate points, and also secondary data such as;-Population number and crop product amount of the Woreda were used in this study. Geospatial technologies which are;- Remote Sensing, Geographic Information System, Global Positioning System, and others are used in this study. Maximum Likelihood Supervised Classification method was used for land use land cover change detection. The result of this research shows that cultivated land was continuously decreased by 18.53% from 2008 to 2014, 22.46% from 2014 to 2020 and 40.99% from 2008 to 2020. Forest area was increased by 30.69% from 2008 to 2014, 7.75% *from 2014 to 2020 and 38.44% from 2008 to 2020. And also, settlement area was expanded with in the study period by 11.44% from 2008 to 2014, 0.6% from 2014 to 2020 and 12.03% from 2008 to 2020. Open space was decreased 23.6% from 2008 to 2014, increased 14.11% from 2014 to 2020 and 9.48% decreased from 2008 to 2020. Depending on the results, this study was concluded as the increment of forest area and decrement of cultivated land were obtruded and also normal crop product amount was decreased in Damot Pullasa Woreda by 7.82, 4.51 and 3.14 hectares in 2008, 2014 and 2020 respectively. Therefore, the relevant decision must be taken by concerning governmental bodies regarding to up scale the crop products amount through keeping the crop land to fill the gap between a shortage of food and population demand in the Woreda.*

Keywords: Crop Products, Geospatial Technologies, Land Use Land Cover Change, Maximum Likelihood Supervised Classification, Population.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Land is crucial natural resources, both for the survival and prosperity of humanity, and for the upkeep of all global ecosystems. One concept that has much merit is that land use refers to, "man's activities which are directly associated with the land (Hall, 1968). Land use is a series of operations on land, carried out by humans, with the intention to obtain products and benefit through using land resources including soil resources and vegetation resources which is part of land cover (De Bie, 2000). Land use land cover (LU/LC) is an area which covered by different types of land features for different purposes. Land cover, in the other hand describes the vegetation and artificial constructions covering the land surface (Kalura et al., 2017). Land-use change is that the key driver of worldwide change (Science, 2020). It is estimated that nearly half of the earth's land area has been converted or deteriorated to accommodate human requirements (Vitousek et al., 1997). Changes in land use and land cover are influenced by human activity and population growth, socioeconomic factors, forest development, urbanization, and agricultural activities (Science, 2020).

Globally land cover and land use change today is altered principally by direct human use, agriculture and livestock rising, forest clearing, over tree plantation and mismanagement and urban and suburban construction and development. Hence, so as to use land optimally, it's not only necessary to possess the knowledge on existing land use and land cover but also the potential to watch the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape (Meyer, 1995). The spatial and temporal distribution of land use and land cover is very important in understanding a wide variety of global change phenomenon.

Man is that the most progressive creature on the world. For his progress he has made many changes on the world surface like industrialization, urbanization, farming and construction activities. Land use-land cover change over time is a doubtless phenomenon occurring in the world to both temporary and permanent interest of the humans during a particular area. The phenomenon might be revealed either during a small or large scale but the foremost interesting and fundamental observation is that change occurs over time during a particular place. Land use land cover is the biophysical state of the earth's surface and immediate subsurface is that the source and sinks for several of the fabric and energy movements and interactions between the geo-sphere and biosphere. A serious problem the world is facing at present is the deterioration of both the natural environment and natural resources. Human activities generate environmental pressure in different ways. Among them there is overexploitation of renewable resources such as forests, and degradation of basic resources such as land and water.

There are about 525million farmlands of which small holdings of less than two hectares constitute 85%; out of this 87% of small holdings farms are located in Asia, followed by Africa (8%), and the rest 5% small holdings are located in Europe and America (Chand, 2011). According to (Hazell, 2013), many of the advantages of smallholders disappear as countries develop and it becomes more efficient to have progressively larger and more mechanized farms. A research report on land tenure and agricultural development in Ethiopia by (Leykun & Jemma, 2014), further came across that the landholding size is less than a hectare for the majority of rural households. It is evident that for a developing countries, agriculture forms the basis for every economic activity (Leykun, 2014).

The Ethiopian economy remains dominated by agriculture. It contributes a significant share to the national economy. It makes 45% of GDP, generates 85% of foreign currency, and employees about 83% of the population, main sources of raw materials, and the majority of the population grinds out their livelihoods from it (Abera, 2009). More than 80 percent of people in Ethiopia rely on agriculture and livestock for their livelihoods (Kassegn Amede, 2020). According to studied by Seyoum Taffesse in 2013, the Ethiopian crop agriculture is complex, involving substantial variation in crops grown across the countries different regions and ecologies. Crop is a cultivated plant that is grown and harvested extensively for profit or subsistence. Crop production is concerned with growing crops for use as fiber and food. Five major cereals that teff, wheat, maize, sorghum, and barley are the core of Ethiopian's agriculture and food economy, accounting for about three-fourths of the total area cultivated, 29 percent of agricultural gross and domestic product(GDP) in 2005/06 (14 percent of total GDP), and 64 percent of calories consumed (Seyoum Taffesse et al., 2013).

Damot Pullasa Woreda is one of the districts in Wolaita Zone and the problems regarding to crop products is appeared in case of superfluous eucalyptus plantation and fluctuation of land use land cover from season to season. The most initiative problem which used to study on this research topic was shortage of food. This teething trouble occurs familiarly in the study area. The motivation of this study is to give specific insight for scientists, policymakers, local farmers and various stakeholders in the agriculture sectors to overview the impacts of land use land cover changes on crop products within the Woreda and to intimate the solution regarding to conservation of crop land for production. The main purpose of this research was to examine trend of crop products when LU/LC was changing and to produce LU/LC map and interpretation of that products of study area and also get insight learning about starvation due to LU/LCCs on variability of crop products.

Geographical information system, remote sensing and other geospatial technologies are used to assess LU/LCCs from Landsat 8 OLI/TIRS image and Landsat 5 TM image to interpret the condition of crop products with respect to land use and land cover change of the study area and to provide the existing situation of agricultural crop products in DPW.

1.2. Statement of the problem

Land use is continually changing over time and the main driving force is the human needs. Population is increasing and it causes transformation of natural ecosystem into human landscapes. According to World Population Review, the total population of Ethiopia in 2018 was about 108 million and also as studied by (Degife et al., 2019), with an annual growth rate of 2.46%, this number is expected to grow to 174 million by 2050. Population growth is outpacing agricultural production in Ethiopia and domestic food production has failed to meet the food requirements of the country. A series of production failures has resulted in chronic food insecurity and adequate food production has been a serious problem in the country for decades (Endalew et al., 2015).

According to the UN, Ethiopia has been the largest recipient of food aid among Sub-Saharan African countries (Boussard et al., 2006). According to FAO's 2010 report, the 5.2 million people in Ethiopia face an uncertain food security situation. Smallholders account for 96% of the total area cultivated in Ethiopia (Fang & Cao, 2014). According to studied by (Seyoum Taffesse et al., 2013), teff, wheat, maize, sorghum and barley are the five major cereal crops in Ethiopia. However, the Ethiopian population is still undernourished; underscoring the importance of increasing domestic food productivity (Degife et al., 2019). One of the greatest challenges for Ethiopia therefore is to meet society's growing food needs whilst reducing the environmental impact of agriculture (Cesar & Ekbom, 2013). The earth's environment is dynamic system including many interacting components (physical, chemical, biological and human) that are constantly changing (Chuvieco et al., 2010). One of the most important factor that are responsible for the variability of crop product is land use land cover change. At recent time, global warming and environmental change related problems are the major issues for both developed and developing countries. These environmental problems are also mainly attributed to the expansion of urban and increasing of needs of land for industrial activities. Practices such as over grazing, over tree plantation, unplanned land use for settlement and other activities are leads to decrement of crop productions. Geospatial technologies are now providing new capabilities for advanced environmental management. Satellite data facilitate synoptic dissection of the earth system, patterning and changes from local to global scales over time. Therefore, attempt has been made in this study to evaluate, analyze and to map out the status of LU/LC with regarding to trends of crop products.

In Damot Pullasa Woreda, population is rapidly growing and also land use land cover is changing quickly. Therefore, a shortage of food is a major problem in the study area because of decrement of cultivated land in the study area. According to (Red, 2009), the DPW was one of a district which affected by the shortage of food. The gap which used to study on this research topic was there is no related study with this topic has been conducted to detect LU/LC change and existence of shortage of food in the study area. Therefore, the aim of this research is to assess the impacts of LU/LC on crop products change in study area using geospatial techniques. It provided better understanding on LU/LC, crop products and the trend of their changes. Considering the influence of LULC change on crop products is a fundamental input to the land management and planning strategies that needs to focus on mitigation of crop products.

The basic argument why this research study has been under taken in the study area is that:

i. There is different LU/LC in general and augmented Land -Use Land- Cover changes in the area.

ii. The area is more characterized by eucalyptus plantation.
iii. The population of the area is rapidly increases from time to time.
iv. Shortage of food familiarly occurs in the area.
v. This research is a unique study addressing the problem with this perspective and dimension that means there is no related research with this topic has been conducted in the study area.

1.3 Objectives of the study

1.3.1 General objective

The general objective of this research is to assess the impacts of land use land cover changes on Crop production in Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia using geospatial technology.

1.3.2 Specific objectives

- ✓ To evaluate land use land cover change dynamics of the study area,
- ✓ To analyze the relationship between NDVI and LU/LC changes in the study area,
- ✓ To identify the impact of land use land cover change on crop production in the study area.

1.4 Research questions

- ✓ What is the extent of LU/LC change dynamics in DPW?
- ✓ What is the range of NDVI when LU/LC changes in the study area?
- ✓ What is the impact of land use and land cover changes on crop production?

1.5 Significance of the study

LU/LC change leads to environmental changes. Extensive LU/LCCs are due to the rise in the demand of land for settlement and other intervention in human activities. Land is a scarce natural resource that can change when the number of population increases. In order to mitigate such environmental change and its influence on crop production variations in Damot Pullasa Woreda, this study is deserved. Therefore, this research has been conducted with the following significant goals:

- ✓ The study enhanced to understand about the impact of LU/LC change on crop products in the study area.
- ✓ It provided the direction of the increment and decrement of CP in the study area.
- ✓ The results of this study can use as input for government policy making, for later researchers and other concerned organizations.

Primary beneficiaries after this research work implementation are community people at all through increases of crop products and decreases of shortage of food in progressively. And also other beneficiaries are institutions like agricultural organizations, government policy makers and later researchers due to acquiring enough consideration about LU/LCCs impact on CP and to practice good management systems regarding to LU/LCCs and crop products.

1.6 Limitations of the study

The study was conducted with all possible efforts in collecting the required inputs as both primary and secondary data with clear procedural analysis and technical interpretations. Nevertheless, the following limitations were encountered in this study:

- ✓ The routine process to get real data from different organizations.
- ✓ The limitations of internet bandwidth for download Landsat images.

1.7 Scope of study

This study focused on the use of geospatial technology to assess the impact of LU/LC change on crop products. Spatially, this study limited to the Damot Pullasa Woreda, Wolaita Zone, Southwest Ethiopia.

1.8 Organization of the thesis

This master thesis research is organized into four 4 chapters and conclusion and recommendation are in separate page as follows: The first Chapter presents introduction, statement of problem, objectives of the study, research questions, the scope of the study, significance and limitations of the study in general. Chapter two essences on literature review which related to this study. This section presents a brief understanding of LULCC, CP, and NDVI in general. The third chapter focuses on the general methodology followed, description of the data used in the study and detail explanation of the study area. Chapter four explains the analyses, results and discussion which present the detailed results from image classification. In this section LU/LC maps generated using maximum likelihood classification and NDVI result presented. Moreover, change analysis of LU/LC was prepared for comparison of changes in each year and trends of CP were clearly interpreted in this portion. The last one is conclusions and recommendations. In this section, key findings and critical points that need further treatment has been forwarded as a recommendation for decision makers and for future research.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents related studies that have been conducted in different geographic area, the basic concepts and the inter-relationships among land use land cover change Crop products and applications of geospatial technology. Furthermore, it tries to explore the findings of relevant studies that have been carried out studied previously in different areas and identification of the gap for the current study area.

2.1 Concept of land-use/land-cover change

The earth's surface has been changed considerably in the past decades by humans as a result of human induced factors such as deforestation, agricultural activities and urbanization. Land is the ultimate resource of the biosphere, and the terminology Land-Use /Land-Cover has been used as one in different research. However, land use/land cover explain two different issues and have different meanings. Land-cover refers to the observed biophysical cover on the earth's surface, including water bodies, vegetation, soil and hard surfaces. In this context, as variation in the surface component of the landscape and is only considered to occur if the surface has a different appearance when viewed on at least two successive occasions (Abraha et al., 2011).

The definition also given by Food and Agricultural Organization in1999 for land-use is as the arrangements, activities and inputs people undertake in a certain land cover type to produce change or to maintain it. According to (Meyfroidt et al., 2010), transition in LU/LC can be caused by negative socio-ecological feedback that comes from a rigorous (severe) degradation in ecosystem services as a result of socio-economic changes and innovations.

2.2 Causes of land-use and land-cover changes

Changes in the land-use reflect the history and perhaps, the future of humankind. Such changes are influenced by a variety of factors related to human population growth, economic development, technology and environmental changes (Houghton & Tipper, 1994). Land-cover changes, which is conversion of the land-cover from one type to another and modification of the conditions within a category and land-use change occurs initially at the level of land parcels when land managers decide that a change towards another land utilization type is desirable (W. B. Meyer & Turner, 1992). According to above scholars, the land use and land cover changes have great roles on environmental changes. And also, when it changes into over tree plantation area, unplanned settlement area and bare land, the crop products minimized as that much.

However, Land-use reflects the importance of land as a key and finite resource for most human activities such as forestry, agriculture, industry, energy production, recreation, settlement and water catchment and storage (http://www.ciesin.org/docs/002-105/002-105b.html). Land-use/land-cover changes have become major problems for the world, and it is a significant driving agent of global environmental changes (FAO, 1999). The other factor for LU/LC change is population growth. People are the most important natural resources, which are mutually inter-related and interdependent for their sustainable development (Mensah, 2019). The land use land cover dynamics of a region is an outcome of natural and socio-economic factors and their utilization by the man in time and space(Abate, 2011).

2.3 Land-use and land-cover change in Ethiopia

In Ethiopia, the availability of natural resources changes and management differs significantly from place to place. This variability is because difference in biogeography, topography and climate. Land-use/land-cover changes are accelerating, by human actions, but also producing changes that affect humans (Fasika et al., 2019).

The dynamics of LU/LC alters the existence of different biophysical resources, including water, vegetation, soil, animal feed and other (Belete, 2017). Previous studies reported that, in Ethiopia there have been considerable LU/LCCs in different part of the country. Especially in the highlands of Ethiopia, agricultural practices and human settlement have a long history and recently a highland population pressure including depletion of natural resources and unsustainable practices (Miheretu & Yimer, 2017). More recently, expansion of eucalyptus tree plantation in the study area has been a major land use land cover change. Several land use/land cover studies have been done by different researchers in various part of the country with different objectives to intimate the direction of solution for the problem. However, some studies have given emphasis on Eucalyptus tree expansion. The study which conducted to assess land use/land cover changes in the Meja River watershed in central Ethiopia from 1976 to 2015 showed with emphasis on expansion of Eucalyptus and farmers' perception regarding the expansion (Jaleta et al., 2016). However, Eucalyptus is blamed for many controversial ecological and agricultural grain production effects (Jaleta et al., 2017). Due to the effect of Eucalyptus trees on ecological health and agricultural products; ecologists, policy makers and politicians have had a negative view on this tree species (Aklilu et al., 2019). Hence, attempts are made to remove the Eucalyptus tree from the agricultural landscape in some part of Ethiopia (Aklilu et al., 2019). According to (Aklilu et al., 2019), in contrast, the farmers of Ethiopia prefer the fast growing, economically attractive, and the quality wood yields of Eucalyptus tree species. It is very important to choice alternative trees species to replace Eucalyptus trees (Aklilu et al., 2019). According to Aklilus study in 2019, eucalyptus tree is harmful effect on the environment. It uses a lot of nutrient which is leading to soil exhaustion and reduction of crop yields, secretion of allele chemical and decreasing crop production.

2.4 Land use land cover change impact on crop products

A serious problem which, peoples globally facing at present is the deterioration of both the natural environment and natural resources. Human activities generate environmental pressure in different ways. Notable among them are over exploitation of renewable resources such as forests, and degradation of basic resources such as land and water. Agricultural growth depends on productivity promotion through proper resource management, development of adequate infrastructure, application of appropriate technology, new farming methods, and farm management improvement. In recent years countries with traditional agricultural practices have developed fragmented, non-geometric small plots of different household's farmland and created some difficulties for agricultural development, especially the limitation for agricultural mechanization. It leads to low productivity (Houmy et al., 2013). Agricultural systems are dynamic in the sense that they are in a continual state of change and evolution; whereby, events, which occur at the present time, affect its performance both financially and biologically in the future, which, in turn influence the biological and economic efficiency of the system.

Agriculture is practicing in the form of production systems, enterprises, or farming systems. Their economic viability generally is an important evaluation criterion, although it is not the only one. Agricultural systems are ideally analyzed from economic, social, and environmental points of view, but common analyses mostly concentrate only on the economic views. FAO in (1999) suggested that four functions for agricultural activities and land use: food security, environmental, economical, and social, all of which are defended by different stakeholders.

According to Rosegrant study in 2009, land degradation has significant costs, particularly in developing countries. Land degradation in most developing countries is becoming a major constraint to future growth and development (Raina et al., 2009). About 40-75% of the world's agricultural land's productivity is reduced due to land degradation (Environment, 2020). This land degradation has many causes in Ethiopia. In addition to this, the combined effects of deforestation, overgrazing, expansion of cropland and unsustainable use of natural resources has contributed to land degradation (Descheemaeker et al., 2011). According to above scholars, they tried to conclude that the decrement of crop products is depend on different factors, like; land degradation by deforestation and overgrazing. But, according to existing condition of study area, there is over tree plantation practices are highly occurred. Therefore, this situation is one of the problems in the area. One of the major factor that are responsible for the increment or decrement of crop production is LU/LCC, and different researchers agree with that land-use change and unplanned use of land resources lead to change of crop products.

2.5 Role of Remote Sensing and GIS in Land-use and Land-cover change

2.5.1 Remote sensing

Remote sensing is the capability to gather information without being in direct contact with objects (Hay, 2000). The modern use of the term RS has more to do with technical ways of collecting airborne and space borne information. The earth observation from airborne platforms has 150 year of history, although the majority of the innovation and development has taken place in the recent decade years (Abebe, 2018). According to Lillesand and Kiefer on (Abebe, 2018) study, the first earth observation using balloons in the year 1860s were regarded as an important benchmark in the history of remote sensing technologies.. Information is gathered by instruments at the natural level by our naked eyes, or by cameras (radiometric which measure radiation). Satellite based remote sensing provides valuable information that can be used in the assessment of the various aspect of atmospheric environment, climatology, meteorology, ecology, agronomy and environmental protection (Melesse, 2007). The essence of RS is measuring and recording of the electromagnetic radiation emitted or reflected from the earth's surface (Hardegree, 2006). This technique enables to investigate and know the tendency of LU/LC change through time.

2.5.2 Geographic Information System

As examined by Selçuk in 2003, LU/LC mapping has given a useful and detailed way to improve the selection of areas designed to different types of land use land cover classes with the invention of remote sensing and Geographical Information System (GIS) techniques. Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Rawat, 2015). In association with GIS that provides suitable platform for data analysis, update and retrieval (Cihlar, 2000). GIS is defined as a system designed to capture, store, manipulate, analyze, manage and present spatial or geographic data (Ali, 2020). The data type in GIS can be classified into two major groups as spatial and non-spatial or attribute data. The spatial data are the data that have location value and that non-spatial data are a data, which describe more the spatial data in the form of a table. According to (Raju, 2003), data in GIS is composed of three dimensions that mean spatial (geographic), time and attribute. Some people believe that GIS as the system of hardware and software, which contribute to analyze applications or information processing. Geographic information system is not only digital store of spatial objectives. According to (Deakin, n.d.), the combination of computer technology and cartography in the 1960s paved the way for the possibility of using techniques of super imposing and overlaying maps in fields other than cartography. The power multiplication, which results from the integration of climate, environment, terrain, agronomic, economic, social and institutional management data, makes available for managers and scientists alike a new and powerful modeling.

2.6 Crop Production in Ethiopia

Ethiopia‘s crop agricultural practice is varies from place to place involving substantial variation in crops grown across the country‘s different regions and agro ecologies. Smallholders account for 96 percent of total area cultivated and generate the key share of total production for the main crops (Abrha, 2015). According to studied by Mekuria in 2018a, Ethiopia is one of the least developed countries in Sub-Saharan Africa with nearly 100 million people, of which 80.5% of the rural population is relied on agriculture for their livelihoods. In Ethiopia, one-third of rural households cannot produce satisfactory food to meet their subsistence needs of food as they cultivate less than half hectares of land per capital (Mekuria, 2018b). As population rises, demand for food is also increases. Increasing population couple with land degradation exaggerates challenges of crop products. Producing adequate food for a rapidly growing population is a prime challenge for development (Mekuria, 2018a). According to the study of (Mekuria, 2018a), despite economic development improved in Ethiopia, the country has suffered with multifaceted challenges including land scarcity, malnutrition, recurrent drought and lack of agricultural technologies.

The existing agricultural land is unable to feed the growing population and thus many Ethiopians remain trapped in vicious circle of poverty, disease and hunger (Mekuria, 2018a). Over the last 50 years global population has more than doubled and this factor has inevitably reduced the land available per person to live and grow food (Mekuria, 2018a). According to Mekuria, the population of the study area was rapidly growing from year to year and in the same manner the over tree plantation are increasing and cultivated land was decreasing with in the study period. Therefore, there is a contradiction of population number and crop product amount with in the Woreda. There are two variables used to manage the feed a rapidly growing population with ever-shrinking land resources. They can change to produce more food crops. It can opt for:

•Expansion: increase the area of land to grow the food over and

•Intensification: increase the yield amount per unit area. This is achieved through a combination of chemical inputs such as fertilizer, pesticides and herbicides; improved water use and improved farming practices and also using of higher-yielding crop strains or seeds. From above two variables, this study focused on expansion of crop lands rather than intensification.

2.7. Review of related studies

Olumana et al., in 2019 were studied on Land use/land cover changes at Adei watershed (Ethiopia) over a period of 23 years (1986‑2009) has been analyzed from LANDSAT imagery and ancillary data. They are examined on patterns of LULC change and the final land use land cover maps were produced after a supervised classification with appropriate post-processing. Their image analysis result revealed that study area has undergone substantial Land Use/Land Cover changes, primarily a shift from natural cover into managed agro systems, which is apparently attributed to the increasing both human and livestock pressure. Their findings indicated that rate of LU/LC change over the study period, particularly deforestation due to the expansion of farmland need to be given due attention to maintain the stability and sustainability of the ecosystem. In opposite to the above finding, in this research, the afforestation of the area was resulted.

Ahmad in 2016 investigated on analysis of Maximum Likelihood (MLH) classification on multispectral data by means of qualitative and quantitative approaches. In their study, they have used Maximum Likelihood Classification method to classify a diverse tropical land covers recorded from Landsat 5 TM satellite. In relation to above study, maximum likelihood supervised classification method were used due to upscale the accuracy of the classification through supervision of the extent of study area.

Alawamy et al., in 2020 were studied on region of Al-Jabal Al-Akhdar in northeastern Libya. Their study examined using geographic information system and remote sensing techniques to gain a quantitative understanding of the dynamics of LULC. A post-classification comparison approach was used to detect LULC changes in their study area between 1985 and 2017 using four Landsat images from 1985, 2000, 2010, and 2017. The observed changes were indicative of a decrease in the expanse of forest. According to above studies, post classification techniques was used in this research to know discernible conversion of land use land cover classes from one class to another class with in the study period.

Rawat in 2015 investigated on digital change detection techniques by using multi-temporal satellite imagery helps in understanding LULC change dynamics. Their study shows the spatio-temporal dynamics of land use land cover of Hawalbagh block of district Almora, Uttarakhand, India in the year February 2015. Landsat images of two different time periods were acquired to quantify the changes in their study area. A supervised classification technique has been employed using maximum likelihood technique in ERDAS 9.3 Software in their study. Their results indicate that, vegetation and built up area have been increased while agriculture, bare land and water body have decreased with in their study period. Oppositely to the above, in this study ERDAS EMAGINE 2014 and ArcGIS10.4.1 were used to analyze the LULC change using PCT and similarly with this study the forest area increased and cultivated land decreased.

Bayle, G. K in 2019 in Bahir Dar studied on Ecological and social impacts of eucalyptus tree plantation on the environment and its harmful effect on the environment, uses a lot of nutrient which is leading to soil exhaustion and reduction of crop yields, secretion of allele chemical and decreasing crop production. According to above studies, the eucalyptus tree plantation was highly expanded in the study area.

Bekele in 2019 investigated on the title of Analysis of Land use and Land Cover Change, Drivers and Impact on Agricultural Productivity using GIS and Remote sensing satellite data in Esera Woreda, Dawro Zone, Southwest Ethipoia between 1986 – 2014. In their study, land use/land cover maps and change maps of study area were produced. Results from land use and land cover change analysis shown an increase in agricultural land from 33.3 % in 1986 to 63.03 % in 2014. Forest cover decreased from 61.89 % in 1986 to 22.41 in 2014. Their study also found that the main causes of land use and land cover changes were mainly, demand for agricultural land, increased demands for forest products such firewood and charcoal. Unlikely with the above result, in this research work there is an increment of forest area and decrement of cultivated land.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

This research was conducted in Damot Pulasa Woreda, which is located in Wolaita Zone, Southwest Ethiopia. Wolaita zone is also located in south nation nationalities peoples of Ethiopia, and DPW located at 317 km South of Addis Ababa. Shanto is the administrative center of the Damot Pulasa district. Overall elevation of the area is between 1,850 to 1950 meters above sea level. The woreda is bounded by 6°58’12’’-7°6’36’’ N and 37°57’36’’-38°27’36’’E. (Woreda Municipality).

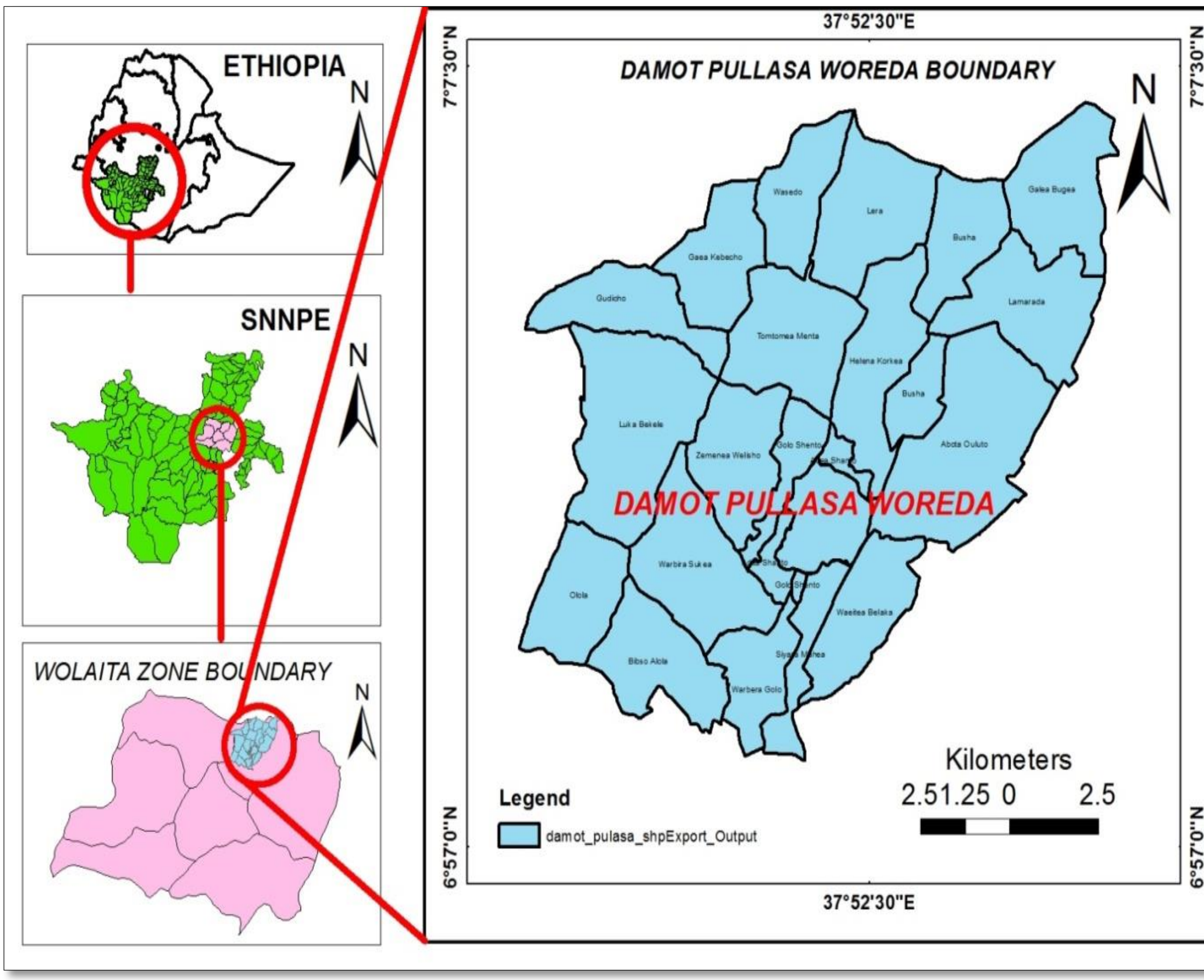

Figure3. 1 Location map of study area

3.1.2 Population

As national census report, a total population of the Damot Pulasa Woreda is 142444, 168 111 and 198404 in the year 2008, 2014 and 2020 respectively. From whom 6665, 7866 and 9283 were men and 6799, 8025 and 9471 were women in urban area; and also 63065, 74427 and 87838 were male and 65915, 77793 and 91812 were female lives in rural area in 2008, 2014 and 2020 respectively.

Table3.1. Population data of Damot Pulasa Woreda (from ECSA)

No	**Year**	**Sex**	**Urban**	**Rural**	**Total**	**Total population**
1	2008	Male	6665	63065	69730	142, 444
		Female	6799	65915	72714	
2	2014	Male	7866	74427	82293	168, 111
		Female	8025	77793	85818	
3	2020	Male	9283	87838	97121	198, 204
		Female	9471	91812	101283	

The below diagram shows that a total population amount of Damot Pulasa Woreda in 2008, 2014 and 2020 years.

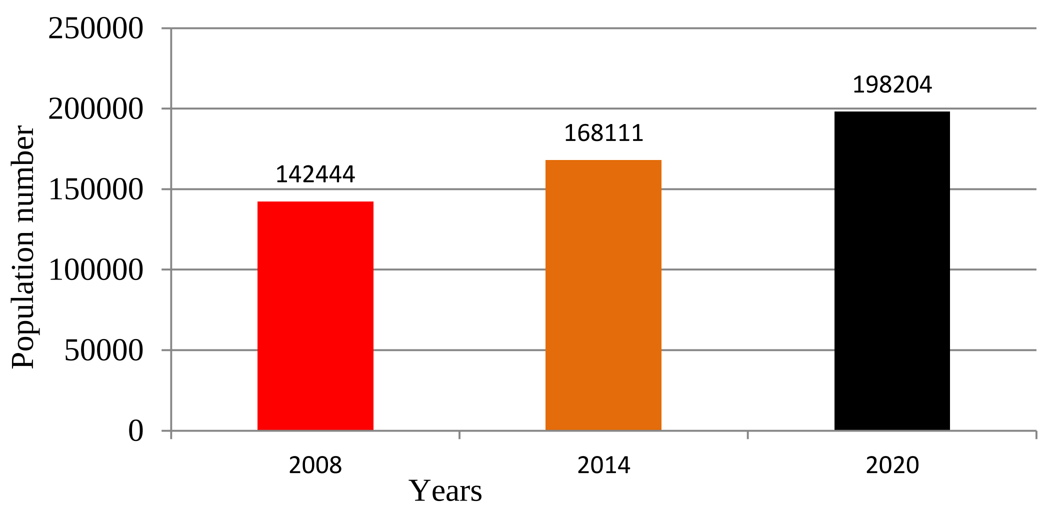

Figure3. 2 Total population of DPW in 2008, 2014 and 2020

As the above charts shown, the population number of the Damot Pulasa Woreda is continuously increasing from year to year. This increment is also one of the factors for decrement of crop products through expands the settlement area. Ethiopian agriculture faces the challenge of providing food for a growing population (FAO, 2019). Proximate or direct causes of land-use change constitute human activities or immediate actions that originate from intended land use and directly affect land cover (Lambin et al., 2003).

3.1.3 Climate

The climate is stable, with the mean annual temperature variation between 17.6° and 20 °C all year round. The year is divided into two seasons: the wet season (Balguwa) from June to October, and the dry season (Boniya) from November to May, broken in February by a short period of so called “little rains” (Badhessa). The average rainfall for the entire region is 780 millimeters per year. Damot Pulasa Woreda Monthly Climate variations: Warmest months (with the highest average high temperature) are March, April and May. The months with the lowest average low temperature are: June, July and August. Source (WSI).

3.2 Data collection

3.2.1 Primary data

Collecting accurate and reliable data is the most determinant factor for any research as it determines the quality of the research. Accordingly, the necessary data are collected from the respective secondary and primary data sources. Today, earth resource satellites data are very applicable and useful for land use/land cover change detection studies (Imran Basha et al., 2018). The primary data includes; - Landsat satellite image (Landsat data): Landsat8 Operational Land Imager/Thermal Infrared (OLI/TIRS) (2014 and 2020) and Landsat 5 TM (2008) with pixel resolution of 30*30 are obtained from USGS, Vector (polygon) data, GPS points are used in this study. The acquired data is in world datum (WGS84) projection system. However, factors such as the image quality as determined by cloud cover, land cover characteristics and the methods used for atmospheric correction and image classifications impact on the final product quality (Zhu et al., 2016). Additionally, table3.2 shows clearly that data types, purposes and its sources. The selection of year interval for this research was depended on the availability of data.

3.2.2 Secondary data

The secondary data sets which are published data and unpublished documents from varies websites and organization, population data from Ethiopian central statistical agency, amount of crop products within three years (2008, 2014 and 2020) from Woreda Agricultural Institute and other relevant data's are gathered for the study. The following tables shows that different types of data, their sources, purposes and duration when it was acquired.

Table3. 2. Types of data, their sources and purpose of them

No	Data type	Data source	Purpose	Duration
1	Landsat 5 TM and Landsat8 (OLI/TIRS) with resolution 30*30m	USGS	For NDVI calculation and LU/LC classification	2008-09-21, 2014-02-26 and 2020-02-11 for each image respectively
2	Population data	ECSA	To know population number	2008, 2014 and 2020
3	Crop types and its amount in each year	WAI	To know the amount of crops products of the study area	2008, 2014 and 2020
4	Point data	Field	To check ground truth	2021
5	Topographic sheet	EGSI	To geo referencing	2020
6	Vector data	Google Earth	To clip the study area from Landsat image	2020

The above table shows that different types of primary and secondary data which used in this research work. To collect, analyze and interconnecting the data collected, the different equipment's and software's are used in this research.

Table3.3. Types, models and purposes of soft wares used

No	Types of software	Model	Purpose
1	ArcGIS	10.4.1	To analyze LU/LC classification with accuracy assessment and mapping the overall data.
2	ERDAS EMAGINE	2014	For Preprocessing of Landsat image
3	USGS	Earth explorer	To download Landsat image
4	Microsoft word	2010	To write all the document
5	Microsoft excel	2010	To convert GPS points into CSV (comma delimited), for accuracy check and prediction
6	Microsoft power point	2010	To prepare slide notes for presentation
7	Handle GPS	Garmin 12	To collect field data
8	Mendeley Desktop	1.19.8	For referencing

3.3 Methods

The following methodology is used to analyze the land use land cover changes with regarding to crop products in the study area.

The following three–tier methodological approach is employed in carrying out of this research.

i. Thematic data preparation: Appropriate data which are Landsat 8 OLI/TIRS and Landsat 5 TM image of 2008, 2014 and 2020 and ancillary data such are; - Population and crop product amount were prepared.
ii. Data analysis: Depending on the data prepared in stage 1, MLHSC, Attribute Table Design and entry, data editing, data validation, and LULC change map preparation were undertaken. Data analyze in this research includes; - GIS Analyses, Remote Sensing Analyses and Cartographic Analyses.

- GIS Analysis

A GIS is a collection of computer hardware, software, and trained personnel designed to capture, store, manage, manipulate, and communicate data that is spatially referenced Classification results and topographic information of the study area were subjected to GIS analysis in order to determine the relationship between topographic characteristics of the LULC of the study area. Under GIS analyses; personal geo database, feature data sets and feature classes are managed. And also, area calculation of each land use land cover classification types with in each years and preparation of maps has been done.

- Remote Sensing Analysis

Remote sensing is the gathering of information related to the Earth’s surface and without contact with the object. Aerial photography, radar and satellite imagery are some of techniques which included in Remote Sensing. Satellite imagery downloaded from USGS and used as primary data in this study. Under remote sensing analyses, the image composite or stake has been done and also image enhancement process with haze reduction, noise reduction is done.

- Cartographic processing

Cartography is the science, art and technology of studying, mapping and using maps. Geographic information systems and remote sensing have established a beneficial synergy with cartography. In this study, Cartographic processing has been used to finalize by mapping with full map elements the result of GIS and RS analysis work of the study area.

iii. Developing decision rule: The following consecutive procedures were undertaken knowing the influence of LU/LC on crop products is useful for land management and planning strategies focused on crop product problem mitigation.

3.3.1 Evaluation of Land Use / Land Cover change dynamics

In here, the following methods are used to evaluate land use land cover change dynamics in the study area.

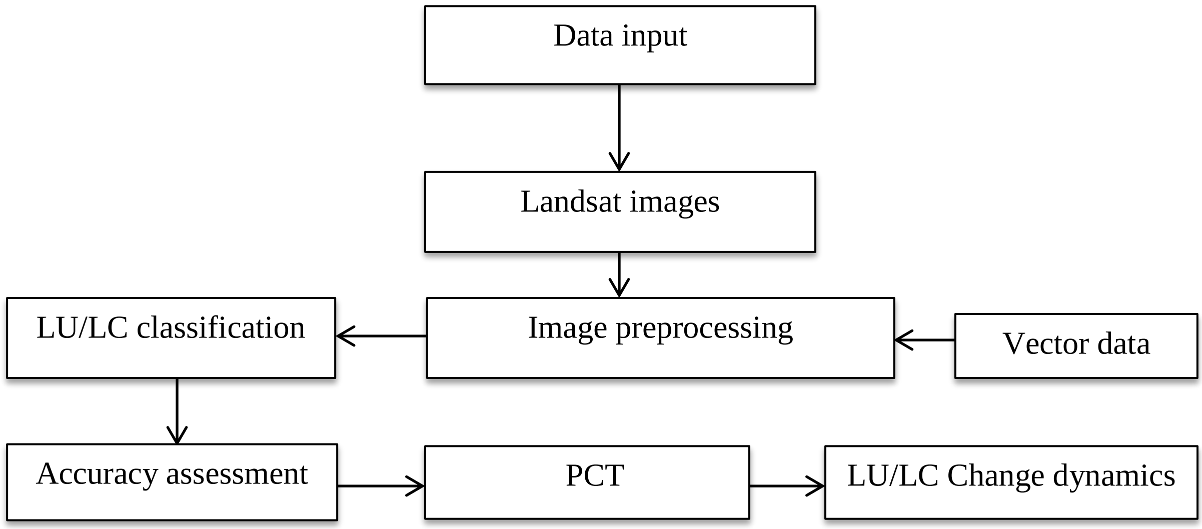

Figure3. 3. Flow chart for LU/LC change dynamics

3.3.1.1 Image preprocessing

In this portion the following steps has been followed to enhance the Landsat images to download from Google earth for expected works related to objectives. Which are:-

- ✓ Creating Google account
- ✓ Downloading Landsat images
- ✓ Layer stacking
- ✓ Image enhancement
- ✓ Clipping study area using shape file
- ✓ Preparing true color map of each year

According to (Branger, 1990), land use and land cover classification system is presented for use with remote sensor data of the study area within different time period. Image selection was one of the most difficult processes to extract from cloud cover. Geometric correction of image includes cloud cover enhancement, atmospheric reduction, haze reduction, noise reduction and histogram correction. Most change detection algorithms using Landsat have used two dates of Landsat images (Singh, 1989); (Gopal, 1996); (Coppin et al., 2004); (Healey & Jenkins, 2009); (Masek et al., 2015). According to above scholars, these kinds of algorithms are relatively simple to implement and also they are not always applicable.

To find change over shorter time intervals, several new change detection algorithms using many dates of Landsat images (typically one image per year) are appearing in the literature (Vogelmann et al., 2012). To make a classification of LULC in this study, it used MLHCS. The standard implementation of supervised maximum likelihood classification requires the selection of "training' samples representing the feature types to be mapped (Showqi et al., 2014).

3.3.1.2. Maximum Likelihood Supervised Classification

In remote sensing, a pixel with the MLC is classified into the matching classes/categories. It is a statistical decision measure to assist in the classification of overlapping signatures; pixels are assigned to the class (categories) of the highest probability. However, it is slower to extract computations. The MLC tool considers both the variances of the class signatures when assigning each cell to one of the classless represented in the signature file. In supervised classification, the user or image analyst supervises the pixel classification process. In order to classify land covers, many researchers have showed greater interest in supervised rather than unsupervised methods (Ahmad, 2013). According to the Ahmad, the maximum likelihood classification is higher accurate than other classification algorisms. According to (Ahmad, 2016), the general procedures in ML are as follows:

- The number of land cover types within the study area is determined.
- The training samples for each of the desired classes are chosen using land cover information for the study area. Six samples for each LU/LC classes are randomly taken from field by using GPS instrument to classify the land use classes.

3.3.1.3 Accuracy assessment

Accuracy Assessment of Classification of land use land cover is used to ground truth validation. Sufficient numbers of randomly distributed sample points were selected from ground observation with forest cover, cultivated land, open space and settlement area using GPS instrument. The error matrix in attribute table and kappa method was used to assess the mapping accuracy. The general acceptance of the error matrix as the standard descriptive reporting tool for accuracy assessment of remotely sensed data has significantly improved the use of such data. An error matrix is a square array of numbers organized in rows and columns which expresses the number of sample units (i.e. pixels and clusters of pixels) assigned to a particular category relative to the actual category as indicated by reference data (Becker, 1998). Validation or accuracy assessment is an integral component of most mapping projects incorporating remotely sensed data (Congalton, 2001).

The importance and power of the Kappa analysis is that it is possible to test if a LULC map is significantly better than if the map had been generated by randomly assigning labels to areas as (Dengiz, 2018) cited (Congalton, 1996). According to (Congalton, 2001), the Kappa coefficient lies typically on a scale between 0 (no reduction in error) and 1 (complete reduction of error). The latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. Kappa is computed as,

$$\mathbf{K} = \frac{N\sum_{i=1}^{r} xii - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

Where N is the total number of sites in the matrix, r is the number of rows in the matrix,

xii is the number in row i and column i,

$x{+}i$ is the total for row i, and

$xi{+}$ is the total for column (Gumma et al., 2019) and Data, C. (2004)

The accuracy assessments are used to determine the overall accuracy, user's accuracy, procedures accuracy and kappa coefficient calculation. Kappa value greater than 0.80 (80%) represents strong agreement, a value between 0.40 and 0.80 (40 to 80%) represents moderate agreement, and a value below 0.40 (40%) represents poor agreement (Congalton, 1996). The acceptance and rejection of the supervised land use land cover classification value is depends on the value of Kappa. (Fung & Ledrew, 1988) examined the use of different accuracy indices, including overall, average and combined accuracies and the Kappa coefficient of agreement to determine an optimal threshold level for changes detection images. They recommended the Kappa coefficient because it considers all elements of the confusion matrix. All procedures for accuracy assessment were listed under appendices section.

3.3.1.4. Post Classification Techniques

The post classification approach which is the comparative analysis of independently produced classifications for different dates(Raja, 2013). This section presents the Land Use Land Cover classification after Maximum Likelihood Supervised Classification Analyses.

To analyze LU/LC change detection, the following activities has been taken after post classification. These are:

- ✓ Use two classified image
- ✓ Convert raster to polygon in geo processing window box on ArcGIS Map
- ✓ Make Dissolve in geo processing window box
- ✓ Make Union in geo processing window box
- ✓ Generate LULC change map and change dynamics of DPW

3.3.2. The relationship between NDVI and LU/LC changes

The following flow chart shows that relationship between NDVI and LU/LC changes.

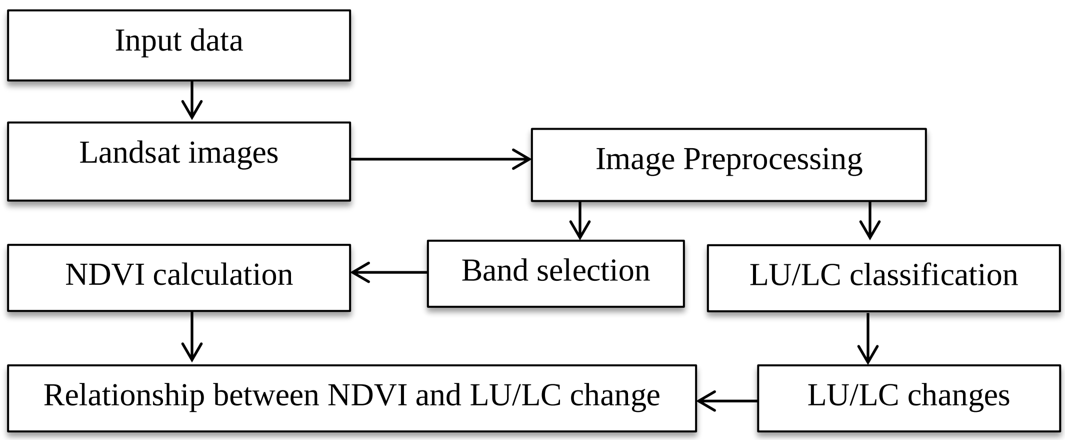

Figure3. 4. Flow chart for analyzing the relationship between NDVI and LU/LC changes

3.3.2.4 Normal Difference Vegetation Index

Normalized Difference Vegetation Index is the difference of near infrared and visible red reflectance values normalized over reflectance and calculated from reflectance measurements in the near infrared (NIR) and red portion of the spectrum. The NDVI values range from -1 to 1, the negative values are indicative of water, snow, clouds, non-reflective surface and other non-vegetated, while the positive value expresses reflective surfaces such as vegetated area as (Belete, 2017) cited (Burgan and Hartford, 1993). The index is expressed as NDVI= (NIR-IR)/ (NIR+IR), it evaluates the different content of humidity from the landscape elements, especially in soils, rocks and vegetation's and it is an excellent indicator of dryness. Bands of the image are different for different image to determine the NDVI value. For instance, for

Landsat 8 image, the near infrared and visible reds are band 5 and band 4 respectively. For Landsat 5, the near infrared and visible reds are band 4 and band 3 respectively. It can use the same formula to calculate NDVI, and use different bands. For Landsat 5 used the band value (4, 3) that means, Near Infrared (4) and Visible Red (3).

NDVI = (NIR -VIS)/ (NIR + VIS)

NDVI = (NIR -VIS)/ (NIR + VIS)

NDVI = (4 - 3/ (4 + 3)

For Landsat 8 used the band value (5, 4) that means, Near Infrared (5) and Visible Red (4)

NDVI = (NIR -VIS)/ (NIR + VIS) Where:-

VIS = Visible Red

NIR = Near Infrared

NDVI = (NIR - VIS)/ (NIR + VIS)

NDVI = (5 - 4/ (5+ 4)

The result of NDVI value after generates are always between -1 and +1. If there is low reflectance (or low values) in the red channel and high reflectance in the NIR channel, these yields a high NDVI value and vice versa.

3.3.3 Identification of the impact of LU/LC change on crop production

Before identify the impact of land use land cover change on crop products, the above procedures has been carried. The land use land cover change impacts on crop products was analyzed after land use land cover change detection and after analysis of population and crop products of Woreda. So, the identification of land use land cover change impacts on crop production was the last objective in this research. Therefore, it was intended to inform on the direction of solution to increase crop production after identified land use land cover change impacts on it. Incontestably, the findings of this research work were cannot solve the problem identified in the community of study area, but, it intimate the direction to solve that problems. According to the statement that ‘’any person must be fussed until identifying the problems’’. This means that main thing must to consider was to identify the troubles. Once a problem was identified, methods are developed and solutions are followed to diminish that troubles appeared in the study area. Consequently, in this research, a main problem which is shortage of food and factors which leads to it were identified in the Damot Pullasa Woreda. Such factors are trends of land use land cover changes from cultivated land to forest area with in the study period. Therefore, below methods enable that how to go to identify the impacts of land use land cover changes on crop production.

The following chart was designed to identify the impact of LU/LC change on crop products.

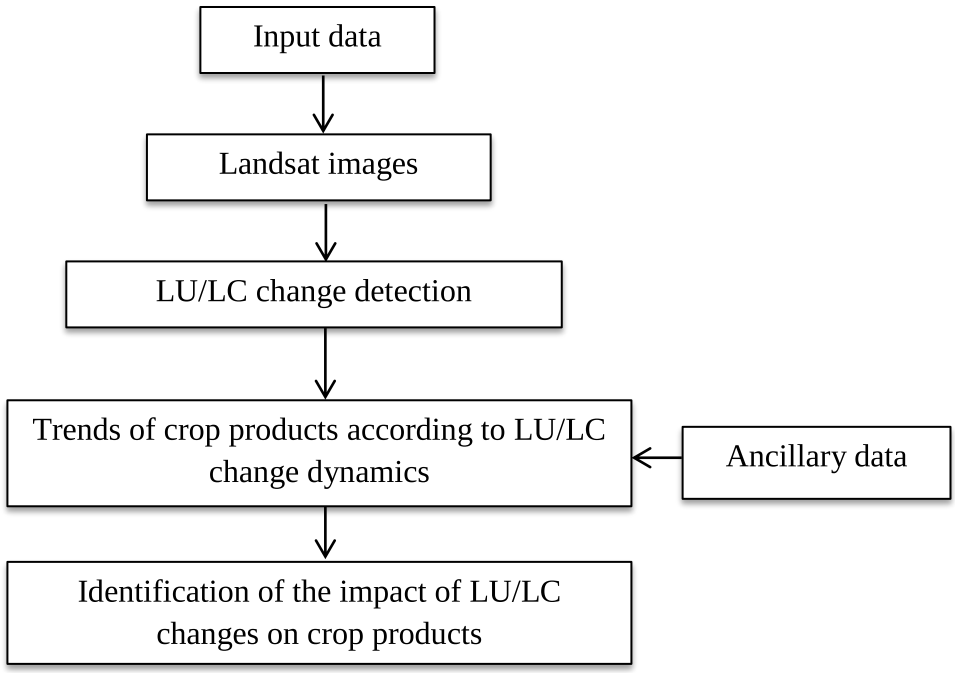

Figure3. 5. Flow chart for identification of the impact of LU/LC change on CP.

Above methodologies are designed by depending on the specific objectives of this research work.

In general, in this research, there are three specific objectives are fixed and coiled to overcome the identified problems in the study area. The general work flow in this research was designed sequentially as bellow chart. This flow chart shows that overall activities which are used in this study associated with general and specific objectives. All methods are listed starting from data input up to final output. Therefore, overall procedure's that followed to get out put in this research work were not stick out from below methodological flow chart listed in figure3.6.

Overall view of the methodology and the approach is followed for this research work is illustrated in the following flow chart.

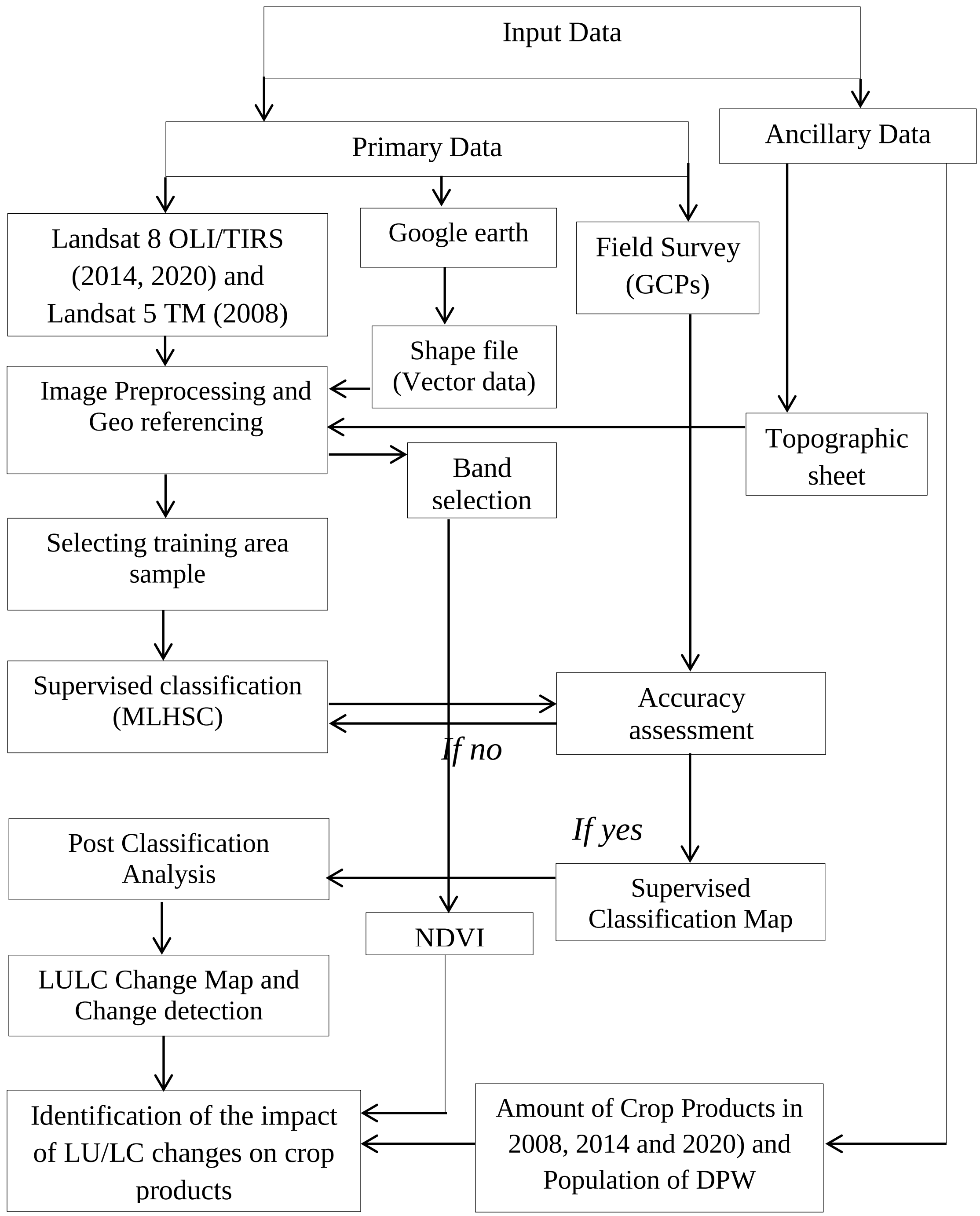

Figure3. 6. Methodological flow chart of the study

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Data analyses

4.1.1 True color map of study area

Three sets of cloud free Landsat images were selected for this research work are Landsat 5 TM of 2008 and Landsat 8 of 2014 and 2020 used in this analysis respectively. The figures below represent the true color map of 2008, 2014 and 2020 respectively of the study area which extracted from the stake layer processed by ERDAS IMAGINE 2014. The study consider the gap between the years of 2008, 2014 and 2020 which is the time gap between 2008 to 2014 is six(6) and 2014 to 2020 is six (6) respectively. The below Landsat imagery directly taken from the United State of Geological Survey with full metadata Information Sources and Geo tiff code. The below study area figure is masked from Landsat imagery by Geographical Information System software. It enables to classify the land use land cover of the study area as necessary as the methodology designed. Below figure shows that true color map of DPW in 2008. This true color maps are generated by using selected layer after layer stacked Landsat images. Below legends are shows that selected layer for different images.

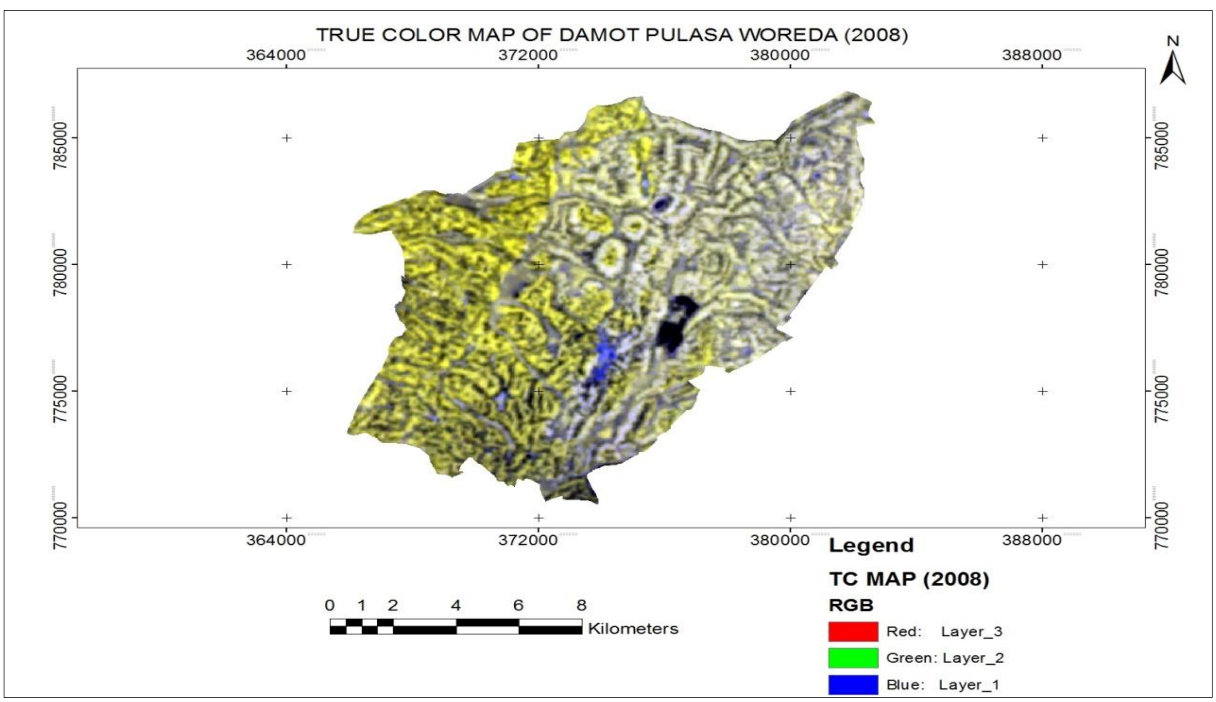

Figure4. 1. True Color Map of DPW in 2008

The figure4.2 is the 2014 year Landsat image of Damot Pullasa Woreda taken after six year to compare the land use land covers in the study area. It is impossible to determine the land use land cover change simply from one year image because it needs different year image to know the differences of land use land cover changes. The color of Landsat image was different for different images because of seasonal variation when operational satellites detect the ground features to capture the ground features.

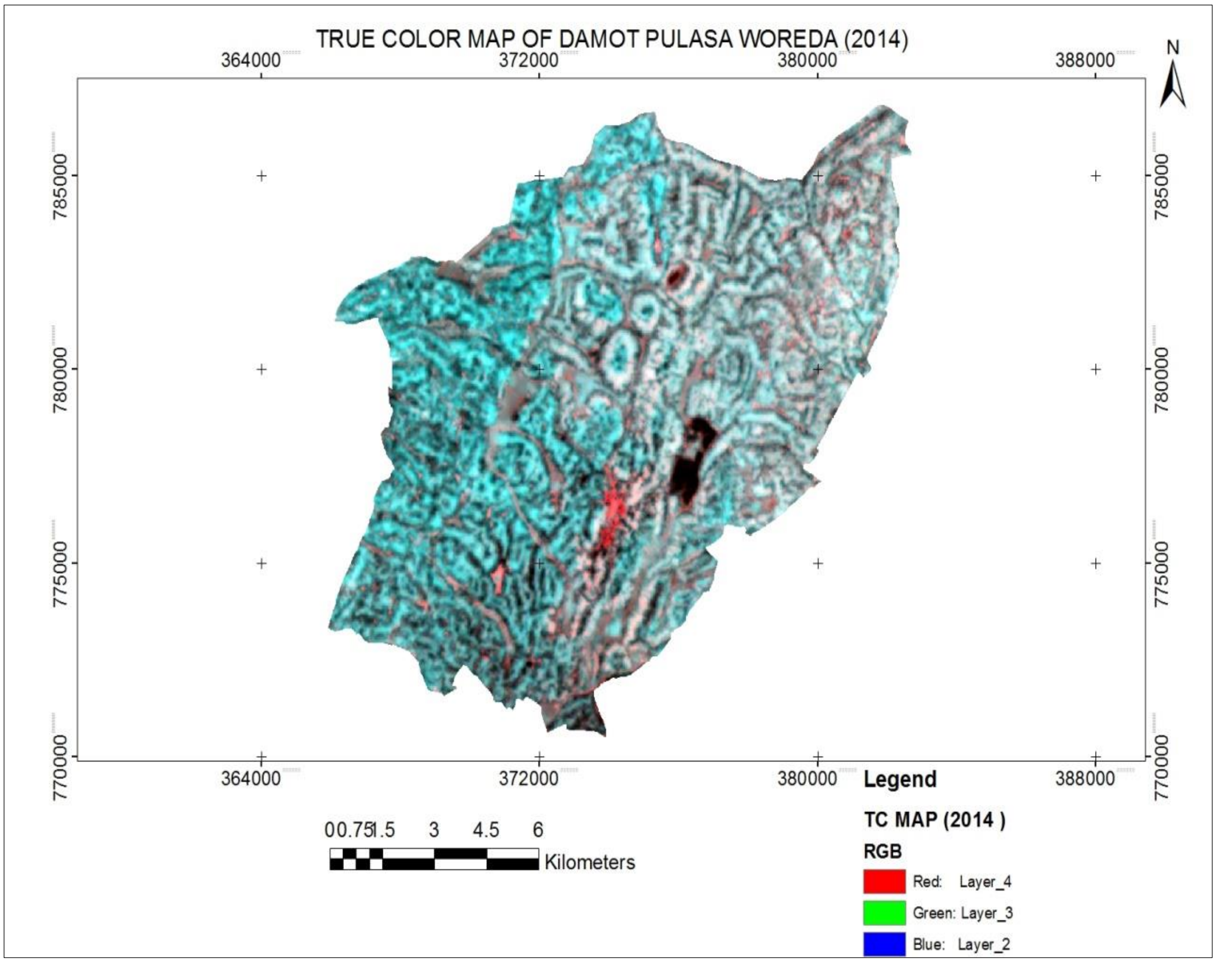

Figure4. 2 True Color Map of DPW in 2014

The change of land cover types from 2014 to 2020 was changes as shown on the below figure. As seen by color, there is an expansion of eucalyptus tree plantation which is one of the causes of crop products through decreases the cultivated land within the area as stated under problem statement.

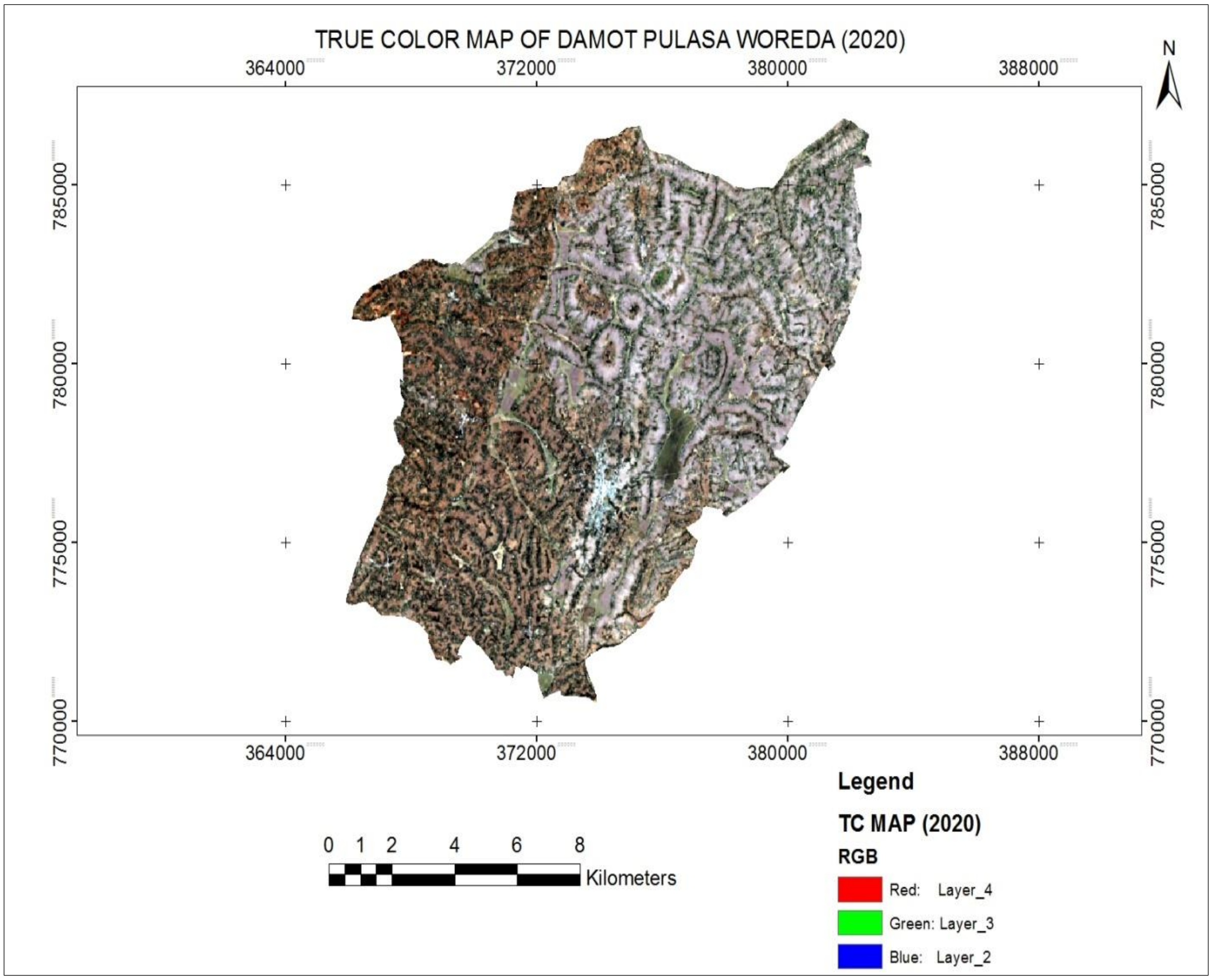

Figure4. 3. True Color Map of DPW in 2020

Above figure shows ground features clearly. This indicates that an image that captured in 2020 by sensor has comparatively high quality than that of 2008 and 2014 images. It is mainly depends on seasonal variation.

4.1.2 Normal Difference Vegetation Index of DPW

The Figure4.4 is the NDVI values of the study area calculated based on their band and Landsat data types. This is the result from Landsat5 and Figure4.5 and Figure4.6 are from landsat8. Normalized Difference Vegetation Index is the important ERDASIMAGINE and ArcGIS algorithm to differentiate the vegetation coverage of the study area. The figure4.4 is the first NDVI value of the vegetation cover classification of 2008 year of the study area. The map clearly shows that where dense vegetation covers and rare vegetation covers of the study areas exist. The value categorized in to two: high vegetation cover and low vegetation cover.

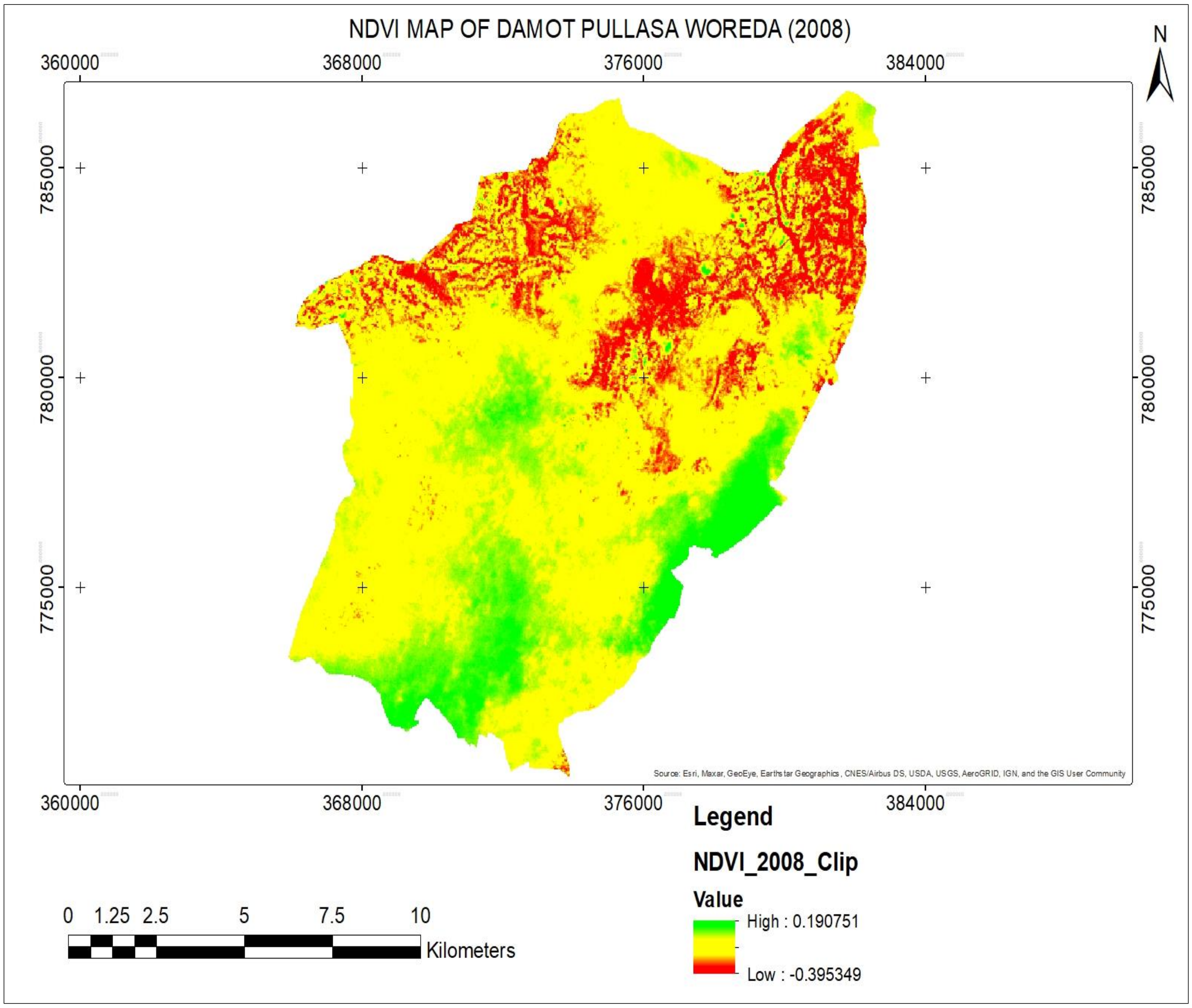

Figure4. 4. NDVI map of DPW in 2008

In fig 4.5, NDVI Value indicates that the amount of vegetation cover in the study area is increases from time to time. The figure4.5 has shown that expanding of tree plantation with in the study area from 2008 to 2014. The image analyze process of normalized difference vegetation index in 2008 Landsat image was used and the output result map indicated that the forest cover change in 2008 is less dense than that of 2014. Land use land cover change analysis always needs more than one image to compare the land cover change between the determined time gaps and also used to take action based on the report of land use land cover change image classification analysis. The change between two images difference in six years as the below figure4.5 clearly indicated that a lot of tree plantation was expanded in the Woreda.

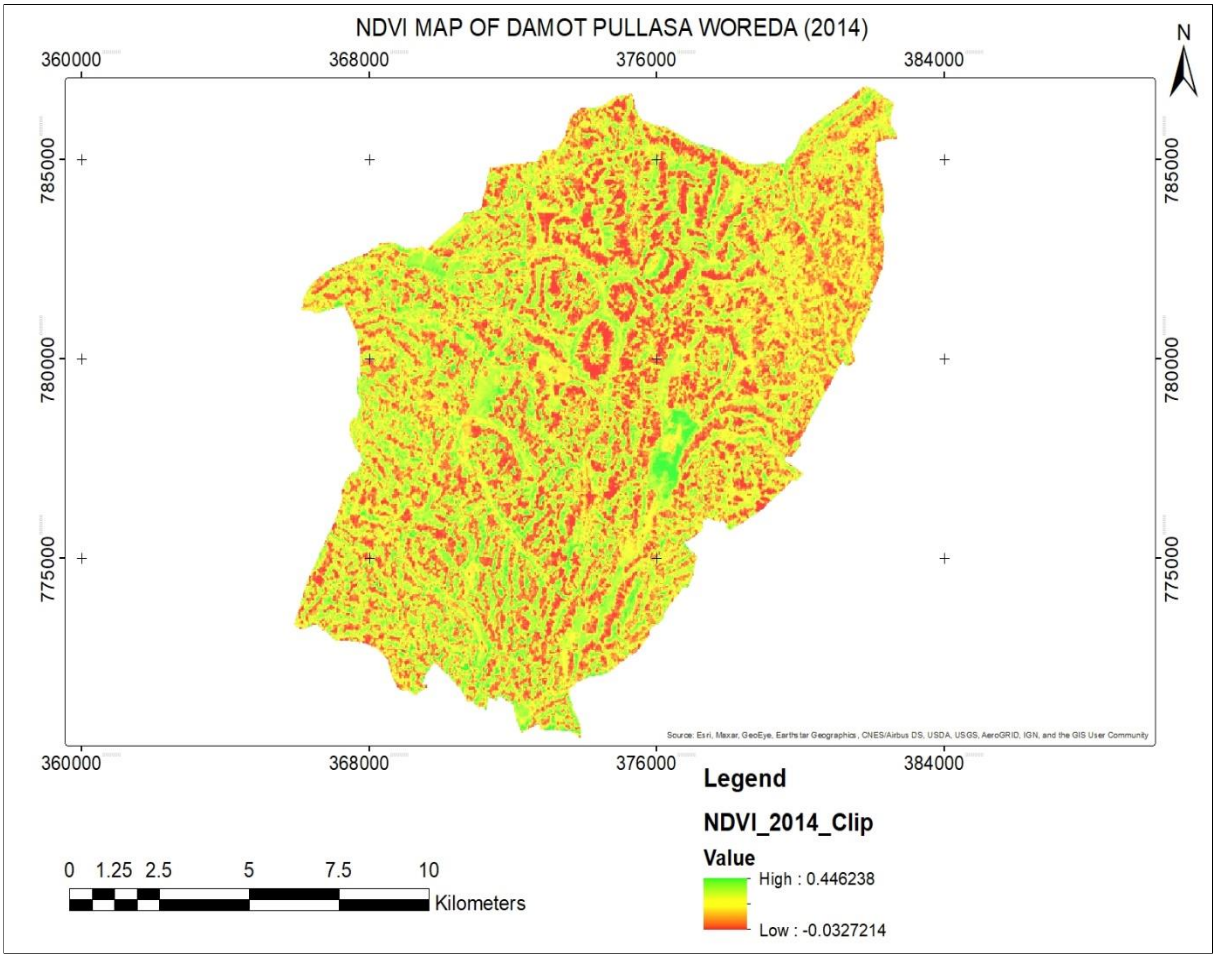

Figure4. 5. NDVI map of DPW in 2014

The amount of vegetation cover continuously increased again as observed from the NDVI value scientifically calculated of each data. Figure4.6 indicates that vegetation coverage in the same area increases from 2014 to 2020. Normal difference vegetation indices calculate the vegetation cover of the study area based on the Landsat band value which is Red, Green, and Blue, which is different in different Landsat. In Landsat5 the NDVI formula uses (Band 4, Band 3) as NIR infrared and Red while Landsat 8 uses (Band 5, Band 4) as NIR infrared and Red Respectively. The figure4.6 tells that there is very serious spreads of vegetation in the study area in 2020 rather than the previous two different years over the study period. Therefore, matching with this result, land use land covers change in the study area was analyzed and forest area coverage is increased from 2008 to 2020.

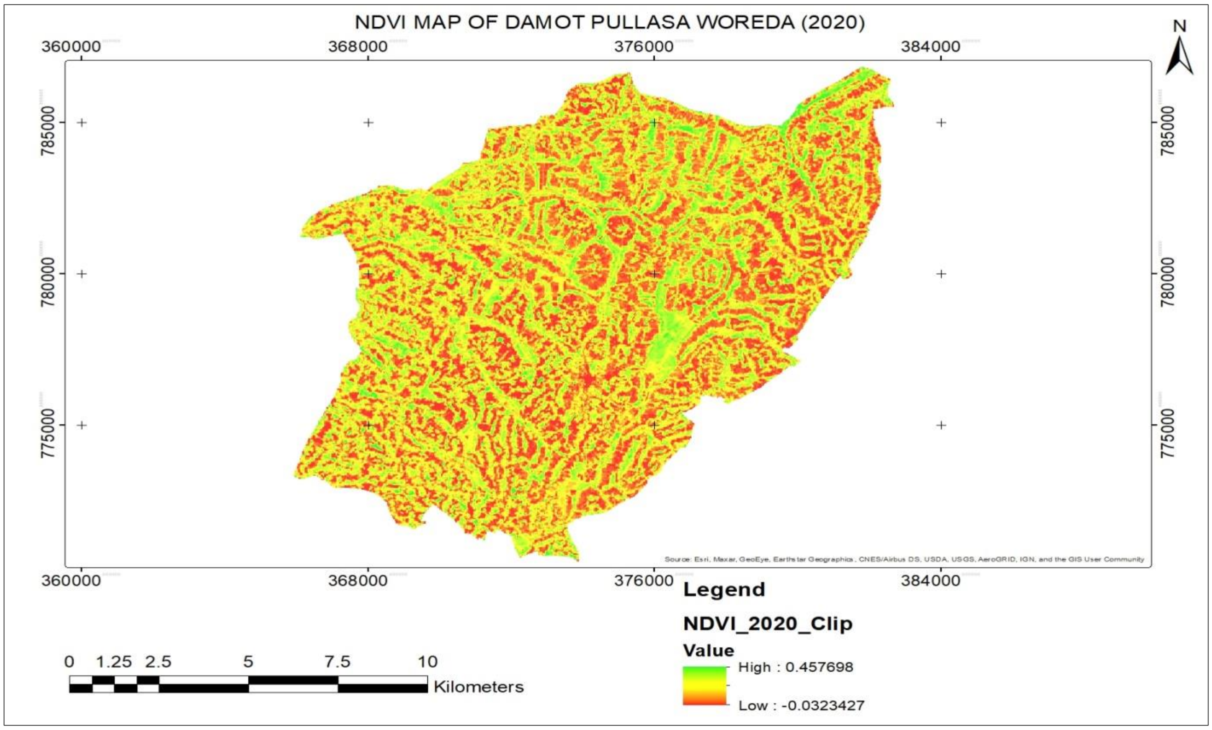

Figure4. 6 . NDVI map of DPW in 2020

4.1.3 Land use land cover classification of DPW in 2008, 2014 and 2020

To determine and classify LU/LC of the study area by using supervised classification; prior knowledge about the area is important. During field observation, four major LU/LC class were identified. Land-Use-Land-Cover classes and its description are presented in below table. To determine and classify LU/LC of the study area, prior knowledge about the area is important. During field observation, four major LU/LC classes were identified as follows:

Table4.1.Major LU/LC classes and its description of DPW

No	LU/LC class	Description
1	Cultivated Land	Area used for crop cultivation
2	Forest area	Area which covered with trees
3	Settlement Area	Area occupied by houses buildings includes residential and mixed urban and other facilities
4	Open Space	Areas which non vegetated area, out of crop lands and free from any kind of natural and artificial ground features

(Source: Field observation)

During supervised image classification methods, land cover types were identified. In this study the forest cover and cultivated land cover are more significantly important role than other types of land use land cover in the study area. Based on the characteristics of Landsat satellite image of the year 2008, 2014 and 2020 a number of land cover types were determined to run supervised classification, which aided the preliminary field visit. Therefore, in this study area the same procedure followed to classify the study area before the process held. There are four major land use land cover classes for all three Landsat images of different times; forest area cover, cultivated land cover, settlement area cover and open space are classified by using maximum likelihood supervised classification with support of ERDAS Imagine 2014 Software and Arc GIS 10.4.1. The map of supervised classification of Landsat 2008, 2014 and 2020 image classification was produced accordingly as figures below.

- LU/LC classification of DPW in 2008

The supervised Landsat image classification of 2008 indicated that the forest cover in the study area was comparatively less than that of 2014 and 2020. Cultivated land is dominant in 2008. The figure4.7 is the first supervised classification of the 2008 year Landsat map of the study area. In figure4.7, cultivated land covers heavy area and settlement area covers small area as compared with other classes.

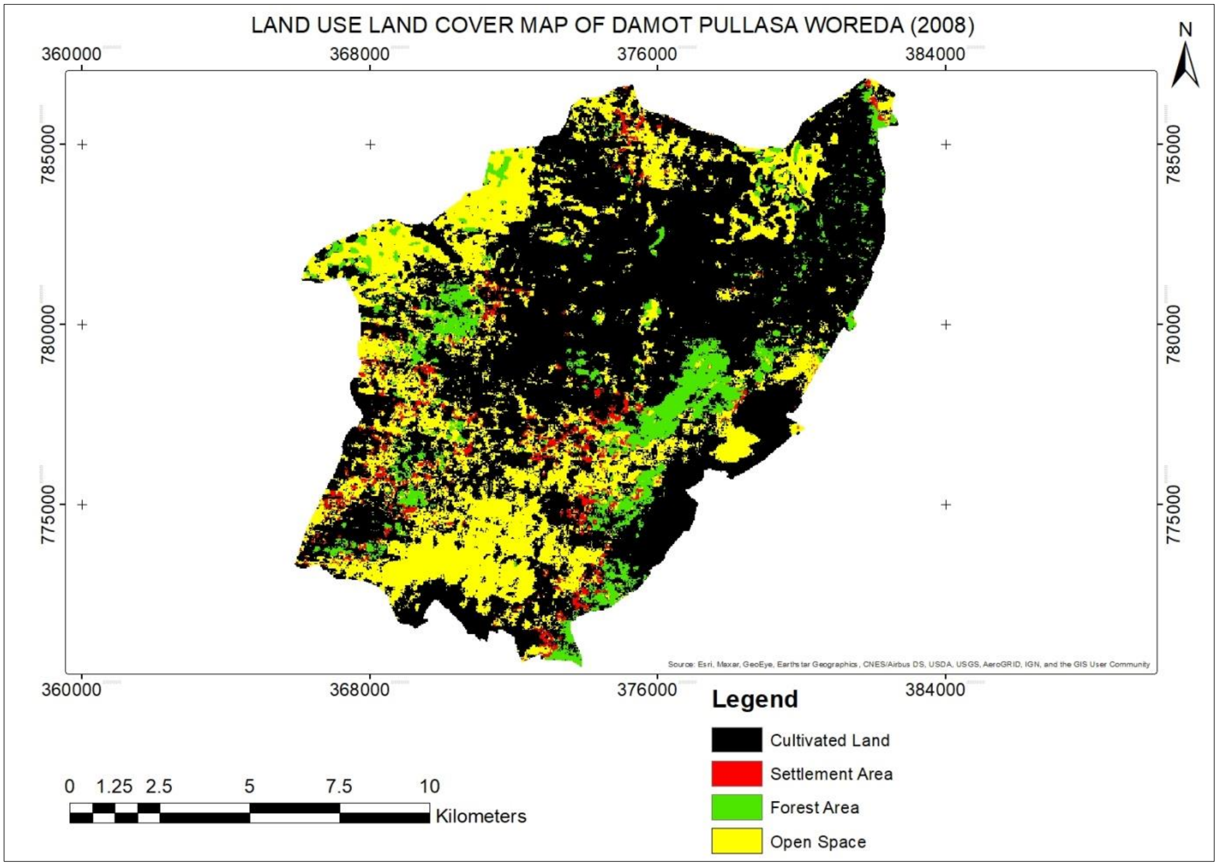

Figure4. 7. Supervised classification map of DPW in 2008

The following chart clearly indicates that normal condition of land use land covers of Damot Pullasa Woreda in 2008. And also, land use land cover classes were distinguished by their area coverage in the study area.

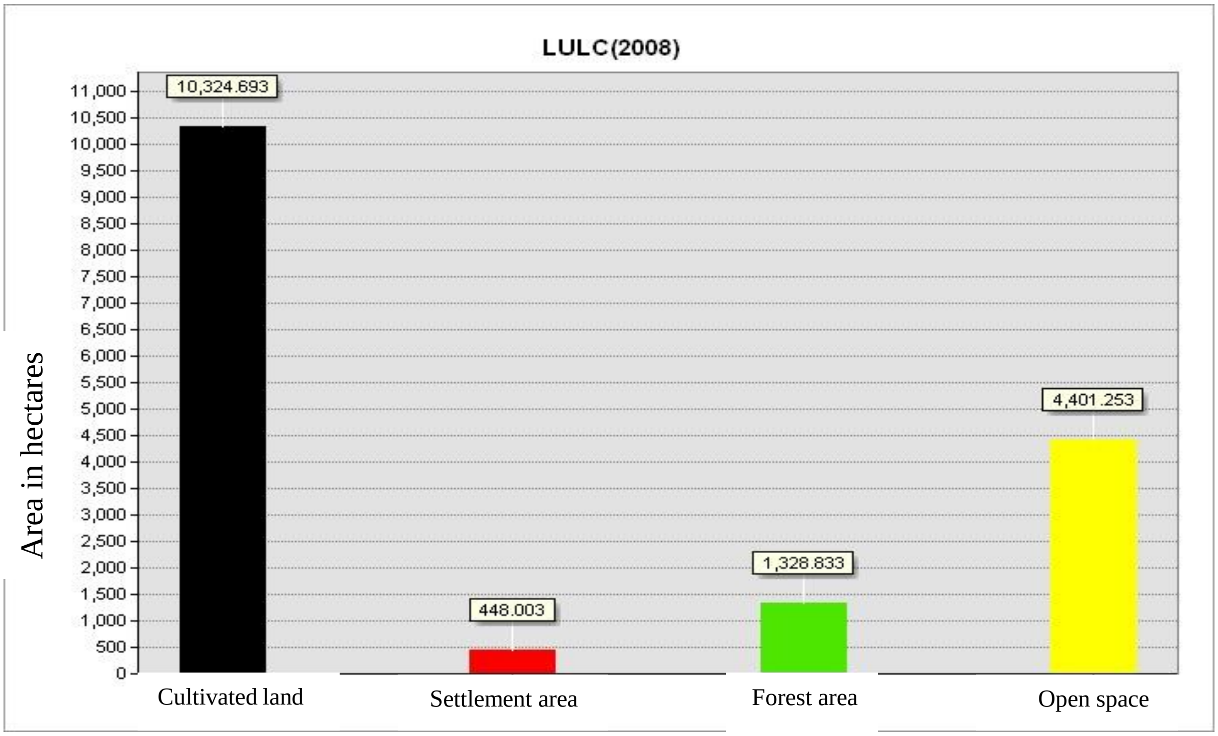

Figure4. 8. Land Use Land Covers of DPW in 2008

The figure4.8 clearly shows that existing condition of land use land cover classes and their area coverage in 2008. Cultivated land covered much area when compared with other types of land use land cover classes. 10324.693 hectares land out of total land was covered by cultivated land in the year 2008. Open space was followed by cultivated land by its area coverage in the same year. 4401.253 hectare land was covered by open space in the same year. Forest area is third level in this year, and also, it followed by open space by its area coverage. 1328.833 areas were covered by forest in the Woreda. Finally, settlement is followed by forest area and its area coverage is 448.003 hectares.

- LU/LC classification of DPW in 2014

In the same procedure, for 2014 year Land sat image, there are also four major land use land cover classes are identified. Such as; - forest area cover, cultivated land coverage, settlement area coverage and open space coverage with the support of specified software algorithms. The map of supervised classification of Landsat 2014 image was produced as below figure4.9. As the supervised Landsat image classification of 2014 indicated that the forest area cover in the study area was comparatively less than that of 2020. As the value obtained from the attribute table of all figures shown as there was increasing of tree plantation area coverage as it seen from the figure below.

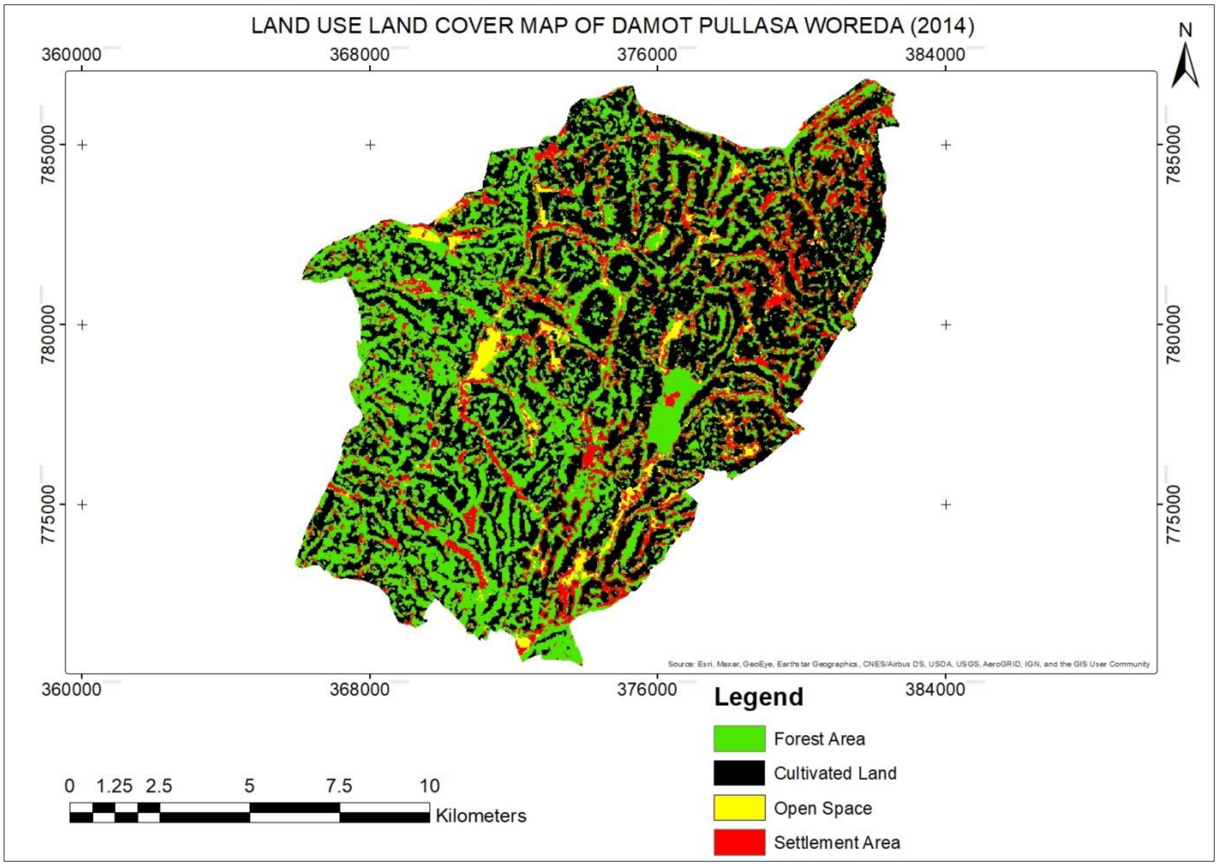

Figure4.9. Supervised classification map of DPW in 2014

The figure itself indicate that difference between the Land use land cover classes by their area coverage after analyses of maximum likelihood supervised classifications clearly shown the difference of the forest area coverage increased and cultivated land coverage decreased from time to time in hectares within the period of six years. The amounts of area coverage in hectares are clearly shown in below figure4.10. And also, the trend of land coverage is clearly identified in below figure4.10.

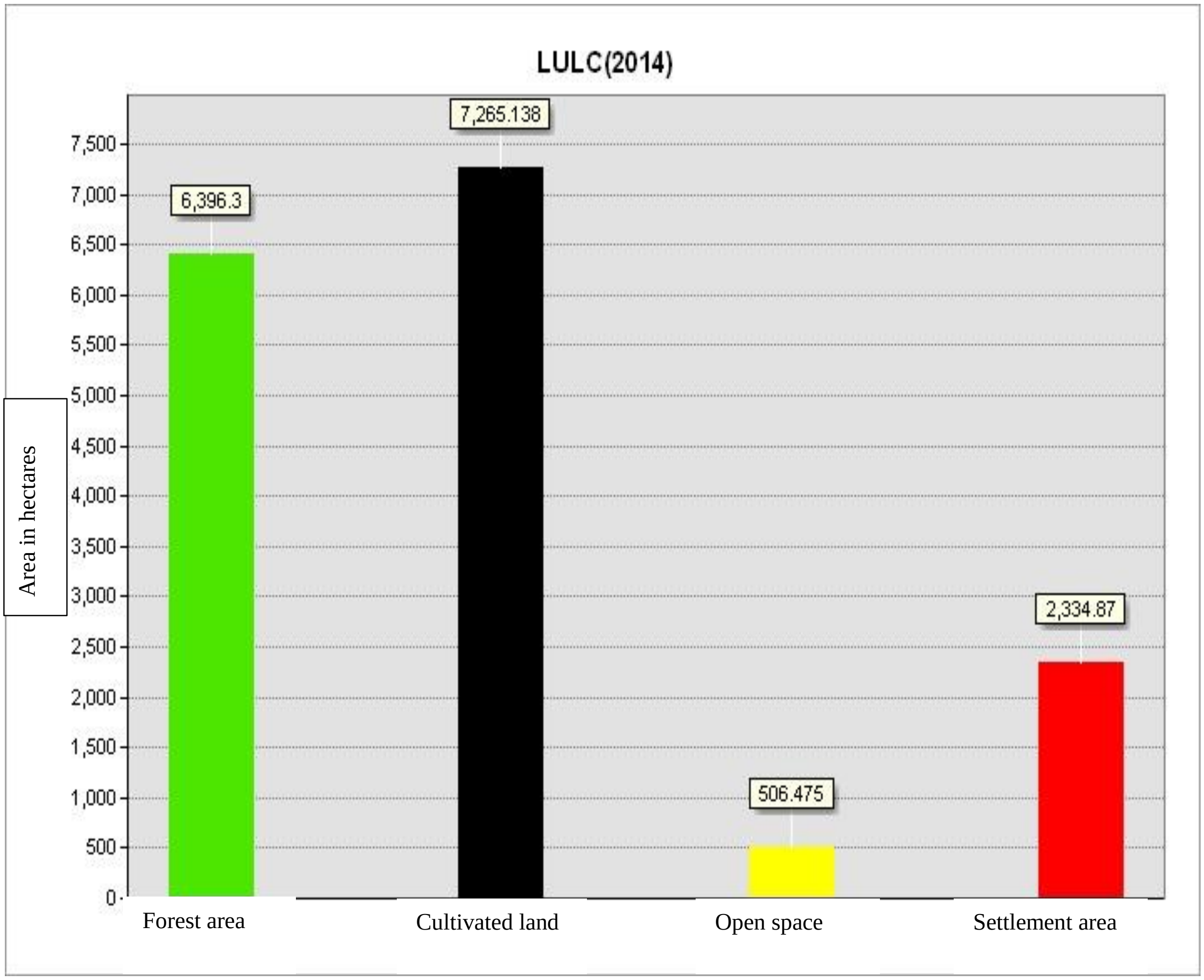

Figure4. 10 Land use Land Covers of DPW in 2014

As shown in the above figures4.10, there are a lot of differences in land use land covers of the study area. In general there is an increment of tree plantation, settlement area and decrement of cultivated land and open space from the year 2008 to 2014 with in the study period. In above figure4.10, the area of cultivated land was decreased to 7265.138 hectares from 2008 to 2014. And also, inversely, the forest area was increased to 6396.3 hectares from 2008 to 2014. Settlement area and open space are decreased and increased respectively from 2008 to 2014.

❖ LU/LC classification of DPW in 2020

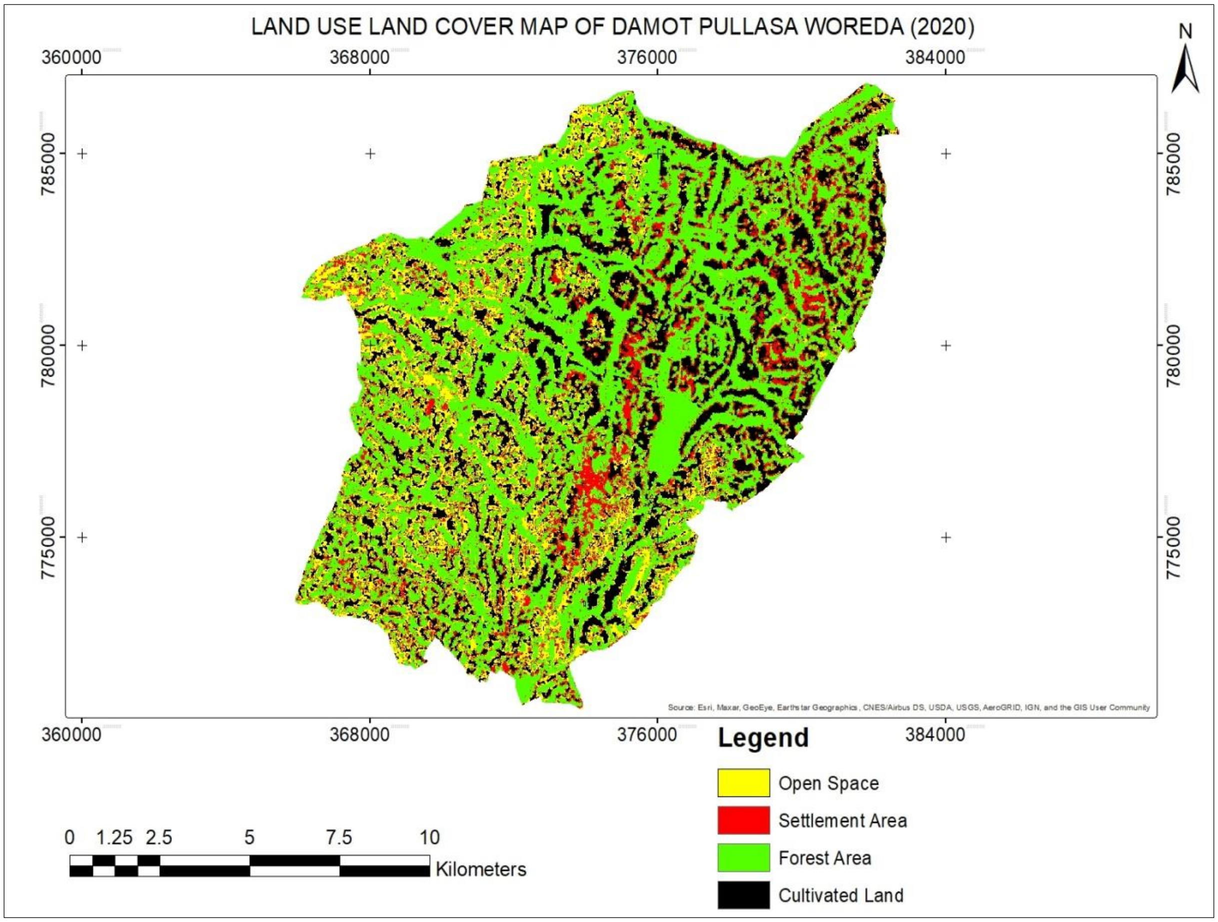

Figure4.11. Supervised classification map of DPW in 2020

The figure4.11 is supervised classification of the 2020 year Landsat image of the study area and the classification based on the four major land use land covers. Which are; forest area, cultivated land, settlement area and open space. The figure4.11 shows that forest area coverage was more increased and cultivated land coverage decreased from 2014 to 2020 in the study area.

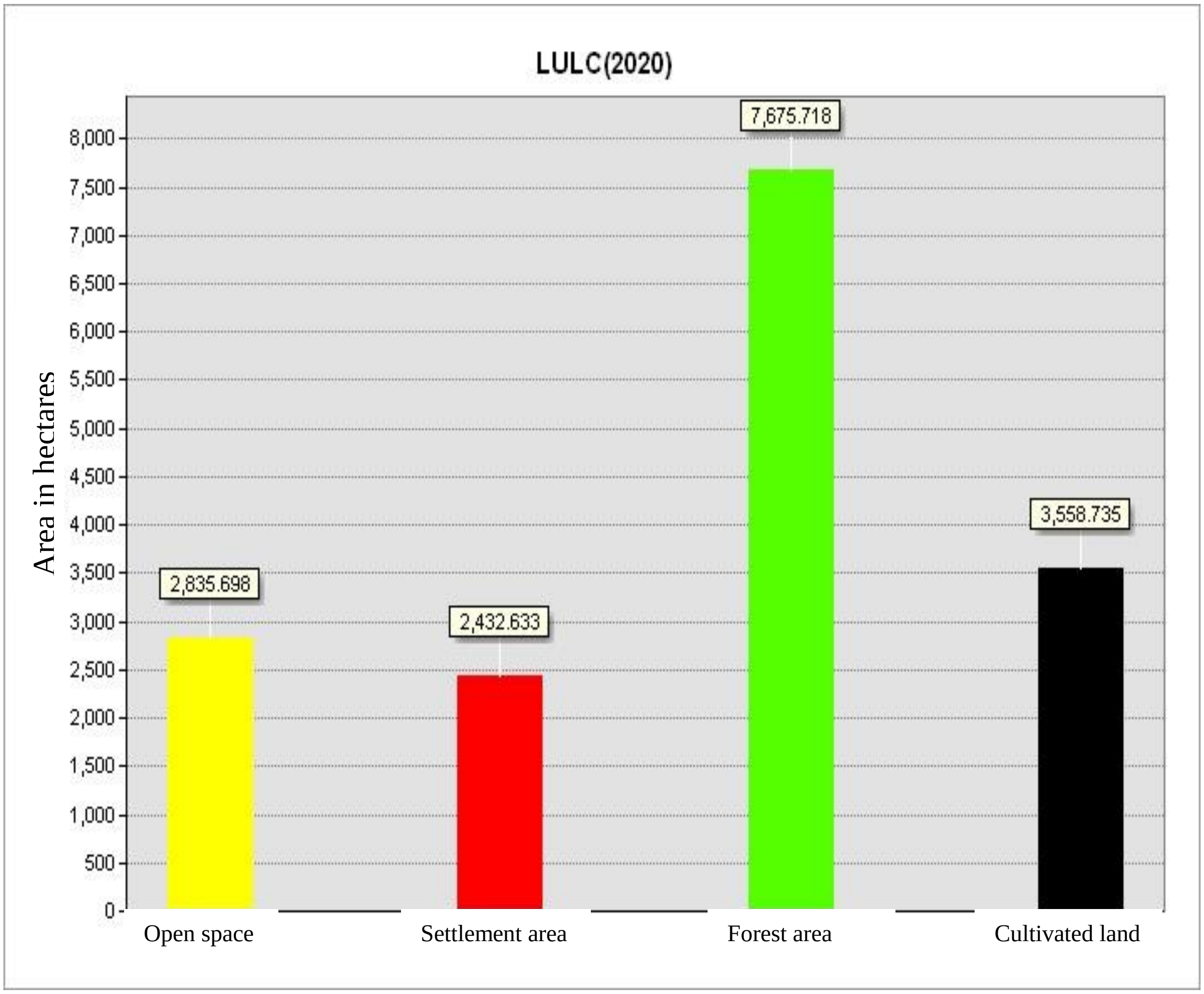

Figure4. 12 Land use Land Covers of DPW in 2020

Finally, as the results after whole data analysis, there is forest area coverage and settlement area increases, open space is increases partially and cultivated land decreases in the last three years. According to the finding, the Land Use Land Cover change in the period of 12 years, over tree plantation was increases and cultivated land decreases in Damot Pulasa Woreda. As stated in problem statement, when the cultivated land is decreases, it leads to shortage of food in the study area by considering other factors constant. As the computed values of computer software based mainly shown that forest area extensively expanded and cultivated land decreases from 2008 to 2020 in Damot Pulasa Woreda. The result of maximum likelihood supervised Landsat image classification of 2008 indicated that the forest area coverage in the study area was comparatively smaller than that of 2014 and 2020. And also, cultivated land coverage was decreased from 2008 to 2020.

4.1.4 Accuracy assessment

The all procedure for accuracy assessment calculation was done under appendix at the end of paper for each year LULC classified classes by using ground points to justify the true location of LULC classes. Therefore, when the value of Kappa coefficient is greater than 80%, the accuracy of the classification is very high, 40% to 80% is moderate and below 40% is insufficient to take (Congalton, 1996). Thus, the Kappa coefficient result after accuracy calculation for each year land use land cover classes shows that 80.82% for 2008, 66.20 for 2014 and 85.71 for 2020 land use land covers. Therefore, these values were accepted to run the next step. Below table shows that amount of accuracy was applied in land use land cover classification of study area. The overall procedures followed to overcome this value were calculated step by step under appendix. Higher kappa value was resulted in 2020 and the lower value of kappa was resulted in 2014. This result is depending up on the accuracy of data which collected to analyze it for the true location of land use land cover area justification. Total numbers of points which are collected from field are 28 points for LU/LC classes.

Table4.2. Accuracy assessment summary (from field data).

	Year	LU/LC classes				Overall accuracy in %	Kappa (%)
		Forest area	Settlement area	Cultivated land	Open space		
User accuracy in %	2008	100	62.5	100	83.33	85.71	80.82
	2014	100	62.5	100	33.33	75	66.20
	2020	100	100	100	83.33	89.3	85.71

Above table reflects that a condition of accuracy assessment value after all calculation procedures. Each and every step of these analyses including data collection from field survey was briefly carried out under sections of appendices.

4.2. Results

4.2.1 Land-use/land-cover in 2008, 2014 and 2020

Land-use/land-cover classification result of 2008 shows that the dominant LU/LC classes were cultivated land, forest area, settlement area and open space. From the total area of 16,502.784 hectare, cultivated land accounted for 10,324.693 hectare (62.56%), forest area accounted for 1328.833 hectare (8.05%), settlement area accounted for 448.033 hectare (2.71%) and open space accounted for 4401.253 hectare (26.67%). The results of 2014 shows that, from the total area of 16,502.784, cultivated land accounted for 7265.138 hectare (44.02%), forest area accounted for 6396.3 hectare (38.76%), settlement area accounted for 2334.87 hectare (14.15%) and open space accounted for 506.475 hectare (3.07%). The results of 2020 shows that, from the total area of 16,502.784, cultivated land accounted for 3558.735 hectare (21.57%), forest area accounted for 7675.718 hectare (46.5%), settlement area accounted for 2432.633 hectare (14.74%) and open space accounted for 2835.698 hectare (17.18%). The other small area covered unclassified LU/LC classes which are grassland and little water bodies are merged in to the same color land use land cover types. For instance, some ponds and grasslands which covers very small area in somewhere within the Damot Pullasa Woreda are merged in to other land use land cover classes with their approximate similar colors when software detects the classification of land use land cover types.

The table4.3 and table 4.4 are shows that different types of land use land covers in Damot pullasa woreda and their area coverage by hectares and percentage respectively with in specific years.

Table4.3.LU/LC types and their area in Hectare

No	LULC classes	Area in Hr(2008)	Area in Hr(2014)	Area in Hr(2020)
1	Open Space	4401.25	506.47	2835.69
2	Settlement Area	448.00	2334.87	2432.63
3	Cultivated Land	10324.69	7265.13	3558.73
4	Forest Area	1328.83	6396.30	7675.72
Total		16, 502.78	16, 502.78	16, 502.78

Table4.4. LU/LC types and their area coverage in Percent

No	LULC types	Area in % (2008)	Area in %(2014)	Area in % (2020)
1	Open Space	26.67	3.07	17.18
2	Settlement Area	2.71	14.15	14.74
3	Cultivated Land	62.55	44.02	21.56
4	Forest Area	8.07	38.76	46.51
Total		100%	100%	100%

In above tables large area LU/LC class covered in 2008 was cultivated land and small area LULC class covered in 2008 was settlement area by 62.55% and 2.71% respectively. In the year 2014, the large area covered was cultivated land and small area covered was open space by 44.02% and 3.07% respectively. Finally in the year 2020, the large area covered was forest area and small area covered was settlement by 46.51% and 14.74%. This value mainly indicates that the inverse relationship between cultivated land and forest land. The following diagram used to differentiate the value of land use land cover classes of Damot Pulasa Woreda within three years interval.

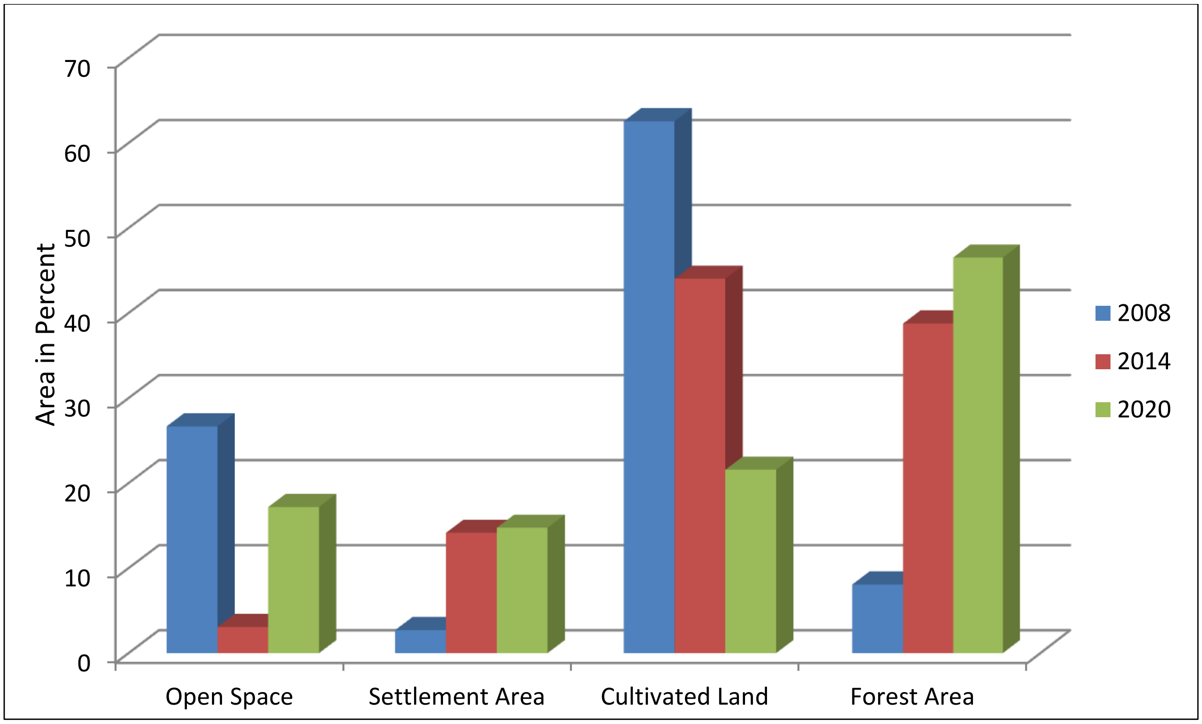

Figure4.13. LU/LC types and their area coverage in DPW

The above figure makes that clear understands about the different types of land use land coverage in the study area. For instance: - the blue, red and green colors are indicates that the different years and the numbers starting from 0 to 70 which are listed at left side are the percent value for each type of land use land covers with in different years.

Table4.5 shows that different land use land cover types in the study area and their changes from one year to another year as specified in this research.

Table4.5. LU/LC change value in percent

No	LULC types	Change from 2008 to 2014 (in %)	Change from 2014 to 2020 (in %)	Change from 2008 to 2020(in %)
1	Open space	-23.6	+14.11	-9.48
2	Settlement area	+11.44	+0.60	+12.03
3	Cultivated Land	-18.53	-22.46	-40.99
4	Forest Area	+30.69	+7.75	+38.44

From above table, the positive sign shows that the increment of the land use land cover area in percent from previous year to following year after six year interval and negative sign shows that the decrement of land use land cover area. In this study, there are three consecutive years are used to determine change detection. Cultivated land decreases from 2008 to 2014 by 18.53%, from 2014 to 2020 by 22.46% and from 2008 to 2020 by 40.99%. Forest area increases from 2008 to 2014 by 30.69%, from 2014 to 2020 by 7.75% and from 2008 to 2020 by 38.44%. Settlement area increases from 2008 to 2014 by 11.44%, from 2014 to 2020 by 0.60% and from 2008 to 2020 by 12.03%. Open space decreases from 2008 to 2014 by 23.6%, increases from 2014 to 2020 by 14.11% and decreases from 2008 to 2020 by 9.48%. These result shows that the augmented change of forest area by increasing and augmented change of cultivated land by decreasing from 2008 to 2014, 2014 to 2020 and 2008 to 2020.

The figure4.20 shows that trends of different types of land use land cover changes in Damot Pulasa Woreda with in different year interval.

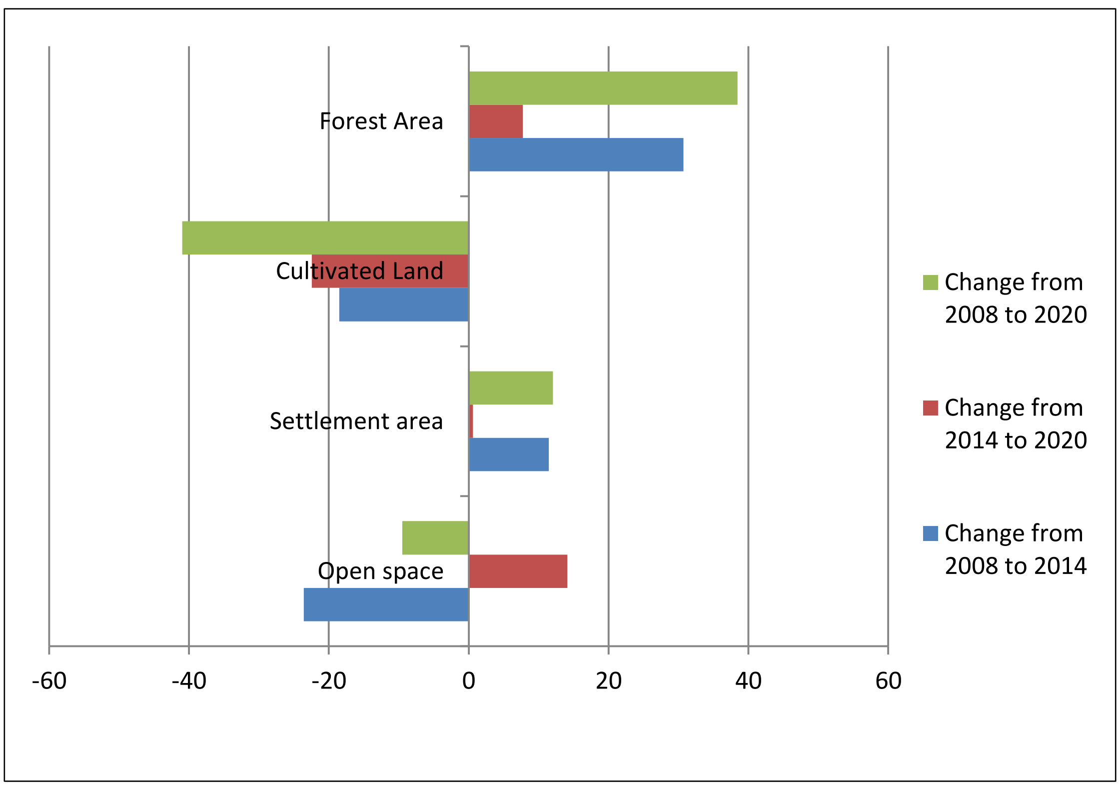

Figure4. 134. Trends of LU/LC changes in DPW

In this study it was done by using three years which are 2008, 2014 and 2020. Within these time period the result shows that changes of land use land covers. The overall interval for change of land use land cover in percent is from negative 40.99% to positive 0.60% (-40.99% to +0.60%). Negative side shows that decrement of the area coverage of land use land cover types. In this study, the result shown that the cultivated land is decreases from year to year around all year and open space is decrease from a year 2008 to 2014 and from 2008 to 2020. Other land use land cover types are increases from year to year. For example: - forest area and settlement area are increases from time to time with in all three years (2008, 2014 and 2020). And also, open space is increase only from the year 2014 to 2020.

4.2.2. LU/LC change dynamics of DPW in 2008, 2014 and 2020

i. LU/LC change dynamics of DPW from 2008 to 2014

The following map shows that the converted land use land covers class from a year 2008 to 2014. In this map, there are four types of land use land cover classes which are; cultivated land, forest area, settlement and open space are converts by some area amount with each other.

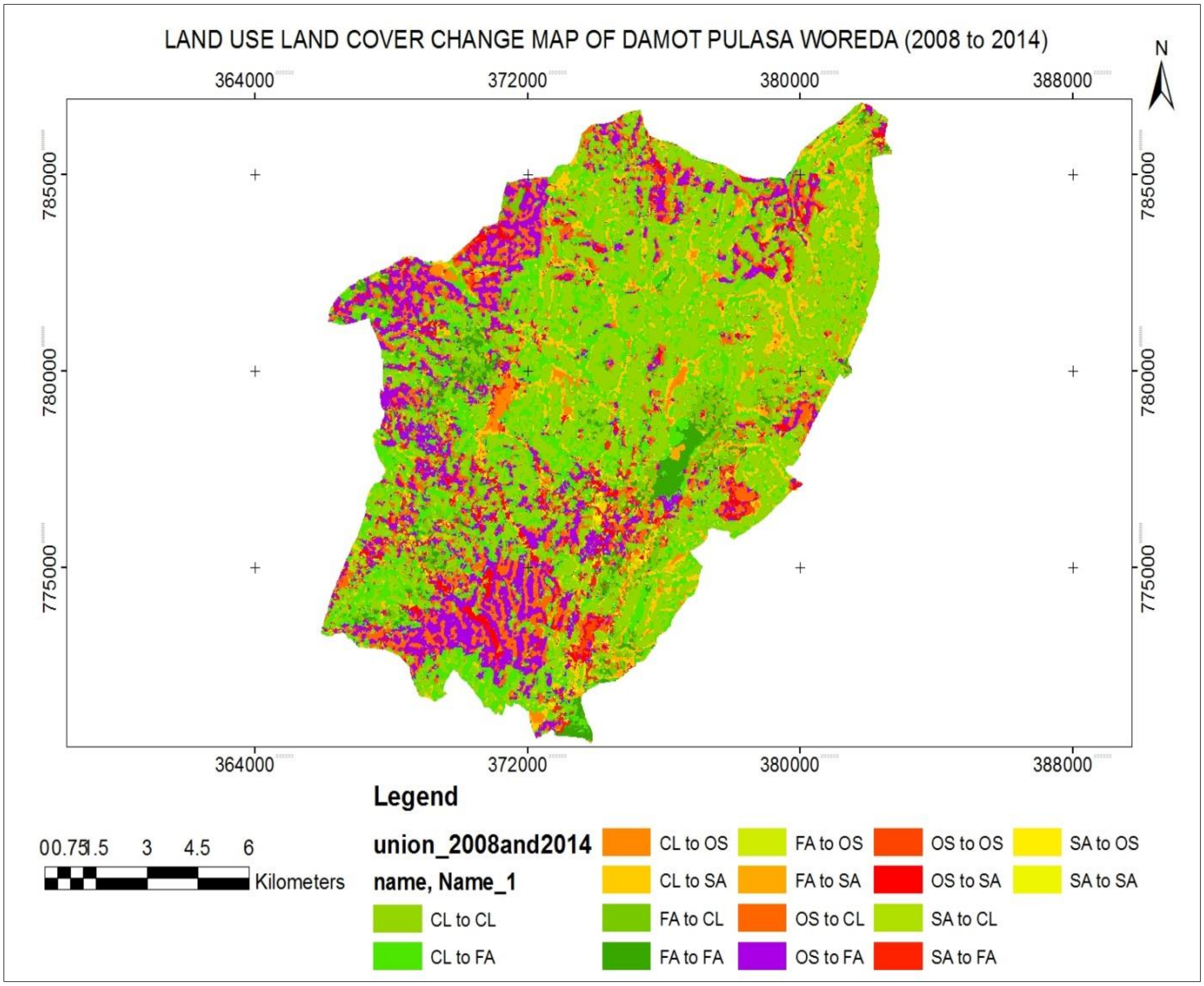

Figure4.15. LULC change map of DPW from 2008 to 2014

The trends of conversion of one land use land cover class to another land use land cover classes were determined in below figure4.15 with its area coverage in hectares. The above map clearly shows that sixteen land use classes conversion between each other from 2008 to 2014. The above map is not shown obviously. Because of, there is very high crowdedness of one land use land cover class over another class to show their conversion from 2008 to 2014.

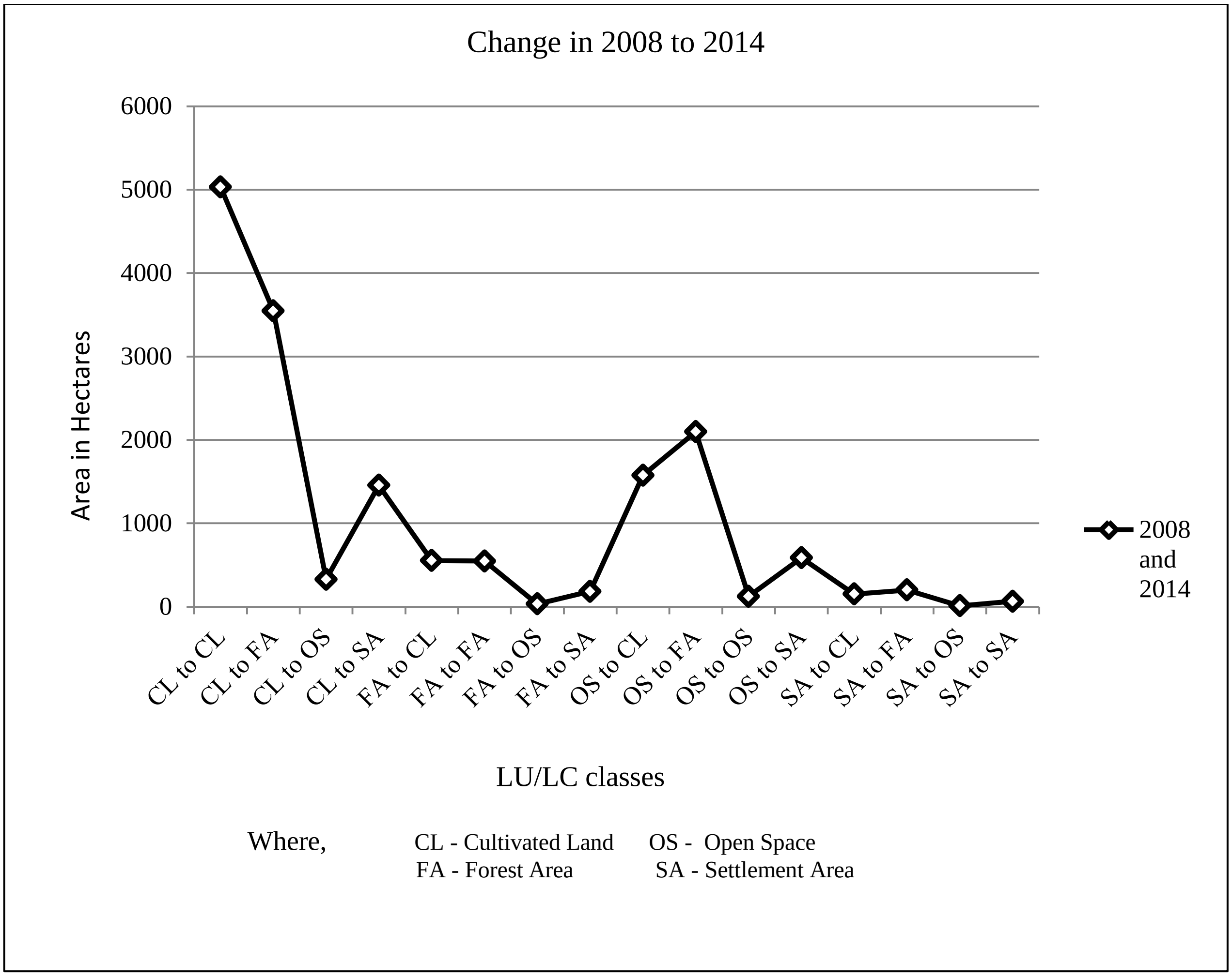

Figure4. 16. LULC changes from 2008 to 2014

In figure4.16, a conversion of cultivated land to cultivated land recorded as highest area. And, a conversion of settlement to open space was recorded as lowest area in hectares.

ii. LU/LC change dynamics of DPW from2008 to 2020

Below figure4.15 indicates the land use land cover conversions from one land class to another class from 2008 to 2020.

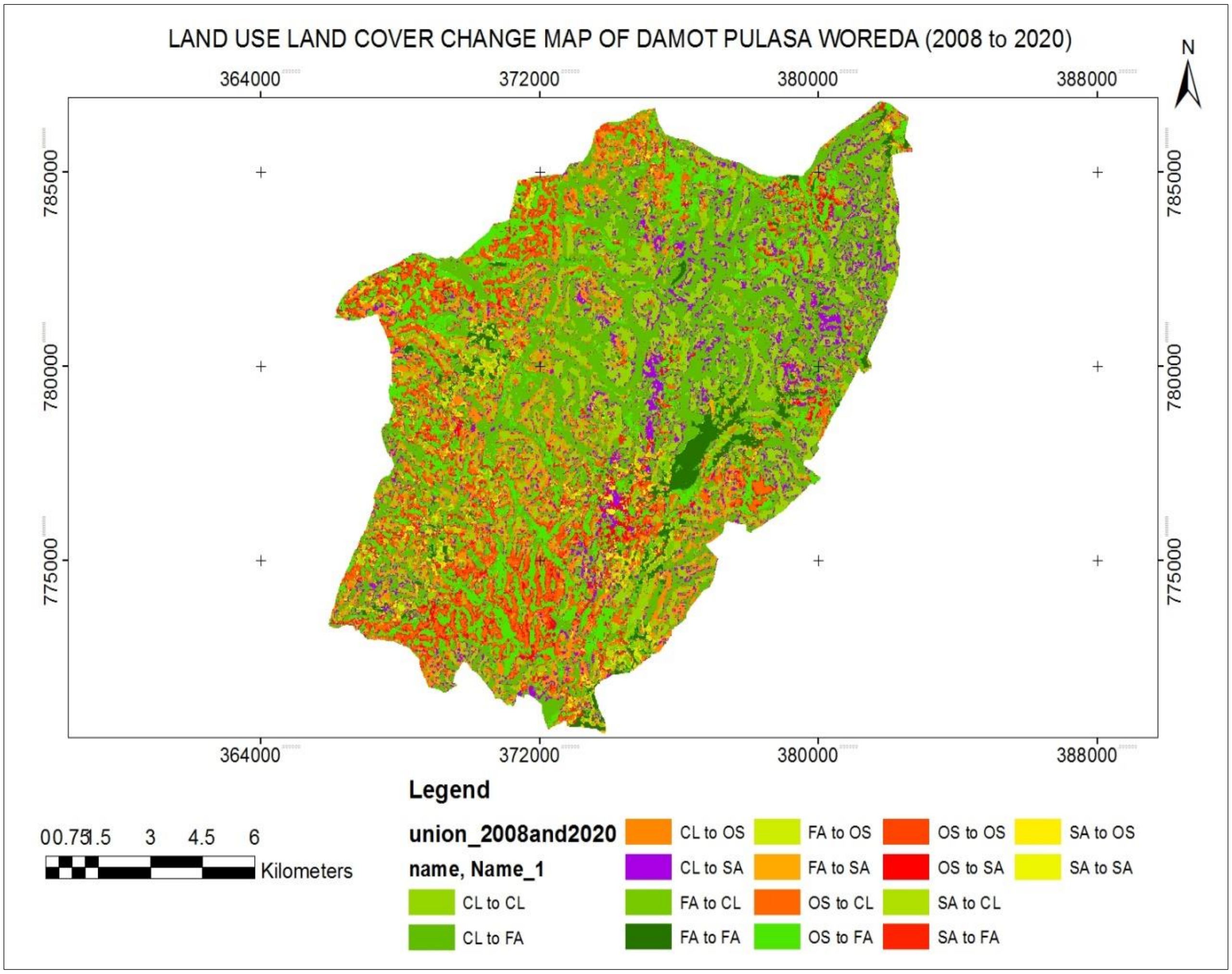

Figure4. 14. LULC Change map of DPW from 2008 to 2020

It enhances to know that how much area of one LULC class was converted to other class. For example: - cultivated land cover area was converted in to cultivated land, forest area, settlement area and open area by some amount. As like these, all other classes are converted in to another class by some amount through increases or decreases of area extent. The converted area in hectares are tabulated in table 4.6.

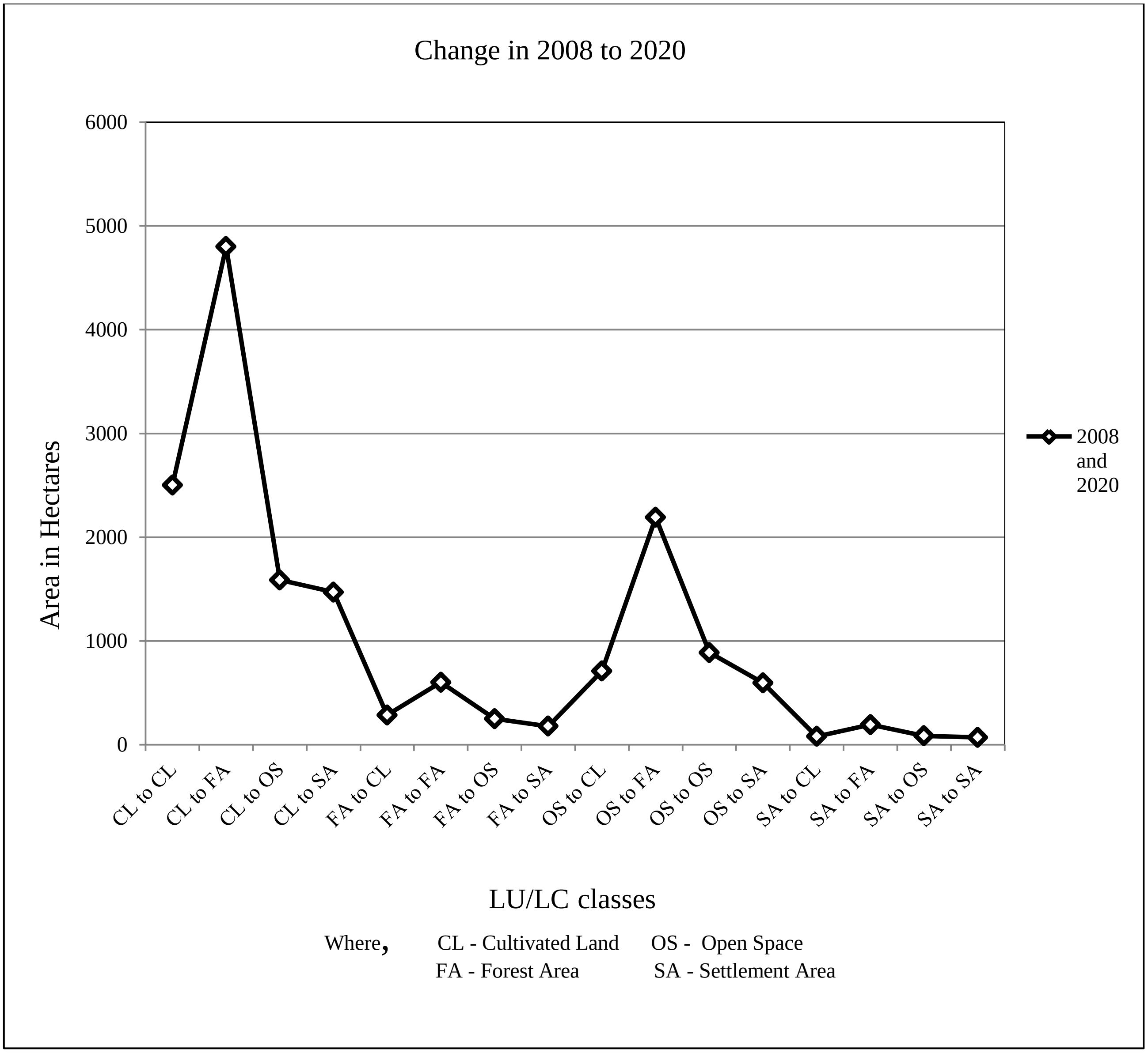

Figure4.158. LULC changes from 2008 to 2020

iii. LU/LC change dynamics of DPW from 2014 to 2020

In the same procedure, the following map also shows that the land use land cover changes and its conversions between the year 2014 and 2020.

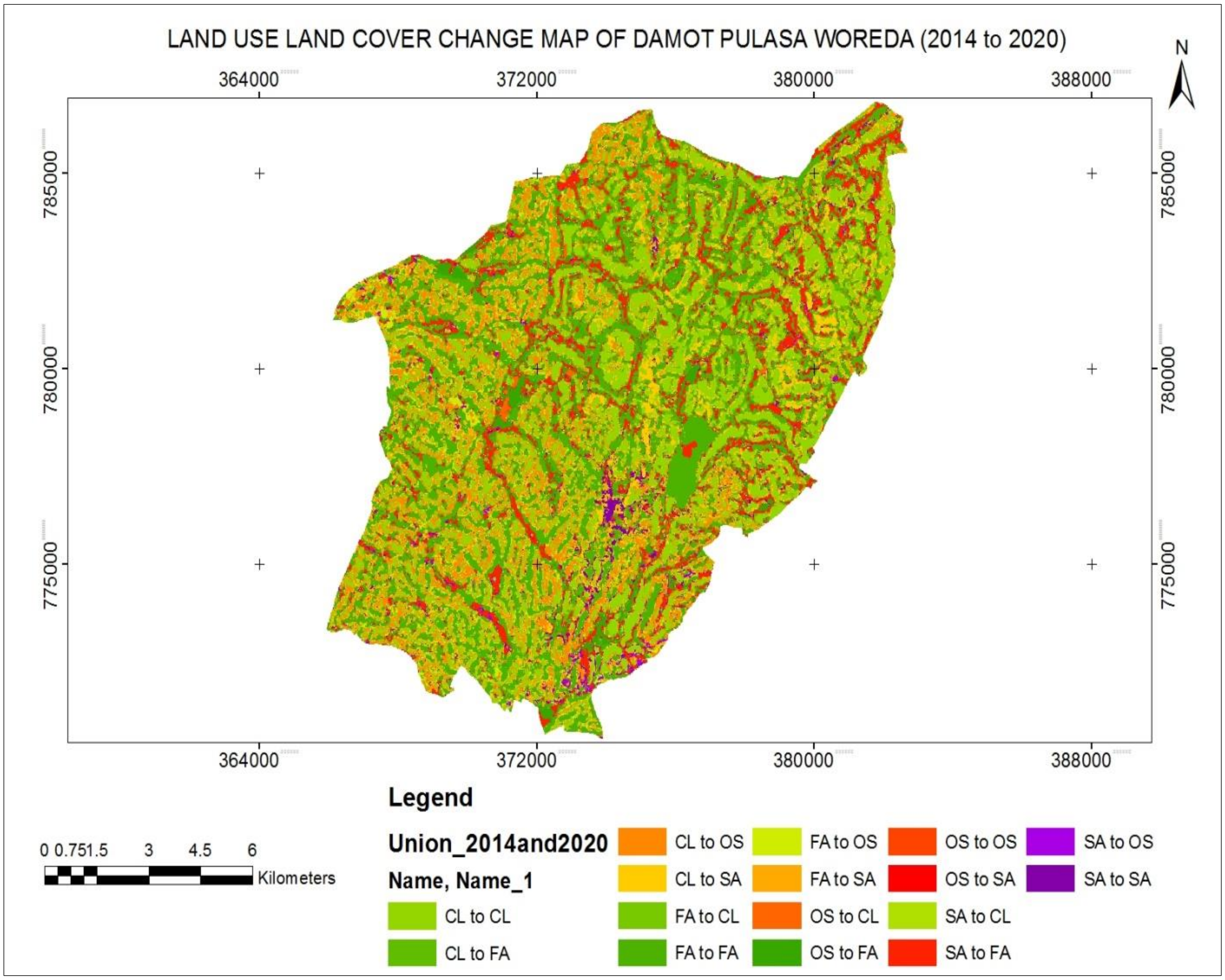

Figure4.169. LULC Change map of DPW from 2014 to 2020

In figure 4.17, a conversion of land use land cover classes has done. It shows that the tree plantation is expanded and the cultivated land was decreased from the year 2014 to 2020. So, the study was completed by realizing the trends of land use land cover change dynamics from cultivated land to forest area. The following graph shows that the conversion of land use land cover from 2014 to 2020 in the form of interpretative manner. In addition, it show a drift of the conversion of land use land cover change dynamics from one land class to another land classes from 2014 to 2020.

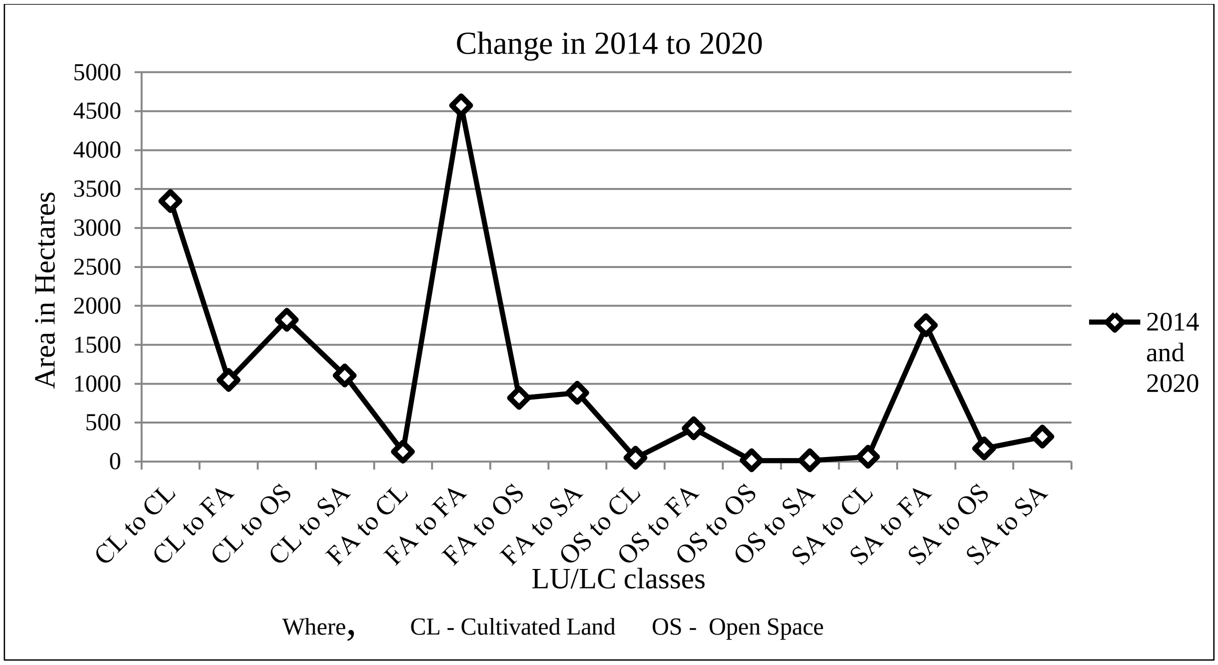

Figure4. 20. LULC changes from 2014 to 2020

Figure 4.18 shows that land use land cover conversion from 2014 to 2020. It shows that highest converted class was of forest area to forest area by 4572.89 hectares and lowest converted area was open space to open space by 13.27 hectares in Damot Pullasa Woreda. Finally, it was examined that most cultivated to cultivated land conversion were identified from 2008 to 2014 and cultivated land to forest land conversion was recorded from 2008 to 2020. And, also forest to forest land conversion was recorded from 2014 to 2020. This shows that, magnitude of land use land cover conversion in the study area was going to forest area. In year from 2008 to 2014, it was in well condition, means that there was no more land use land cover classes of study area were changed to from other land use classes to forest area

Below table4.6 was generated from conversion map of Damot Pullasa Woreda. It clearly indicates that the conversion of one land use land cover classes to another classes by specified hectares. And also, it shows that overall converted value of land use land cover classes from one land use land cover classes to another classes from one year to another year. In general, in this research study, there were three years which are 2008, 2014 and 2020 are selected. Therefore, the problem statement and objectives which identified under chapter one are shortage of food and identifying the impacts of land use land cover changes on crop production in Damot Pullasa Woreda. The result showed that an increment of forest area coverage and decrement of cultivated land area coverage seriously in the study area with in the study period. Consequently, the shortage of food was a main problem of study area through decreases of land for cultivation. Therefore, table4.6 clearly shows that area of converted land use land cover classes in hectare and conversions from one year to another year with in study period.

Table4.6. Land Use Land Cover Change Dynamics of DPW

LULC Types	Area in Htr. (2008 to 2014)	Area in Htr. (2014 to 2020)	Area in Htr. (2008 to 2020)
Cultivated Land to Cultivated Land	5029.685984	3344.863678	2501.47466
Cultivated Land to Forest Area	3546.78333	1045.394663	4800.346432
Cultivated Land to Open Space	327.883232	1818.301054	1587.158741
Cultivated Land to Settlement Area	1455.230732	1104.059946	1470.428692
Forest Area to Cultivated Land	552.174044	126.562569	285.155183
Forest Area to Forest Area	546.761595	4572.892491	600.693707
Forest Area to Open space	32.282751	813.361551	250.38366
Forest Area to Settlement Area	182.645586	881.199607	177.818476
Open Space to Cultivated	1575.792916	45.438058	709.965492
Open Space to Forest Area	2096.357295	423.137119	2190.772525
Open Space to Open Space	124.267996	13.271245	887.248677
Open Space to Settlement Area	586.596741	13.526674	595.095912
Settlement Area to Cultivated Land	151.765391	60.640424	79.693402
Settlement Area to Forest Area	200.394604	1748.005346	193.162717
Settlement Area to Open Space	10.695612	166.194573	84.484018
Settlement Area to Settlement Area	64.540688	316.125092	70.070483

The area which listed in table4.6 was created after analysis of land use land cover change dynamics by using post classification methods and it shows that land use land cover change variations of study area with in the study period.

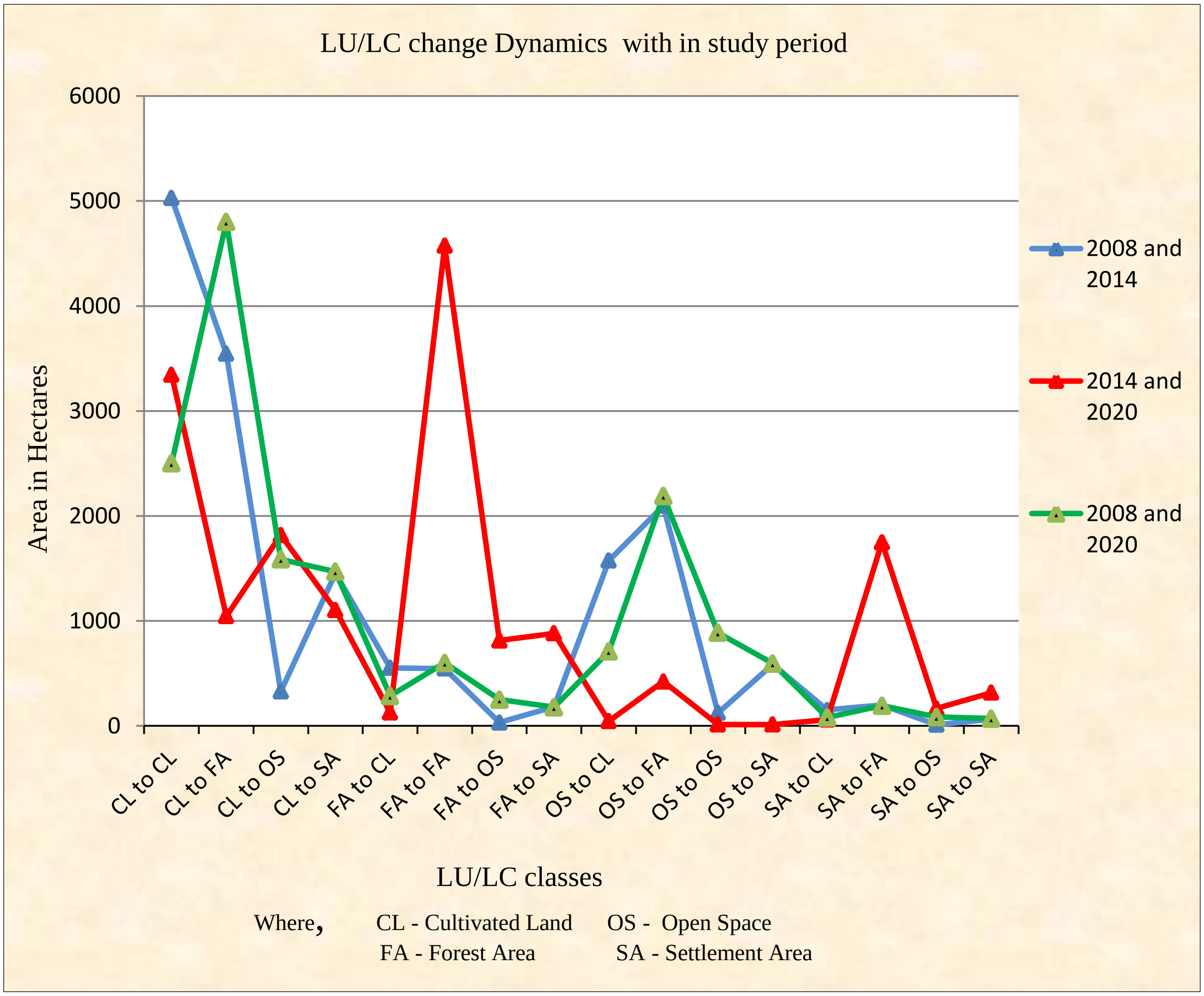

Figure4. 21. LU/LC change dynamics of DPW in 2008, 2014 and 2020

The figure4.21 shows that land use land cover change dynamics of the study area with in the study period. It also clearly shows that increment or decrement of the area of land class from one year to another year. This is the final portion of output of this research study before evaluate the impacts of land use land cover changes on crop products.

4.2.3 Relationship between LULC changes and NDVI

Normalized difference vegetation index measures the vegetation condition by supporting of GIS and Remote sensing techniques. The findings of the present study also revealed that

NDVI varied from the year 2008 to 2020 through the changes of land use land cover with in the study area. As forest area coverage variation in the Damot Pullasa Woreda, the NDVI value was varied. As the result in NDVI calculation, the value of NDVI of study area in 2008 was -0.395349 and 0.190751, in 2014 the value was -0.0327214 and 0.446238 and in the year 2020 that was -0.0323427 and 0.457698 of minimum and maximum value respectively. This value indicates that the amount of tree plantation coverage is increasing from time to time in the study area. As shown in the NDVI value in 2020, it is comparatively higher than that of 2008 and 2014. This value fits the result of LULC classified value in maximum likelihood classification method. Below table4.7 shows that statistical analyzed NDVI value of Landsat images of study area.

Table4.7. NDVI value from statistical analyses

No	Values name	2008	2014	2020
1	Minimum	-0.40	-0.03	-0.03
2	maximum	0.19	0.45	0.46
3	Mean	-0.04	0.22	0.25
4	Standard deviation	0.08	0.06	0.07

4.2.4 Impact of LU/LC change on Crop products in DPW

There are different types of crops has been cultivating in the study area. Some of those are listed in the below table. This listed crop types are the major crops around the area. So, to consider the amount of products of DPW in this research work has been limited to the following types and amount of crops as taken from WSI.

Table4.8. Major types of crops and their products in DPW

No	Major crop types	Years		
		2008 Yield in (Qtl)	2014Yield in (Qtl)	2020 Yield in (Qtl)
1	Wheat	192, 400	19,518	2,748.48
2	Teff	245, 100	65,321	95,207
3	Barley	2, 488	2,364	1,809
4	Lokoma (In local)	61, 295	60,882.2	3,273.75
5	Potato	323, 000	322,960	210,262.5
6	Sweet Potato	281, 000	279,000	307,730.5
7	Others	7810	8850.3	7989.6
Total	Major crops	1, 113, 993	758, 895.5	629, 020.83

According to crop product amount which taken from WAI, the amount of crop products are decreased from year 2008 to 2020. Total crop products in quintal per year were recorded as 1,113, 993, 758, 895.5 and 629, 020.83 in 2008, 2014 and 2020 respectively. In the same manner as seen in LU/LC change detection analyses, the agricultural land is decreased from year to year. Therefore, the decrement of crop products in the study area leads to shortage of food. In other side the population number is increasing time to time. So, this situation has been made a contradiction between population needs and amount of crop products with in the Woreda. For further consideration, the following figure4.22 was created to show the amount of crop products of major crops in study area.

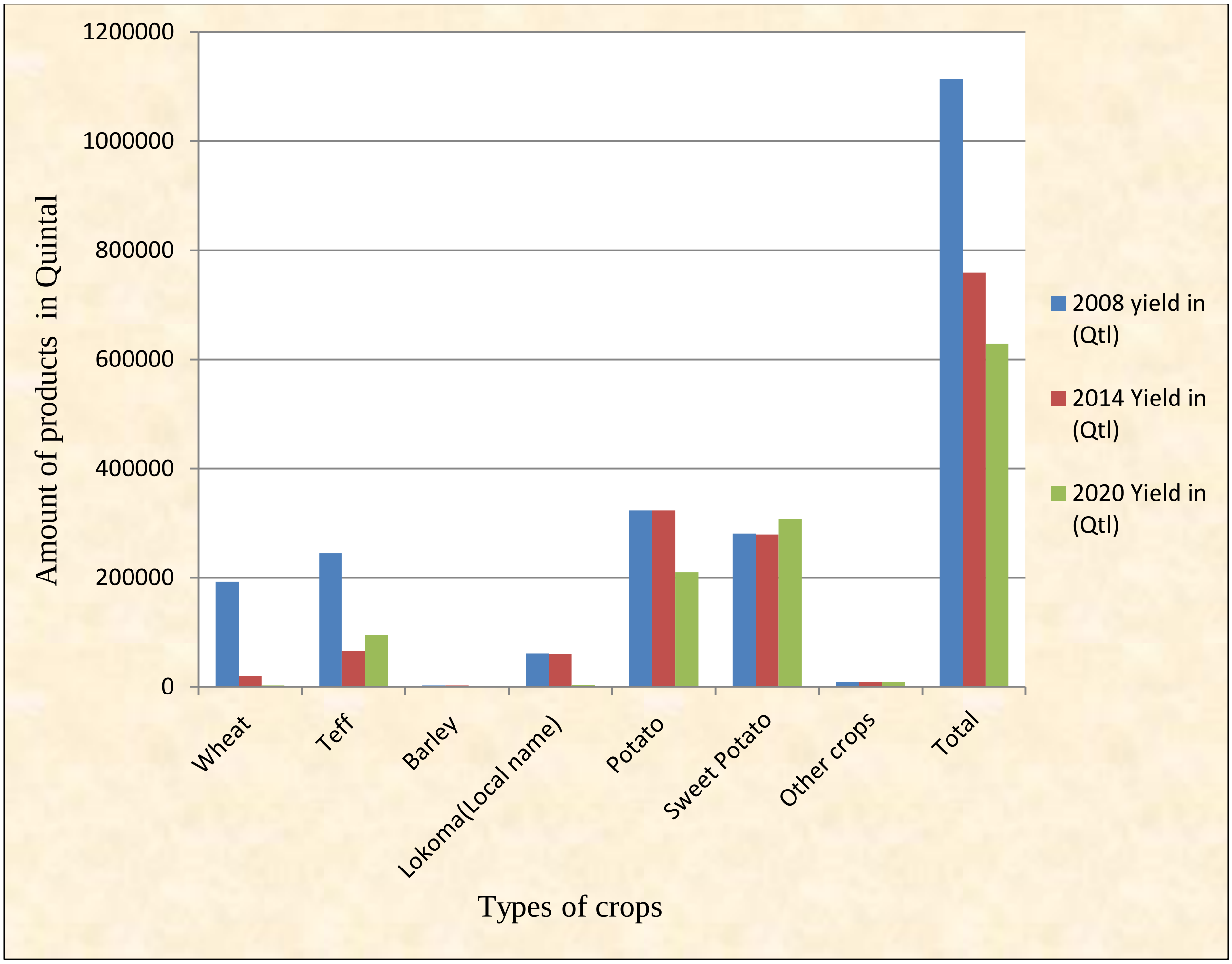

Figure4. 22. Crop product amount of DPW in 2008, 2014 and 2020

In above figure4.22 the amounts of crop products are decreased from year 2008 to year 2020. There is an average maximum crop products amount is recorded in the year 2008 is 1113993 quintal and this value was decreased in 2014 and 2020, recorded as 758895.5 quintal and 629020.83 quintal respectively. After data analyses, the result were shown that there is inverse relationship between agricultural land and population number in the study area. The research has been done by using interconnections of mainly three variables which are: - LULC changes, Population number and crop product amount with in the study area. There are so many factors which affect the crop products but in this research it used LULC changes as major factor and take population number to determine the gap between crop products and demand of humans. Generally the study was coiled through land use land cover changes, crop product amount and population number of the Damot Pullasa Woreda. Consequently, there was a conflict between human needs and amount of food with in the study area.

According to (Fire, 2019), one person eats between three to five pounds in average four pounds per day. One pound is equal to 0.453592 kg. Therefore, 4 pounds equals to 1.814368 kg. So, one person eats 1.814368kg/day. When it converted in to a year, one person eats 662.24432kg/year, and it changed in to quintal, one person eats 6.6224432 Qtl/year. Therefore, the following table shows that correlation of population and crop product amount of the Woreda.

Table4.9. Normal and projected value of crop products population in DPW

No	Year	Population	Cultivated Land in (Hr)	CP in Qtl /TP /Year		CP in Qtl/ Person/Year	
				Normal	Projected	Normal	Projected
1	2008	142, 444	10324.7	1, 113, 993	943, 264.17	7.821	6.622
2	2014	168, 111	7265.14	758, 895.5	1, 113,231.04	4.514	6.622
3	2020	198, 204	3558.73	629, 020.83	1, 312, 506.89	3.18	6.622

The population growth and crop production has inverse relationship with in study period as shown in table4.9. Therefore, a continuous increment of population and continuous decrement of cultivated land are recorded in the woreda with in study period.

Figure4.23 shows that decrement of normal crop product value within study period

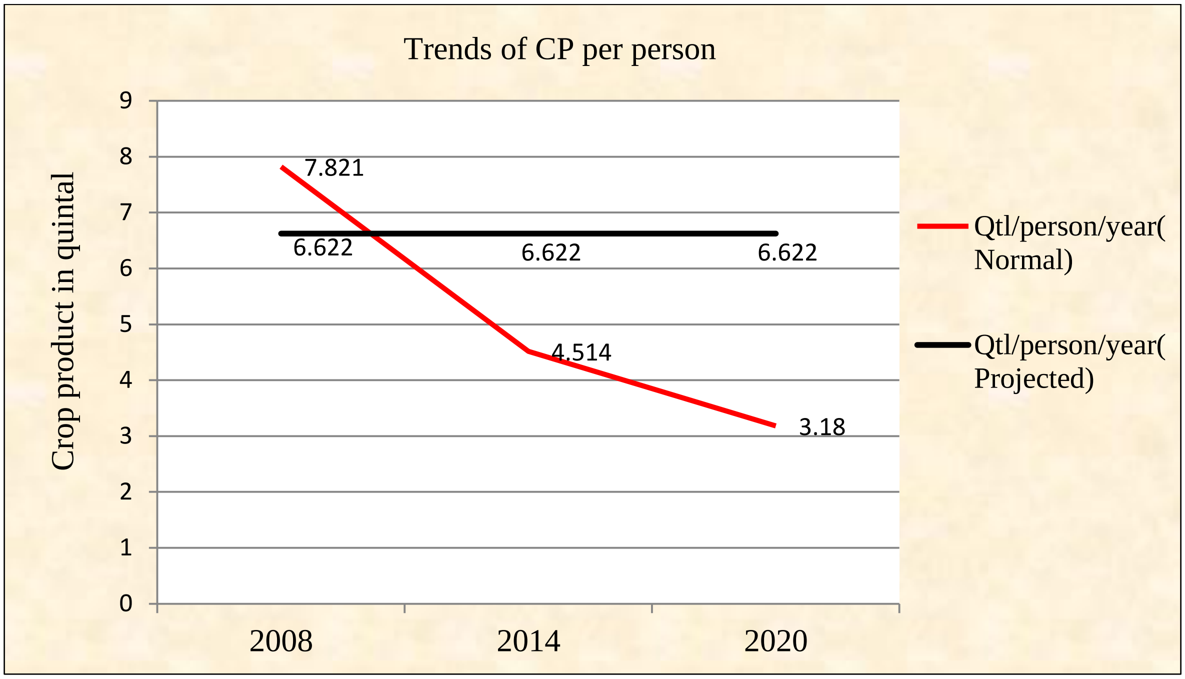

Figure4. 17. Normal and Projected value of crop products in Quintal per Person

4.2.5 Prediction of crop production and population growth for the year 2030

Depending on the result obtained after overall analysis, the major crop product and population for ten (10) years has been forecasted.

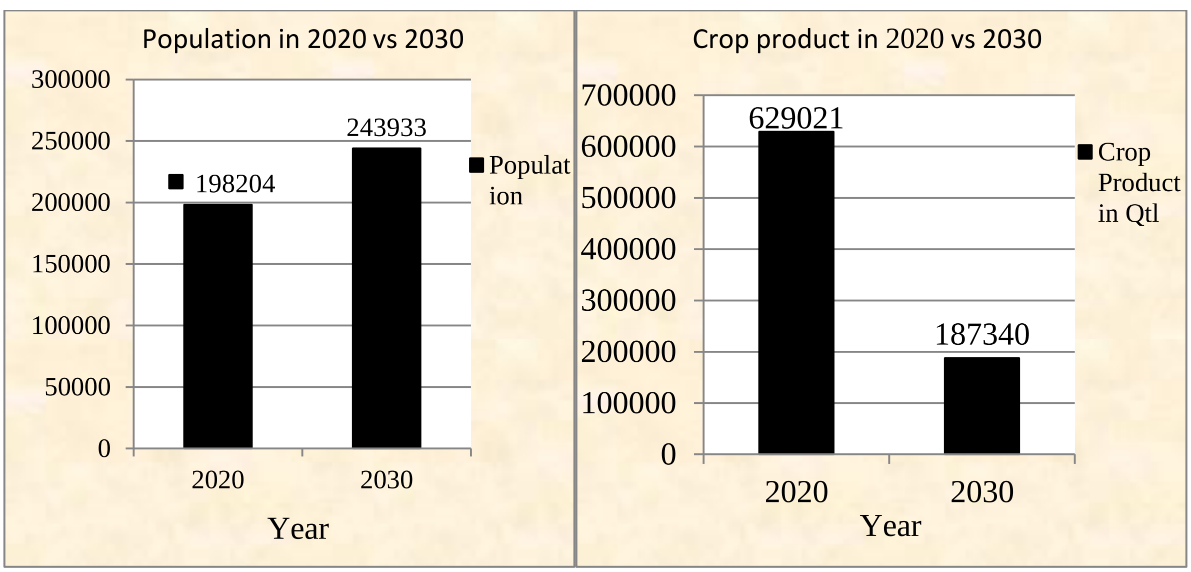

Figure4. 18. Predicted crop yield vs Population Growth for 2030

The figure4.24 shows that, the future occurrence of crop product amount and population number after 10 years standing on the crop product amount and population number taken from WAI and ECSA. By considering LU/LC changing specially forest area and cultivated land change inversely after MLHC analyses with other factors remaining constant, there is no distrust for its happening.

4.3 Discussion

4.3.1 Land-use/land-cover status of Damot Pullasa Woreda

The LU/LC changes observed across the Damot Pullasa Woreda shows that there is an indication of relatively higher population growth and the decrease of land for agriculture. These changes have brought about a series of adverse impacts on the environment. The present study revealed that during the study period of 12 years there were drastic changes in LU/LC. In 2008, the cultivated land and forest area was 10324.693 hectare and 1328.833 and then it reached 7265.138 hectare and 6396.3 hectare in 2014 respectively. After six years, the cultivated land area coverage reached 3558.735 hectare and the forest area reached 7675.718 hectares. It indicates that the increment of land for over tree plantation for the purpose of need money. In general, the classified satellite image indicates that there is a significant change in LU/LC.

4.3.2. Relationship between NDVI and LU/LC changes

As the result in NDVI calculation, the value of NDVI of study area in 2008 was -0.395349 and 0.190751, in 2014 the value was -0.0327214 and 0.446238 and in the year 2020 that was -0.0323427 and 0.457698 of minimum and maximum value respectively. This value indicates that the amount of tree plantation coverage is increasing from time to time in the study area. As shown in the NDVI value in 2020, it is comparatively higher than that of 2008 and 2014. This value fits the result of LULC classified value. These means that, the result of LU/LC changes after analyses was shown that all LU/LC classes mainly cultivated land were converted in to forest area. Therefore, when the value of NDVI increasing, the forest area also increasing with in study period.

4.3.3. Land use/land cover change impacts on Crop Production

In general this research study reveals that the trouble condition of community people in the woreda with food demand. The main causative problem for this contradiction was the decrement of cultivated land through an increment of eucalyptus plantation. As result shows that, the normal condition of crop products in quintal per person per year is decreases from 2008 to 2020. Consequently, the produced crops are not match the population demand. According to (Fire, 2019), the recommended quintal per person per year was 6.622, but, the normal quintal per person per year was 7.76, 4.47 and 3.14 in the year 2008, 2014 and 2020 respectively. By this reason there is contradiction between population and crop products in the Woreda.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Finding in this research is tried to give emphasis on using integrated techniques of geospatial technologies for LU/LC change assessment in Damot Pullasa Woreda starting from data collection up to final map generation and interpretation. In order to explain quantitatively and qualitatively LU/LC cover change, Maximum Likelihood supervised classification techniques and Post classification techniques were used. NDVI algorism was calculated to now the pattern of vegetation coverage in the study area and its values were: -0.395349 and 0.190751 in 2008, -0.0327214 and 0.446238 in 2014, -0.0323427 and 0.457698 in 2020 of minimum and maximum value respectively.

The study area is classified in to four major land use land cover types; forest area, cultivated land, settlement area, and open space. According to final results, Cultivated land decreases from 2008 to 2014 by 18.53%, from 2014 to 2020 by 22.46% and from 2008 to 2020 by 40.99%. Forest area increases from 2008 to 2014 by 30.69%, from 2014 to 2020 by 7.75% and from 2008 to 2020 by 38.44%. Settlement area increases from 2008 to 2014 by 11.44%, from 2014 to 2020 by 0.60% and from 2008 to 2020 by 12.03%. Open space decreases from 2008 to 2014 by 23.6%, increases from 2014 to 2020 by 14.11% and decreases from 2008 to 2020 by 9.48%. Mainly, expansion of forest area and reduction of cultivated land were obtruded in this research. Moreover the pronouncement of government for green plant expansion is supplementary reason for the expansion of over tree plantation in the study area.

In relation to this, currently, from overall condition of the forest cover land area is expanded from time to time.

The population number of DPW was increased from 2008 to 2020. With increasing population, land is being divided amongst every generation and expansion of settlement area. And also, crop products in Damot Pullasa Woreda were decreased with in study period. The recommended quintal per person per year was 6.622 and normal quintal per person per year was recorded as, 7.76, 4.47 and 3.14 in the year 2008, 2014 and 2020 respectively. Due to this reason, the reduction of cultivated land was resulted and also a shortage of food is familiarized in DPW.

5.2. Recommendation

The focus of this study was to assess and investigate the impact of LU/LC changes on Crop Products in DPW based on Landsat imagery of 2008, 2014 and 2020. The study shown that the conversion of LU/LC from one class to another classes with in twelve year interval. Therefore, based on the result of this research, the following recommendations have been drawn.

- ❖ LU/LC change becomes a central component in current plans for managing resources and monitoring environmental changes. Therefore, the governmental and non-governmental bodies should give high attention to the proper land-use management system.
- ❖ The study was coiled between LU/LC changes, population and amount of crop products of the Woreda in order to guidance of title due to fixed time and budget. For later researcher, it will be best that take additional factors which influences the crop product amount to do up on related research title.
- ❖ The pronouncement of the government for green plantation was very important by itself. But, there is a gap in implementation around the society people. So, the governmental bodies should have to take the responsibility and teach to stop superfluous expansion of tree plantation. Therefore, give priority to give awareness for community people at all about the impacts of over tree plantation on the reduction of cultivated land.
- ❖ The LU/LC changes are rapidly making the variation of ground pattern through in the world. So, to know the trends of changes, it is better that detection of LU/LC changes in short period of year.
- ❖ The output of this research can serve as an input for later researchers who want to study the impact of LU/LC changes on crop product area, environmental issues and livelihood of the communities in the Woreda. Therefore, it is better that read in detail this research to get important consideration for their future work.

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7. APPENDICES

The following table shows that point data which collected from the field observation by using GPS instrument for the purpose of accuracy assessment analyze.

field	Easting	Northing	Description	
0	374931.1828	773814.7137	cultivated land	
1	368679.1976	774682.4618	cultivated land	
2	372548.4629	779931.5453	cultivated land	
3	378587.0639	779248.7349	cultivated land	
4	379902.8926	782826.3925	cultivated land	
5	380585.7144	784426.7275	cultivated land	
6	381581.4761	785955.946	cultivated land	
7	377904.2377	784440.9426	cultivated land	
8	374084.7813	776268.5565	settlement area	
9	375443.2776	775230.1061	settlement area	
10	380350.9755	778822.0015	settlement area	
11	375056.4007	785389.7022	settlement area	
12	368131.8012	779003.4531	settlement area	
13	370843.7728	777344.4927	settlement area	
14	374018.7979	775166.9618	settlement area	
15	375034.7813	772423.24	settlement area	
16	374775.4826	773052.9662	forest area	
17	374235.7577	772611.1047	forest area	
18	373696.0039	776460.7877	forest area	
19	374667.0082	776407.8726	forest area	
20	375534.8553	775719.9486	forest area	
21	375561.3159	775161.6696	forest area	
22	378195.2067	776294.4713	open area	
23	375879.0012	776106.3566	open area	
24	374414.5245	775495.1579	open area	
25	370025.0802	776852.4805	open area	
26	371116.4995	782861.1568	open area	
27	375517.8359	784901.1236	open area	

- 2008 error matrix

Table4.2. Error matrix of LULC class in 2008

	Cultivated Land	Settlement Area	Forest Area	Open Space	User
Cultivated Land	8	0	0	0	8
Settlement Area	2	5	0	1	8
Forest Area	0	0	6	0	6
Open Space	1	0	0	5	6
Producer (Total)	11	5	6	6	28

Overall accuracy = Total number of corrected classified pixels (Diagonal) divide by Total numbers of reference pixels multiplied by 100.

- Overall accuracy =24/28 * 100 = 0.8571 = 85.71%

User Accuracy Calculation

Cultivated Land = 8/8*100 = 100%

Settlement Area = 5/8*100=62.5%

Forest Area=6/6*100 =100%

Open Space=5/6*100=83.33%

Producer Accuracy Calculation

Cultivated Land = 8/11*100 = 72.72%

Settlement Area = 5/5*100=100%

Forest Area=6/6*100 =100%

Open Space=5/6*100=83.33%

Kappa Coefficient (K)

$$\mathbf{K}= \frac{\boldsymbol{N}\sum_{\boldsymbol{i=1}}^{\boldsymbol{r}}\boldsymbol{xii}-\sum_{\boldsymbol{i=1}}^{\boldsymbol{r}}(\boldsymbol{x}_{\boldsymbol{i}+\times}\boldsymbol{x}_{+\boldsymbol{i}})}{\boldsymbol{N}^{\boldsymbol{2}}-\sum_{\boldsymbol{i=1}}^{\boldsymbol{r}}(\boldsymbol{x}_{\boldsymbol{i}+\times}\boldsymbol{x}_{+\boldsymbol{i}})}$$

$$N(\sum_{i=1}^{r} xii) = 28 * (8 + 5 + 6 + 5) = 672$$

$$\sum_{i=1}^{r} (x_{i+\times} x_{+i}) = (11*8+5*8+6*6+6*6) = 200$$

$$K = \frac{672-200}{28^2-200} = 80.82\%$$

- 2014 error matrix

Table4.3. Error matrix of LULC class in 2014

	Forest Area	Cultivated Land	Open Space	Settlement Area	User
Forest Area	6	0	0	0	6
Cultivated Land	0	8	0	0	8
Open Space	0	4	2	0	6
Settlement Area	2	1	0	5	8
Producer(Total)	8	13	2	5	28

Overall accuracy = 21/28 * 100= 75%

User Accuracy Calculation

Forest Area=6/6*100 =100%

Cultivated Land = 8/8*100 = 100%

Open Space=2/6*100=33.33%

Settlement Area = 5/8*100=62.5%

Producer Accuracy Calculation

Forest Area=6/8*100 =75%

Cultivated Land = 8/13*100=61.53%

Open Space=2/2*100=100%

Settlement Area = 5/5*100=100%

$$N(\sum_{i=1}^{r} xii) = 28 * (6 + 8 + 2 + 5) = 588$$

$$\sum_{i=1}^{r}(x_{i+\times}x_{+i})=(\mathbf{8*6+13*8+2*6+5*8})=\mathbf{204}$$

$$K=\frac{588-204}{28^2-204}=66.20\%$$

2020 error matrix

Table4.4. Error matrix of LULC class in 2020

	Open Space	Settlement Area	Forest Area	Cultivated Land	User
Open Space	5	0	1	0	6
Settlement Area	1	6	1	0	8
Forest Area	0	0	6	0	6
Cultivated Land	0	0	0	8	8
Producer(Total)	6	6	8	8	28

- Overall accuracy = 25/28 *100 = 89.3%

User accuracy

Open Space=5/6*100=83.33%

Settlement Area = 6/8*100=75%

Forest Area=6/6*100 =100%

Cultivated Land = 8/8*100 = 100%

Producer accuracy

Open Space=5/6*100=83.33%

Settlement Area = 6/6*100=100%

Forest Area=6/8*100 =75%

Cultivated Land = 8/8*100 = 100%

$$N\left(\sum_{i=1}^{r} xii\right)=\mathbf{28*(5+6+6+8)=700}$$

$$\sum_{i=1}^{r}(x_{i+\times}x_{+i})=(\mathbf{6*6+6*8+8*6+8*8})=\mathbf{196}$$

$$K= \frac{700-196}{28^2-196} = \mathbf{85.71}\%$$

Therefore, when the value of Kappa coefficient is greater than 80%, the accuracy of the classification is very high, 40% to 80% is moderate and below 40% is insufficient to take.

SAMPLE OF META DATA OF LANDSAT 5

```
GROUP = L1_METADATA_FILE
  GROUP = METADATA_FILE_INFO
    ORIGIN = "Image courtesy of the U.S. Geological Survey"
    REQUEST_ID = "0501610298277_00244"
    LANDSAT_SCENE_ID = "LT51690552008265MLK00"
    LANDSAT_PRODUCT_ID =
"LT05_L1GS_169055_20080921_20161029_01_T2"
    COLLECTION_NUMBER = 01
    FILE_DATE = 2016-10-29T12:48:00Z
    STATION_ID = "MLK"
    PROCESSING_SOFTWARE_VERSION = "LPGS_12.8.2"
    DATA_CATEGORY = "NOMINAL"
  END_GROUP = METADATA_FILE_INFO
  GROUP = PRODUCT_METADATA
    DATA_TYPE = "L1GS"
    DATA_TYPE_L0RP = "TMR_L0RP"
    COLLECTION_CATEGORY = "T2"
    OUTPUT_FORMAT = "GEOTIFF"
    EPHEMERIS_TYPE = "DEFINITIVE"
    SPACECRAFT_ID = "LANDSAT_5"
    SENSOR_ID = "TM"
    SENSOR_MODE = "BUMPER"
    WRS_PATH = 169
    WRS_ROW = 055
    DATE_ACQUIRED = 2008-09-21
    SCENE_CENTER_TIME = "07:31:51.1920500Z"
    CORNER_UL_LAT_PRODUCT = 8.17084
    CORNER_UL_LON_PRODUCT = 36.27569
    CORNER_UR_LAT_PRODUCT = 8.17960
    CORNER_UR_LON_PRODUCT = 38.41535
    CORNER_LL_LAT_PRODUCT = 6.28692
    CORNER_LL_LON_PRODUCT = 36.28696
    CORNER_LR_LAT_PRODUCT = 6.29364
    CORNER_LR_LON_PRODUCT = 38.41778
    CORNER_UL_PROJECTION_X_PRODUCT = 199800.000
    CORNER_UL_PROJECTION_Y_PRODUCT = 904200.000
    CORNER_UR_PROJECTION_X_PRODUCT = 435600.000
    CORNER_UR_PROJECTION_Y_PRODUCT = 904200.000
```

```
    CORNER_LL_PROJECTION_X_PRODUCT = 199800.000
    CORNER_LL_PROJECTION_Y_PRODUCT = 695700.000
    CORNER_LR_PROJECTION_X_PRODUCT = 435600.000
    CORNER_LR_PROJECTION_Y_PRODUCT = 695700.000
    REFLECTIVE_LINES = 6951
    REFLECTIVE_SAMPLES = 7861
    THERMAL_LINES = 6951
    THERMAL_SAMPLES = 7861
    FILE_NAME_BAND_1 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B1.TIF"
    FILE_NAME_BAND_2 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B2.TIF"
    FILE_NAME_BAND_3 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B3.TIF"
    FILE_NAME_BAND_4 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B4.TIF"
    FILE_NAME_BAND_5 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B5.TIF"
    FILE_NAME_BAND_6 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B6.TIF"
    FILE_NAME_BAND_7 =
"LT05_L1GS_169055_20080921_20161029_01_T2_B7.TIF"
    FILE_NAME_BAND_QUALITY =
"LT05_L1GS_169055_20080921_20161029_01_T2_BQA.TIF"
    ANGLE_COEFFICIENT_FILE_NAME =
"LT05_L1GS_169055_20080921_20161029_01_T2_ANG.txt"
    METADATA_FILE_NAME =
"LT05_L1GS_169055_20080921_20161029_01_T2_MTL.txt"
    CPF_NAME = "LT05CPF_20080701_20080930_01.03"
  END_GROUP = PRODUCT_METADATA
  GROUP = IMAGE_ATTRIBUTES
    CLOUD_COVER = 93.00
    CLOUD_COVER_LAND = 93.00
    IMAGE_QUALITY = 9
    SUN_AZIMUTH = 102.31316756
    SUN_ELEVATION = 61.34708493
    EARTH_SUN_DISTANCE = 1.0038965
    SATURATION_BAND_1 = "Y"
    SATURATION_BAND_2 = "Y"
    SATURATION_BAND_3 = "Y"
    SATURATION_BAND_4 = "Y"
    SATURATION_BAND_5 = "Y"
    SATURATION_BAND_6 = "N"
    SATURATION_BAND_7 = "N"
  END_GROUP = IMAGE_ATTRIBUTES
  GROUP = MIN_MAX_RADIANCE
    RADIANCE_MAXIMUM_BAND_1 = 193.000
```

```
    RADIANCE_MINIMUM_BAND_1 = -1.520
    RADIANCE_MAXIMUM_BAND_2 = 365.000
    RADIANCE_MINIMUM_BAND_2 = -2.840
    RADIANCE_MAXIMUM_BAND_3 = 264.000
    RADIANCE_MINIMUM_BAND_3 = -1.170
    RADIANCE_MAXIMUM_BAND_4 = 221.000
    RADIANCE_MINIMUM_BAND_4 = -1.510
    RADIANCE_MAXIMUM_BAND_5 = 30.200
    RADIANCE_MINIMUM_BAND_5 = -0.370
    RADIANCE_MAXIMUM_BAND_6 = 15.303
    RADIANCE_MINIMUM_BAND_6 = 1.238
    RADIANCE_MAXIMUM_BAND_7 = 16.500
    RADIANCE_MINIMUM_BAND_7 = -0.150
  END_GROUP = MIN_MAX_RADIANCE
  GROUP = MIN_MAX_REFLECTANCE
    REFLECTANCE_MAXIMUM_BAND_1 = 0.314332
    REFLECTANCE_MINIMUM_BAND_1 = -0.002476
    REFLECTANCE_MAXIMUM_BAND_2 = 0.656984
    REFLECTANCE_MINIMUM_BAND_2 = -0.005112
    REFLECTANCE_MAXIMUM_BAND_3 = 0.560977
    REFLECTANCE_MINIMUM_BAND_3 = -0.002486
    REFLECTANCE_MAXIMUM_BAND_4 = 0.677360
    REFLECTANCE_MINIMUM_BAND_4 = -0.004628
    REFLECTANCE_MAXIMUM_BAND_5 = 0.456188
    REFLECTANCE_MINIMUM_BAND_5 = -0.005589
    REFLECTANCE_MAXIMUM_BAND_7 = 0.635226
    REFLECTANCE_MINIMUM_BAND_7 = -0.005775
  END_GROUP = MIN_MAX_REFLECTANCE
  GROUP = MIN_MAX_PIXEL_VALUE
    QUANTIZE_CAL_MAX_BAND_1 = 255
    QUANTIZE_CAL_MIN_BAND_1 = 1
    QUANTIZE_CAL_MAX_BAND_2 = 255
    QUANTIZE_CAL_MIN_BAND_2 = 1
    QUANTIZE_CAL_MAX_BAND_3 = 255
    QUANTIZE_CAL_MIN_BAND_3 = 1
    QUANTIZE_CAL_MAX_BAND_4 = 255
    QUANTIZE_CAL_MIN_BAND_4 = 1
    QUANTIZE_CAL_MAX_BAND_5 = 255
    QUANTIZE_CAL_MIN_BAND_5 = 1
    QUANTIZE_CAL_MAX_BAND_6 = 255
    QUANTIZE_CAL_MIN_BAND_6 = 1
    QUANTIZE_CAL_MAX_BAND_7 = 255
    QUANTIZE_CAL_MIN_BAND_7 = 1
  END_GROUP = MIN_MAX_PIXEL_VALUE
  GROUP = PRODUCT_PARAMETERS
    CORRECTION_GAIN_BAND_1 = "CPF"
    CORRECTION_GAIN_BAND_2 = "CPF"
```

```
    CORRECTION_GAIN_BAND_3 = "CPF"
    CORRECTION_GAIN_BAND_4 = "CPF"
    CORRECTION_GAIN_BAND_5 = "CPF"
    CORRECTION_GAIN_BAND_6 = "INTERNAL_CALIBRATION"
    CORRECTION_GAIN_BAND_7 = "CPF"
    CORRECTION_BIAS_BAND_1 = "CPF"
    CORRECTION_BIAS_BAND_2 = "CPF"
    CORRECTION_BIAS_BAND_3 = "CPF"
    CORRECTION_BIAS_BAND_4 = "CPF"
    CORRECTION_BIAS_BAND_5 = "CPF"
    CORRECTION_BIAS_BAND_6 = "CPF"
    CORRECTION_BIAS_BAND_7 = "CPF"
  END_GROUP = PRODUCT_PARAMETERS
  GROUP = RADIOMETRIC_RESCALING
    RADIANCE_MULT_BAND_1 = 7.6583E-01
    RADIANCE_MULT_BAND_2 = 1.4482E+00
    RADIANCE_MULT_BAND_3 = 1.0440E+00
    RADIANCE_MULT_BAND_4 = 8.7602E-01
    RADIANCE_MULT_BAND_5 = 1.2035E-01
    RADIANCE_MULT_BAND_6 = 5.5375E-02
    RADIANCE_MULT_BAND_7 = 6.5551E-02
    RADIANCE_ADD_BAND_1 = -2.28583
    RADIANCE_ADD_BAND_2 = -4.28819
    RADIANCE_ADD_BAND_3 = -2.21398
    RADIANCE_ADD_BAND_4 = -2.38602
    RADIANCE_ADD_BAND_5 = -0.49035
    RADIANCE_ADD_BAND_6 = 1.18243
    RADIANCE_ADD_BAND_7 = -0.21555
    REFLECTANCE_MULT_BAND_1 = 1.2473E-03
    REFLECTANCE_MULT_BAND_2 = 2.6067E-03
    REFLECTANCE_MULT_BAND_3 = 2.2184E-03
    REFLECTANCE_MULT_BAND_4 = 2.6850E-03
    REFLECTANCE_MULT_BAND_5 = 1.8180E-03
    REFLECTANCE_MULT_BAND_7 = 2.5236E-03
    REFLECTANCE_ADD_BAND_1 = -0.003723
    REFLECTANCE_ADD_BAND_2 = -0.007719
    REFLECTANCE_ADD_BAND_3 = -0.004705
    REFLECTANCE_ADD_BAND_4 = -0.007313
    REFLECTANCE_ADD_BAND_5 = -0.007407
    REFLECTANCE_ADD_BAND_7 = -0.008298
  END_GROUP = RADIOMETRIC_RESCALING
  GROUP = THERMAL_CONSTANTS
    K1_CONSTANT_BAND_6 = 607.76
    K2_CONSTANT_BAND_6 = 1260.56
  END_GROUP = THERMAL_CONSTANTS
  GROUP = PROJECTION_PARAMETERS
    MAP_PROJECTION = "UTM"
```

```
DATUM = "WGS84"
ELLIPSOID = "WGS84"
UTM_ZONE = 37
GRID_CELL_SIZE_REFLECTIVE = 30.00
GRID_CELL_SIZE_THERMAL = 30.00
ORIENTATION = "NORTH_UP"
RESAMPLING_OPTION = "CUBIC_CONVOLUTION"
```

SAMPLE OF STUDY AREA PHOTOS


Eucalyptus tree
expanding on
cultivated land