# REGIONAL AND ZONAL DEFORETATION AND RELATED GHG ESTIMATION BASELINE REPORT FOR OROMIA REGIONAL STATE

# LAND USE LAND COVER CHANGE DETECTION FOR THE PERIOD

## 2007 - 2017

**Oromia Environmental Protection Authority, Oromia REDD+ Coordination Unit**

**In collaboration with**

**Ethiopian Forestry Development, Forest Resources Assessment and Monitoring Directorate**

MARCH, 2023

FINFINNEE, ETHIOPIA

**Working Group Members:**

**A. Writing, editing, QAQC, data processing and analysis:**

1. Dereje Likissa – REDD+ MRV Specialist, Oromia Forested Landscape Programme (OFLP)
2. Heiru Sebrala – Director for Forest Resources Assessment and Monitoring Directorate, EFD

**B. Data collection, processing and analysis:**

- Dereje Likissa – REDD+ MRV Specialist, Oromia Forested Landscape Programme (OFLP)
- Daniel Belay – GIS and Remote Sensing Expert, EFD
- Bizuayehu Alemu – GIS and Remote Sensing Expert, EFD
- Samson Tsegaye – GIS and Remote Sensing Expert, EFD
- Negash Hailegiorgis – GIS and Remote Sensing Expert, EFD
- Gemechu Raji – Forest Inventory Expert, EFD
- Feysel Jemal – Forest Inventory Expert, EFD
- Tamrat Ketema – Forest Inventory Expert, EFD
- Merga Diyessa – GIS and Remote Sensing Specialist, Farm Africa
- Eshetu Gebre – REDD+ MRV Specialist, SNNPRS REDD+ Coordination Unit (SRCU)
- Tariku Megerssa – Forester, Oromia Environmental Protection Authority
- Gadissa Kenno – REDD+ MRV Specialist, Oromia Forested Landscape Programme (OFLP)
- Getu Shiferaw – REDD+ MRV Specialist, Oromia Forested Landscape Programme (OFLP)
- Shiferaw Legesse – Woreda Coordinator with GIS and Remote sensing Background, Oromia Forested Landscape Programme (OFLP)
- Alemu  Legesse – Woreda Coordinator with GIS and Remote sensing Background, Oromia Forested Landscape Programme (OFLP)

# Contents

List of Figures

## Acronyms

| | |
|---|---|
| **AD** | Activity Data |
| **AFOLU** | Agriculture Forestry and Other Land Uses |
| **BAU** | Business as usual |
| **CEO** | Collect Earth Online |
| **CRGE** | Climate Resilient Green Economy |
| **DD** | Deforestation and forest Degradation |
| **EF** | Emission Factor |
| **EFD** | Ethiopian Forestry Development |
| **EFCCC** | Environment Forest and Climate Change Commission |
| **FREL/FRL** | Forest Reference Emission Level/ Forest Reference Level |
| **GHG** | Greenhouse Gas |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **LT-LEDS** | Long Term Low Emissions Development Strategy |
| **LULCC** | Land Use Land Cover Change |
| **LULUCF** | Land use Land Use Change and Forestry |
| **MRV** | Measurement, Reporting and Verification |
| **MtCO₂e** | Million tons of carbon dioxide equivalent |
| **NDC** | Nationally Determined Contribution |
| **OFLP** | Oromia Forested Landscape Programme |
| **REDD+** | Reducing Emissions from Deforestation and forest Degradation |

| | |
|---|---|
| **RF** | Removal Factor |
| **SEPAL** | System for Earth observation, data access, Processing and Analysis for Land monitoring |
| **SOC** | Soil Organic Carbon |

## 1. Introduction

### 1.1 Background

In Ethiopia's Natural resources have been deteriorating over time, which amplifies exposure to substantial environmental and climate risks that affect food and water security, energy, and human health, among other things. Land degradation in Ethiopia has proceeded at an alarming rate and is increasingly aggravated by climate change for the last decades. From 1981 to 2003, 296,812 km$^2$ (29.7 million ha) of land has been degraded, affecting a population of 20.65 million. Conservative estimates suggest that, partly as a result of increased deforestation and forest degradation, augmented by land degradation and soil erosion, will reduce agricultural crop productivity in Ethiopia by 5–10 percent. Decreased agricultural crop productivity would aggravate existing social and economic challenges as close to 80 percent of Ethiopians are engaged in subsistence rain-fed agriculture.

Deforestation and forest degradation has greatly contributed to land degradation in Ethiopia. At the national level, the rate of deforestation and forest degradation ranges from 140,000 to 200,000 ha per year and has resulted in severe land degradation and loss of biodiversity. On deforestation alone, Ethiopia loses about 73,000 ha of forest per year (Ethiopia NFI, 2018). Unless the growing demand is matched with proper forest development, the future scenario will be more deforestation, degradation of existing forest, and increased shortage of wood resources augmented by climate change impacts. A forecast by the Climate Resilient Green Economy (CRGE 2011) indicates that without action to change the country's forestry development path, 90 000 km$^2$ (56 percent of total existing forest area) could be degraded between 2010 and 2030. Over the same period, annual wood fuel consumption could rise by 65 percent, leading to more degradation of woodlands and forests, including plantation stands. The main direct drivers of deforestation and forest degradation are agricultural expansions, fuel wood consumption, and illegal logging and forest fires. Overgrazing, settlement, and uncontrolled and illegal tree harvesting and utilization also contribute to deforestation and forest degradation.

However, in order to tackle the historical and continuous deforestation and land degradation path, Ethiopia has developed two key development strategies: the Second Growth and Transformation Plan (GTP-2) and the Climate Resilient Green Economy (CRGE). Both strategies prioritize attainment of middle-income status by 2025 through implementation of low carbon, resilient, green growth actions. Both strategies emphasize agriculture and forestry as 45 and 25 percent contributors of projected green hose gas emissions, respectively under business-as-usual scenario, and also together account for around 80 percent of the total abatement potential

Ethiopia's largest forested landscapes are found in Oromia National Regional State and accounts about 9.8 million forest cover (52 % of national forest resources), which provide critical ecosystem services, products for livelihoods, and employment to the country as a whole and region in particular. As part of the national REDD+ readiness process, the region has been selected to implement the first national pilot jurisdictional REDD+ program (OFLP). Its objective is aligned with the CRGE and subsequent phases of GTP Plan, key national development agenda of the the country. Its long-term program will contribute to a transformation in how forested landscapes are managed in Oromia to deliver multiple benefits such as poverty reduction and

resilient livelihoods, climate change mitigation and biodiversity conservation. It is fostering equitable and sustainable low carbon development through three series of Components: (a) on the ground investment activities that address deforestation, reduce land use based emissions, and enhance forest carbon stocks (enabling investments); and (b) state wide and local enhancements to institutions, policies, information, and safeguards management to scale up investment (enabling environment), including coordinating and leveraging multiple REDD+ relevant interventions across the regional state, and (c)  promote and provide rewards to the local community for result based payments (ERPA).

The OFLP is supported by a five-year $18 million grant which is followed by results-based payments for verified emission reductions for up to 8 years. The OFLP is expected to meet the Initiative for Sustainable Forest Landscape ER Program requirements and account for emission reductions at landscape level, including a number of carbon pools beyond forest. The advanced draft Benefit Sharing Plan (BSP) for Ethiopia's Oromia National Regional State Forested Landscape Program is prepared in anticipation of benefits coming as a result of verified emission reduction (ER) to be generated in in the region due to interventions of enabling environment (policy and institutions, incentives, information and environmental and social safeguards), and enabling investments (integrated land use planning, sustainable forest management/participatory forest management, afforestation and reforestation), leading to reducing emission from deforestation and forest degradation, and enhancement forest carbon stock. However, eligibility for benefits was determined transparently using agreed upon criteria mainly on the basis of roles and responsibilities potential beneficiaries would have and contribution made to attain ER.

Accurate and consistent information on forest area and forest area change is important given the reporting requirements for countries to access results based payments for REDD+ (Assessment & Assessment, 2016; Gallego, 2004; ISFL, 2019). Ethiopia has signed Emission reduction result based payments for results-based actions of $40 million through Oromia Forested Landscape program for the period of January 2022 to December, 2029, which was signed on February 9, 2023. The objective is to provide access funds from a sustainable forestry programme to reduce emissions by tackling deforestation and land degradation. For this, there is a need to work in conducting and setting Zonal level deforestation baseline data for the Land Use, Land Use Change and related deforestation on which result based payment will be based. The performance of this task is important for the continuation of the following steps towards Emission Reduction result based payment and to update Emission Reduction Program Document (ERPD).  In order to increase the accuracy of estimation and align this task with existing documents in the region, additional work was required in order to improve the quality of data at Zonal level. Methodology similar to that implemented for regional Forest reference baseline from 2008 - 2017 can be used to account for changes between land use classes and to calculate GHG baselines at Zonal level. This document is a guide for implementing a systematic sampling design to estimate the IPCC land use categories and sub-categories including shrub land as independent land cover class.

During the virtual mission conducted in April 2022, there was a discussion on the issue of conducting deforestation baseline for ER result based payment. The main conclusion is that there is an immediate need to work on zonal level deforestation and GHG baseline setting to ease ER result based payment to be conducted at Zonal level. In the Aide Memoir it was agreed to conduct classification based on the IPCC

goodprctice guide line. In addition, there was an advice from ERPD Audit team (SCS) to classify shrub land independently of Grassland, due to existence of more shrub lands in the region than considering it as sub category of Grassland. Moreover, on the meeting conducted at Adama on 30 June 2022 the National MRV task force also agreed to see/classify shrub land of the country as independent land cover class due to its potential to store more carbon than actual grassland.

Therefore, expertise drawn both from national and regional team were assigned to conduct new baseline data for 21 zones, including updating the regional level baseline data with dense sample size, from which ER result based payments will be calculated to Zonal forestry sector ER beneficiaries during ERPA phase I. The result was intended to increase the accuracy of estimation aligning the study with existing methodologies applied during ERPD reference baseline preparation for the region. A methodology similar to that implemented in the national and Oromia Forest Reference Level was used to account for changes between land uses classes, except for the inclusion of shrub land change categories.

## 1.2 Objective

The main objective of this mission is to generate AD of Oromia & the 21 zones in Oromia for the period of 2007-2017, and estimate Deforestation and GHG baseline

The specific objectives include:

- To undertake IPCC compliant LULC change detection and generate AD based on sample based area estimation using Collect Earth Online (CEO) tool
- To produce LULC map for the current year (2017) using the points of CEO as a training dataset
- To produce LULC transition matrix
- To estimate deforestation and emission baseline
- To compare area estimation through sample based versus mapping
- Building the capacity of national and sub national MRV expertise to autonomously engage in periodic forest monitoring activities using sample based AD estimation method.

## 2. Methods and Materials
### 2.1 Proposed Methodology

The methodology proposed to set zonal baseline will use systematic sampling approach to target potential areas of change and assess the land use and land use changes of the samples. The methodology is consistent

with the approached used to quantify activity data at the regional scale for ERPD preparation and Forest Reference Level baseline setting. Seven Land Use Land Cover Classes (LULC) have used for classification namel; Forestland Cropland, Grassland, Settlement, Shrub land, Wetland and Other land. This is consistent with IPCC LULC classes except that Grassland is subdivided in to two, Grassland and Shrub land. This is done because these two LULC classes are completely different in terms of carbon sequestration but they are merged as one class in IPCC 2006. This was suggested by the assessment team during the review of the report of Oromia LULC change detection in 2019.

The top-level land use and land cover classes analyzed were based on Ethiopian Forest Definition, IPCC Good Practice Guidance and FAO (FAO, 2002, 2005, 2010; IPCC, 2000). These land categories used for deforestation analysis were mentioned below.

- **Forest land:** According to IPCC forestland includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category. Based on forest reference emission level (FREL/FRL) of Ethiopia (UN-REDD, 2017) 'forest' is defined as 'Land spanning at least 0.5 ha covered by trees (including bamboo) (with a minimum width of 20 m or not more than two-thirds of its length) attaining a height of at least 2m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ in due course.' (MEFCC minute cited in UN-REDD, 2017). Non-forest can be defined as any LULC which is neither forest nor bamboo.
- **Cropland:** This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions. Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again).
- **Grassland**: This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land and shrub land category and are not expected to exceed, without human intervention, the threshold used in the forest and shrub land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems.
- **Shrub land**: includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the threshold used in the forest land category.
- **Settlement**: Settlement includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories.
- **Wetland**: Wetland includes land that is covered or saturated by water for all or part of the year (e.g., peat land) and that does not fall into the forest land, cropland, and grassland or settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
- **Other land**: Other Land includes bare soil, rock, ice, and all land areas that do not fall into any of the other six LULC categories.

In the case of LULC change detection, the classes are change or stable. The stable ones are forestland remaining forestland, cropland remaining cropland, grassland remaining grassland, settlement remaining settlement, shrub land remaining shrub land, wetland remaining wetland and other land remaining other land. The change classes are any LULC change from one class to another.

## 2.2    Sampling design

According to IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC GPG LULUCF) (Chapter 5.3.4) areas and changes in areas can be estimated using sampling (sample based activity data (AD) estimation) i.e., Estimation via proportions. This approach requires that the total area of the survey region is known, and that the sample survey provides only the proportions of different land-use classes. IPCC GPG LULUCF (Chapter 5.3.3.2) also states that 'it is efficient to use systematic sampling, since in most cases this will increase the precision of the estimates. Systematic sampling also simplifies the fieldwork'. Therefore, systematic sampling design was adopted for this survey (Figure 1). A 2 x 2 km grid for Oromia Regional State covering the 21 zones was generated. The reason is to determine the relative performance of the zones against each other for fair benefit sharing of emission reductions and removals (ERR).
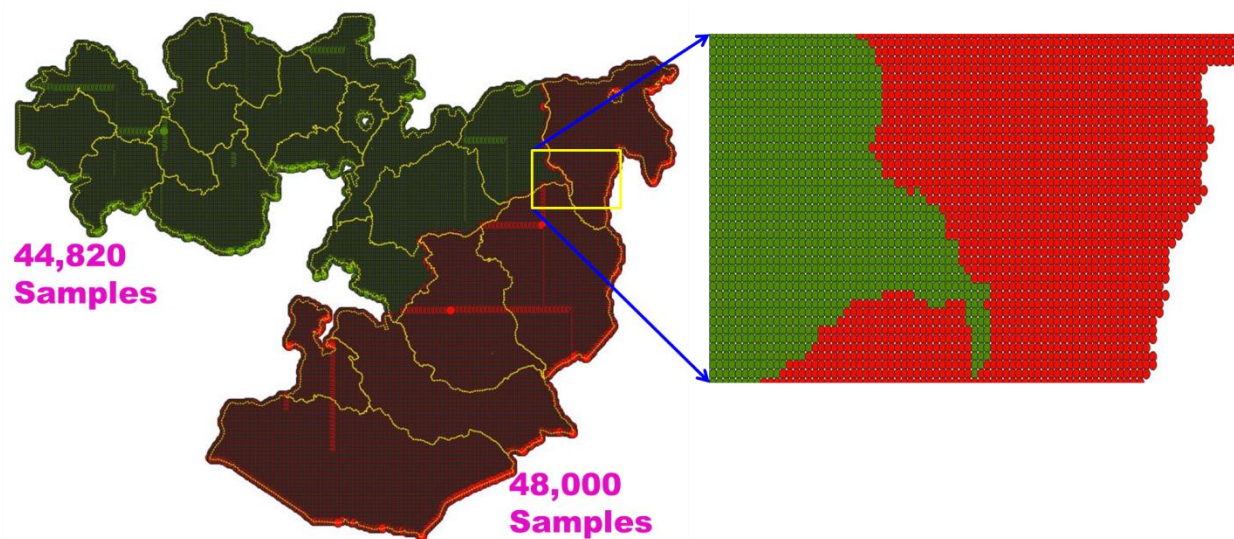


*Figure 1  A 2 x 2 km grid sampling for Oromia Regional State and number of sample points for the two CEO projects*

## 2.3    Interpretation Keys for Sample Data collection

Clear, precise class definitions also make it easier to produce a key. Keys are the collection of rules, imagery, and guidance used to classify land cover elements in earth observing imagery. Well made, comprehensive keys are the cornerstone of effective image interpretation work, and they allow for much more consistent and reliable results. Keys most often include example images representing each class. These images may be annotated to highlight the class in question and may be created for the various types of imagery that will make use of. Keys can also include written guidance explaining the possible difficulties an interpreter might encounter, detailing landscape elements that commonly occur in a given class, how the class may appear differently in false color imagery, and other helpful tips for separating closely related classes.

5

Accordingly, three days training provided before data collection to have common understanding on each LULC labeling including collecting sample points and sharing information why specific LULC class is assigned to specific class. For this specific regional and zonal land use land cover change assessment way of interpreting and labeling to specific land use was provided to data collectors adopting interpretation Key described by *FAO 2021*. Specifically, each LULC class was characterized based on their interpretation key among which some are; i) tone or color variation during use of True Color Composite (TCC) and false color Composite (FCC) (E.g. light green or light red colors indicate objects healthy condition), ii) texture variation based on each LULC classes smoothness and roughness (E.g. Smoothness for plantation and roughness for natural forest), iii) shape - which includes form, structure or outline of individual land cover classes (E.g. rectangular shape can be Plantation forest and irregular shape for natural forest, small or large rectangular shape for farm lands), iv) location – which indicate arrangement of land cover class respected to one another, v) Shadow - visible shadow of trees/objects like building, vi) Pattern – spatial arrangement of objects (E.g. Rectangular pattern – most probably plantation if forest class),  vii) size – size of objects like small and large sized rectangular farm parcels, viii) Association – relationship between other recognizable objects (E.g. what can be mostly exist around water body or riverine) are main interpretation keys used during data collection for class labeling including visual assessment of each objects and expert judgments discussed.

### 2.4 Sample based activity data (AD) estimation

#### 2.4.1    Sample Data Collection

After generating sample plots at 2x2 km systematic grid across oromia, those reference sample plots were assessed using CEO integration of available online satellite imageries. This dataset involved generating a systematic random sample of 92,820 plots in 21 Zones across Oromia Region for seven LULC classes (Forest, Cropland, Grassland, Settlement, Wetland, shrub land and other land) at point level. Historical trends in land use for the years 2007–2017 have been assessed and labeled for each change and unchanged classes. Online imageries (Mapbox, Planet, spot, Landsat imageries photo) indexed to CEO platform have been used to assess land use types. Collect Earth leverages the power of Google Earth Engine to not only visualize satellite images, but also to process geospatial information in the cloud to generate inter-annual and intra-annual vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), Normalized Degradation fraction Index (NDFI). This Google Earth plugin allow users to visually assess the LULC of sample locations with the freely available datasets.

For this specific task Collect Earth Online (CEO) institution called 'REDD+ OROMIA' was created (Figure 1). About 92,820 reference data (ground truth samples) were collected from visual interpretation using Very High Resolution (VHR) imagery from Google Earth using CEO in all the 21 zones of Oromia for assessing the AD for the period 2007 – 2017 (Figure 2, 3). Two CEO projects were created under the CEO institution called 'REDD+ OROMIA', one for 44,820 samples and the other for 48,000 samples . This is because CEO cannot allow sample size more than 50,000 per one CEO project. Survey design was created for each CEO project. CEO is a tool for collecting reference data from very high, high and medium resolution satellite imageries. It was developed by Food and Agriculture Organization of the United Nations (FAO) under the Open Foris Initiative. CEO is a free and open-source image viewing and interpretation tool, suitable for projects requiring information about land cover and/or land use. CEO enables simultaneous visual

interpretations of satellite imagery, providing global coverage from MapBox and Bing Maps, a variety of satellite data sources from Google Earth Engine.



*Figure 2 Collect Earth Online institution (left) and CEO data collection interface (Right)*

Each sample plot was assessed using visual interpretation of available high resolution images, as well as aided by interpreting vegetation indices derived from available low, medium and high-resolution images. Collect Earth online automatically generates time series of the NDVI, from each Landsat and Moderate Resolution Imaging Spector Radiometer (MODIS) images available from 2007 onwards. First, the data collector should visually review all high-resolution historical imagery available. If there is historical high-resolution imagery available, use this imagery to determine the land use category and land uses sub-division and year of change. If only one date of high-resolution imagery is available or if it is difficult to determine the sub-category or year of change, view the Landsat and Sentinel data imagery and Vegetation indices time series trend available in Google Earth Engine, and then determine the category, subcategory and year of change (if available).
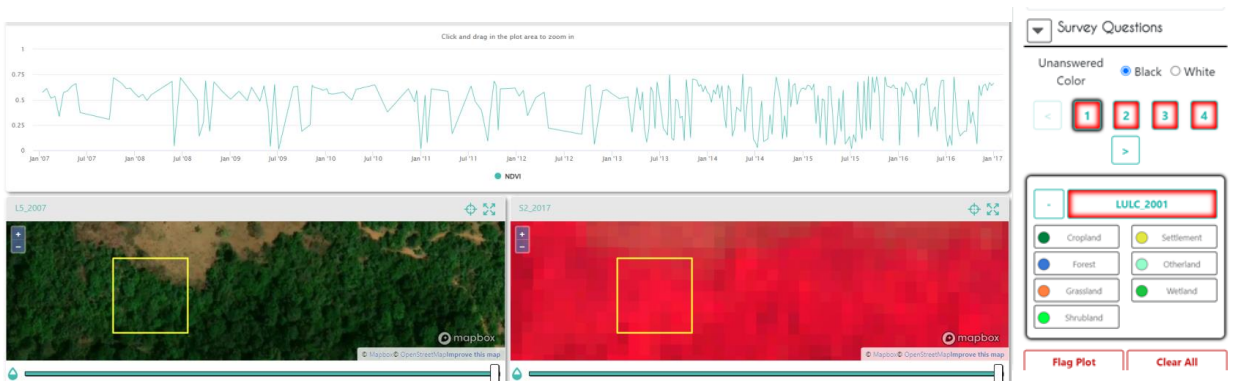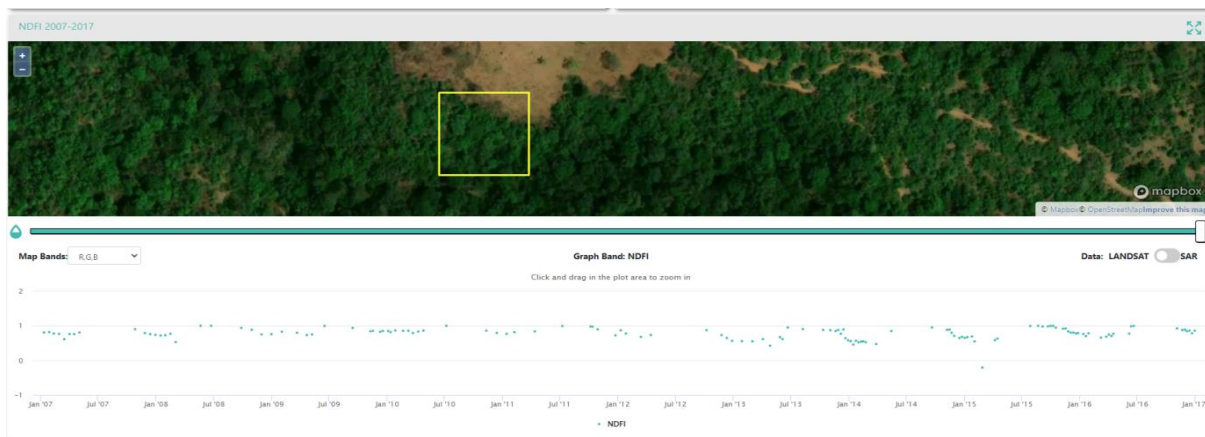
*Figure 3* Collect Earth interface for data collection and Google Earth Engine platform for enabling time series imagery for sample plots using Landsat, MODIS and other available imageries

The Collect Earth online interface used for collecting information about the AFOLU classes is shown in **Error! Reference source not found.**. There are 5 parameters to fill in this interface; land use category, land use category accuracy, land use sub-category, land use sub-category accuracy and year of change. The land use accuracy refers to the confidence of the classification. Is the interpreter sure of the land covering class they assigned? Yes if they are confident about their classification and no if there is doubt about the classification. The same principle applies for the land use sub-category accuracy. The reference period for the analysis was already defined to ease the time trend of the sample plots, i.e., 2007-2017. As shown on figure, two vegetation indices namely Normalized Vegetation Index (NDVI) and Normalized Difference Fraction Index (NDFI) were used to assess vegetation status of each sample plot in addition to assessing high resolution imageries visually since 2007. NDFI was used a new spectral index for enhanced detection of forest canopy damage caused by selective logging and/or forest fire (forest degradation) and deforestation. On the first NDVI plot from 2007 to 2017 the density of greenness was low before 2013 and get very green after and its respective NDFI showed canopy damage due to forest degradation within the same period.

According to good practice guideline (GPG) of the IPCC, emission estimates shall neither over-nor underestimate the actual emissions as far as can be judged, and reduce uncertainties as far as practicable given national circumstances. It is also good practice to quantify uncertainties and report them in a transparent manner. A correct identification and quantification of the various sources of uncertainty helps to assess the robustness of any GHG inventory and prioritize efforts for their further development or improvement.

### 2.4.2    Methods of Data analysis

For this specific section the assessment used sample based area estimation data analysis approach. All collected data was processed and analysed using Microsoft Excel (Functions like 'IF', 'Pivot', 'VLOOKUP', 'LEFT', etc). Moreover, visualization was performed using R-Statistical software version 3.5.3 (R Development Core Team, 2020) with RStudio version 1.1.456 (RStudio team, 2022). The geospatial analysis was carried out using QGIS and Arc GIS software.

### 2.4.2.1 Classification scheme

The six IPCC land-use categories including shrub land and their transitions (subcategories) from IPCC 2006 Guidelines have been used for AFOLU sector activity data generation. Each land-use category is further subdivided into land remaining in that category and land converted from one category to another (e.g., forest land converted to cropland). Related to forest, the assessment tried to to harmonize and incorporate the national forest definition, which is  an area of at least 0.5 hectares, with tree canopy cover of at least 20% and trees of at least 2m, in situ, including bamboo and tree plantations.
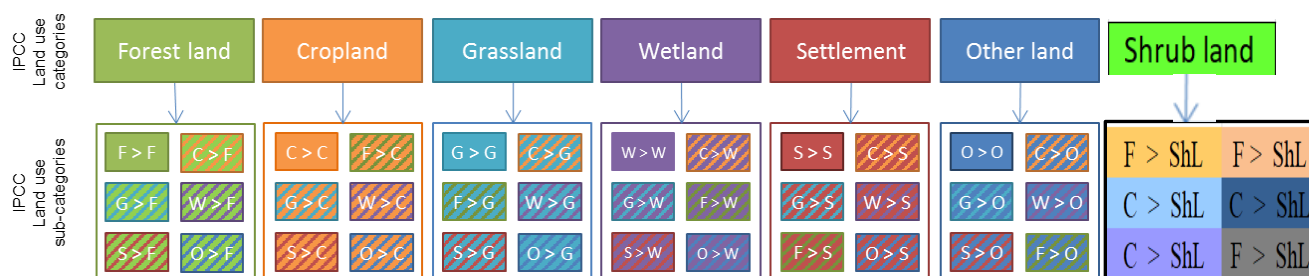


Figure 4: IPCC land use categories and change categories

### 2.4.2.2 Sample based area estimation and analysis

The sample based area estimation analysis protocol involves transplantation of sample based information collected using CEO from diverse types of data, including very high-resolution imagery in to proportional area estimates. Most of the calculations are based on the transition of one land use land cover class in to other land cover classes. The analysis of the samples to calculate stratified area estimates was used on Excel sheet, where proportion matrix and estimating area of each land use land cover has been analysed. Sample based area estimation give an indication of the occurrence of land use/land use change classes and the number of samples needed to adequately capture those classes. This approach requires that the total area of the survey region is known, and that the sample survey provides only the proportions of different land-use classes. The proportions of different land uses have been estimated for the entire study area of the region and each zone by summarizing the data interpreted from all of the plots in each time period. The proportions were then converted to areas and the standard errors of the estimates have been calculated. In a similar fashion, changes were estimated by comparing the interpretations between the years at the point level. The results should be reported in hectares with confidence intervals for each class.The long term goal is to set zonal baseline deforestation and greenhouse gas emissions accounting between the monitoring periods.

In order to get area based estimation of each land use land cover classes, 1st the slandered error (SE) which indicates how different the total area mean is likely to be from a sample mean  was calculated using total area of the each zone or region multiplied by square root of ( Pi*(1-Pi))/(n-1), where  pi  is the proportion of points in the particular land-use class,  'A' is the known total area, and  'n' is  the total number of sample points. In addition, the 95% confidence interval (CI) for 'Ai' is the estimated area of land use class 'i', will be given approximately by 1.96 times the standard error (SE). Then each Land use land cover classes are calculated proportionally using standard error and confidence interval as input. In addition to area based estimated the collected training samples were also used to map spatial data of 2017 LULC as regional input for any forest development plan.

### 2.4.2.3    Quantification and analysis of deforestation

Deforestation has been defined by different scholars and organisations in different senses. According to Nath and Mwchahary (2012) and (Fearnside, 1993) it is  defined as temporary or permanent clearance of forest for other purpose, while  Souza, Siqueira, Ribeiro, and Sales (2013) has defined it as process of converting forest to other land uses. Similarly, study conducted by  Kaimowitz and Angelsen (1998) stated that deforestation is complete long-term removal of tree cover and permanent destruction of indigenous forests and woodland (Collins, 2001).  Different authors suggest different formula to calculate the annual rate of change of forest cover (annual rate of deforestation), while  most literatures (Munthali, Botai, Davis, & Adeola, 2019; Puyravaud, 2003) suggested that annual rate of forest cover change should be calculated as: r= $(1/t_2 - t_1) * \ln((A_2/A_1)$, where $r$ is the annual rate of change for each class per year; $A_2$ and $A_1$ are the class areas (ha) at time 2 and time 1 respectively and $t$ is time (in years) interval between the two periods.  For this specific Regional and Zonal base line deforestation analysis we used annual deforestation rate estimation methodology proposed by the Food Administration Organization (FAO) and described by Souza et al. (2013).  First the methodology suggested by Puyravaud (2003) and also applied by Souza et al. (2013) was used to calculate the annual percentage rate of forest cover lost per zones. Then the  percentage rate of forest loss normalized (r) between the two monitoring periods  was used to calculated annual deforestation rate (in ha/year) for a given reference period following equation: $Dt = A_t - 1 * (1 - e^{rt-1, t})$, where $A_{t-1}$ and $A_{t-2}$ are the forest areas mapped in times $t_1$ and $t_2$, expressed in years, beginning with an initial year.  The result, r (t,t-1), represents the percentage rate of forest loss normalized for the period between $t_1 - t_2$ (2007-2017) and expressed in years.

### 2.4.2.4    Analysis of Gains and Losses of Land use land cover (Net Deforestation)

The Regional and Zonal baseline deforestation assessment study employed of quantitative change in forest cover and other land uses. LULC classes might change to other land cover classes with time, either as gain or loss between land cover categories. While the second option is net change, which shows the result of taking the earlier land cover areas, adding the gains and then subtracting the losses (Mishra, Rai, & Mohan, 2014). Accordingly the transitions and exchanges that took place between the various land use/cover categories and forest classes for the monitoring periods were presented, specifically separately treated forest cover gains and losses in order to estimate net deforestation and GHG emission from deforestation. Changes in the forested area can be detected by comparing forest areas estimated at two different time points (2007 and 2017). The net change in forest area was calculated using the sum of all negative changed due to deforestation minus all positive changes due to afforestation and natural forest development activities. The aim is to examine whether the base year area falls into the same class on the two dates or a change to a new class as gains or losses.

### 2.4.2.5    Monitoring of Carbon Stock and Emissions and Removals

The Carbon stock change method involves measuring forest carbon stocks at two different time points and then determining the difference. The stock change method requires two estimations: forest area estimation and carbon stock estimation per unit area of forest. Forest is one land-use category, but forest land is often converted to another land use through deforestation and/or land in another category may be converted to

forest by reforestation. So that, to estimate the amount of carbon stock in a forest, the area of the forest at the start and end of monitoring period must be known. In this baseline analysis, area estimation was achieved by applying remote sensing technologies, while Carbon stock per unit area was obtained from forest inventory conducted using permanent sample plot (PSP) for second National communication to UNFCCC for emission estimation and using methodology described on OFLP Emission Reduction Program Document (ERPD) Emission and removal estimations including literature sources for removal. Then the calculation of emissions and removals due to carbon stocks changes is developed for the region and each Zone separately.

### 2.4.3 Uncertainty estimates

To quantify and report uncertainty, confidence intervals were calculated and reported around the area estimates, which provide an indication of the precision of the estimate. Precision gives a description of random errors or variability. Large confidence intervals indicate a large statistical variability of the population. The 95% confidence interval for the area estimates are calculated by multiplying 1.96 by the standard error of the area estimate.

The standard error (SE) of an area estimate was obtained as:

$$SE = A\sqrt{(pi * (1 - pi))/(n - 1)}$$

where:

pi = is the proportion of points in the particular land-use class,

A = the known total area, and

n = the total number of sample points.

The 95% confidence interval (CI) for Ai, the estimated area of land use class i, was estimated at approximately by ±1.96 times the standard error (SE)

$$CI(95\%) = 1.96 * SE$$

### 2.5 Quality Control and Quality Assurance

Before data collection training was provided for three days on how to interpret land use and land cover classes and dynamics. Training was provided to all data collectors and analysts regarding the data collection process, interpretation and how to differentiate between each land use class categories and sub categories, use of Collect Earth online and online imagery interpretation modalities and procedures use of interpretation key while assigning sample plots to each land cover classes. In order keep consistency of data collection, training also covered how regional level reference level data was collected and produced for the same years at regional level for Emission Reduction Program Document development. It provided a common understanding between all data collectors and analysts on interpretation keys used during data collection and analysis, minimizing risk of inconsistent definition of land use classes and sub categories between analysts. Before data collection, about 250 other sample points were provided to all and their labeling result was compared and cross checked for common understanding. In addition, one key person was assigned to randomly control the label of LULC classes by other data collectors online and offline. Before data analysis, about 2900 sample points related to forest were extracted and re-data collection was done assigning randomly to different data collectors to check the accuracy and consistency.

### 2.6 Wall-to-wall mapping

#### 2.6.1 Satellite data acquisition

The wall-to-wall mapping was needed for visualizing where each land use land cover (LULC) is spatially located and to increase the understanding of readers of the locations of forests. In order to classify the LULC for the year 2017 for Oromia and each zone (21 zones), high spatial resolution Planet NICFI level-1 imagery was acquired for the years 2017 covering the boundary of Oromia regional state. Planet NICFI level 1 imagery is a product of Norway's International Climate and Forests Initiative (NICFI) satellite program. It has a spatial resolution of 4.77 m. Therefore, there was a chance to capture most trees and smaller patches as small as about 25 $m^2$ in size or with a length/width of 4.77 m. Very high resolution (VHR) imagery from Google Earth was also used as auxiliary data for better visualization.

A total of 1098 Planet NICFI level 1 quads for the year 2017 (Figure 5) were downloaded and mosaicked for regional level using System for Earth Observation Data Access, Processing, & Analysis for Land Monitoring (SEPAL) considering a relatively low cloud cover period of the year, the month of March (Figure 5). For example, Planet NICFI level 1 image mosaics (false colour composite) ready for analysis for Oromia. The same procedure was applied for each Zone in order to asses AFOLU status of each Zones. SEPAL is a web based cloud computing platform designed by the United Nation's Food and Agriculture Organization (FAO) to support the remote sensing and satellite-based forest monitoring efforts of developing countries (Figure 4).
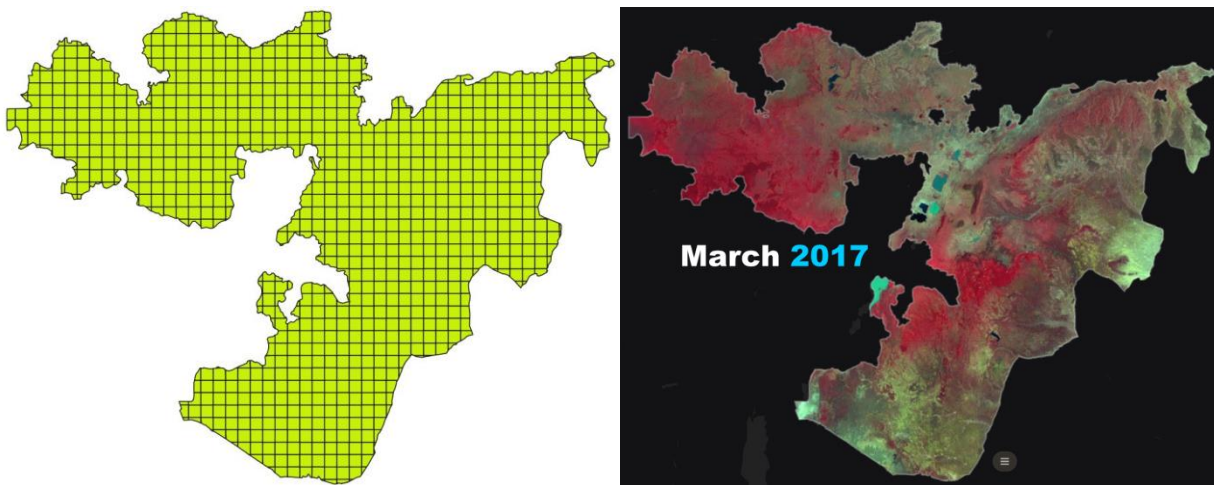


*Figure 5 Quads of Planet NICFI covering the regional boundary of Oromia (left) and mosaic of NICFI Planet on SEPAL platform (right)*

#### 2.4.2 Training data collection

CEO collected 92,820 sample points collected from sample based area estimation using visual interpretation of VHR imagery from Google Earth using SEPAL were used as training points for random forest classification algorithm during classification (Figure 5).
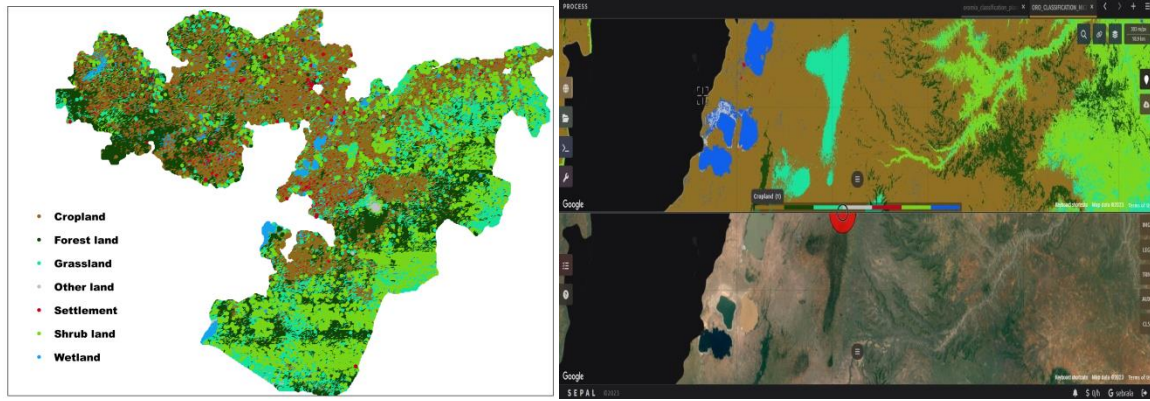
Figure 6  Training points per LULC (Left) and SEPAL interface showing the classification processes of LULCs (right).

### 2.6.2    Mapping process-Image classification and post-classification processing

The mapping process includes imagery data acquisition, training data collection, pre-processing (image stacking, clipping, enhancement and mosaicking), image classification through SEPAL and post-processing. Random forest machine learning algorithm was applied for classification.

The approach chosen to classify LULC was a supervised classification. In this a supervised classification of imagery the user identifies representative spectral samples for each of the classes in the digital image. The representative spectral samples are used as a dictionary and the classification algorithm uses this dictionary to classify all objects/pixels depending on what their spectral signature resembles most in the dictionary. The process assessed one Planet mosaic for the year 2017 to classify LULC. A target day is fixed in order to get the maximum vegetation cover and least cloud cover as possible. All the data collection, correction and composition are implemented within Google Earth Engine (GEE) API (Application Programming Interface) integrated with SEPAL. Downloading was performed using RStudio integrated with SEPAL. As supervised classification is dependent on the quality of samples, about 92,820 training points were used for the seven classes. Sample training data collection for the LULC classes was demonstrated below in SEPAL (Figure 6).
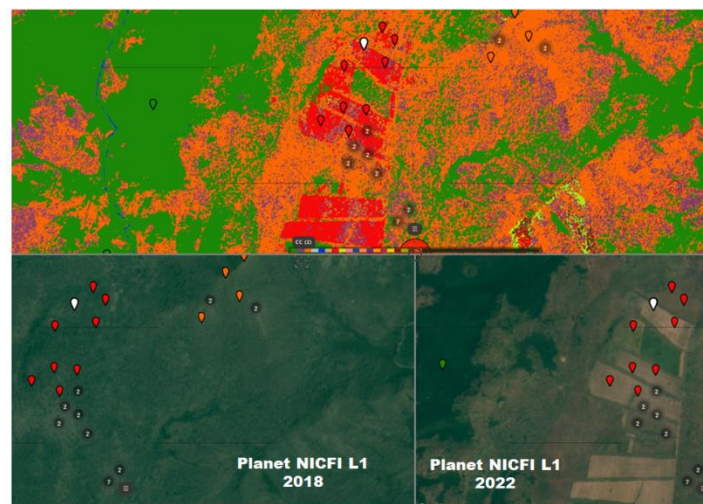


*Figure 7 Additional Training data collection for the LULC classes in SEPA*

## 3. Results and Discussions

The basic concept behind REDD+ is to provide economic incentives such as funding to local communities involved on REDD activities (reducing emissions from deforestation and forest degradation), plus forest management activities to reducing CO2 emissions and CO2 levels in the atmosphere through carbon sequestration (CARBON, 2012). For this there is a need to develop forest reference baseline for the estimation of deforestation and greenhouse gas emissions from forests across OFLP implementation area of Oromia region and its zones for Emission reduction result based payment. To estimate the amount of carbon stock change in a forest, the area of the forest and the conversion between forest land to other land use category (deforestation) and conversion of land in another land use category to forest by reforestation is needed. Accordingly, from the three approaches used to deal with conversions between land-use categories as described by (CARBON, 2012) , i.e. i) Approach 1, where total land-use area is needed with no data on conversions between land uses, ii) Approach 2, where total land-use area, including changes between land use Categories is needed, and iii) Approach 3, where conversions between land use categories and are tracked systematically using detailed spatial information, the second approach was used to assess Zonal deforestation baseline assessment, since it comply with sample based area and bias estimation including accuracy and uncertainty. In addition, approach 3 was employed to detect LULC of 2017 with explicit spatial information. The findings of both approaches (sample based area estimate and wall to wall mapping) are the presented below under regional and zonal level estimates.

### 3.1 Regional Level Area estimates

The study used two steps analysis for regional and Zonal baseline analysis. The 1st step was having Oromia region spatial data from Oromia Planning Commission and Economic Development which has full information of 21 zones with total area of about 37.12 million hectares. Based on this boundary, 92,820 sample points were systematically plotted with 2 by 2 Km grid interval. All information related to each sample plots land use land cover and change information in this boundary was collected using CEO, distributing to 16 data collectors. The second step was cascading each sample plots information to; i) Oromia Regional boundary already documented on Emission Reduction Program Document (ERPD), which is 32,238,018 hectares in order keep consistency, where 80500 sample points were within this boundary, and ii) Each 21 Oromia Zonal boundary-to get deforestation baseline of each zones for phase one Emission Reduction Result Based Payment. Overall, the analysis of each step findings was presented below.

### 3.1.1 LULC area estimate for the base year (2007) and for the current year (2017)

Sample based area estimate from 80500 sample points showed diffirent extent for LULC classes estimated. The major four LULC classes in the current year (2017) in descending order are Cropland (34.4%), Forestland (27%), Grassland (17.36%) and Shrub land (15.6%). Wetland, Settlement and Other land are the rare classes. On the other hand Wetland, settlement and other land shared small proportions accounting 2.72%, 2.32% and 0.29% of the total region area respectively. Similarly, the proportion of each class extent for 2017 is higher for Cropland, Forest land, Grassland and shrub land accounting 34.39%, 27%, 17.4% and 15.6% respectively, where Wetland, settlement and other land classes still shared small proportions (*Figure 8*).
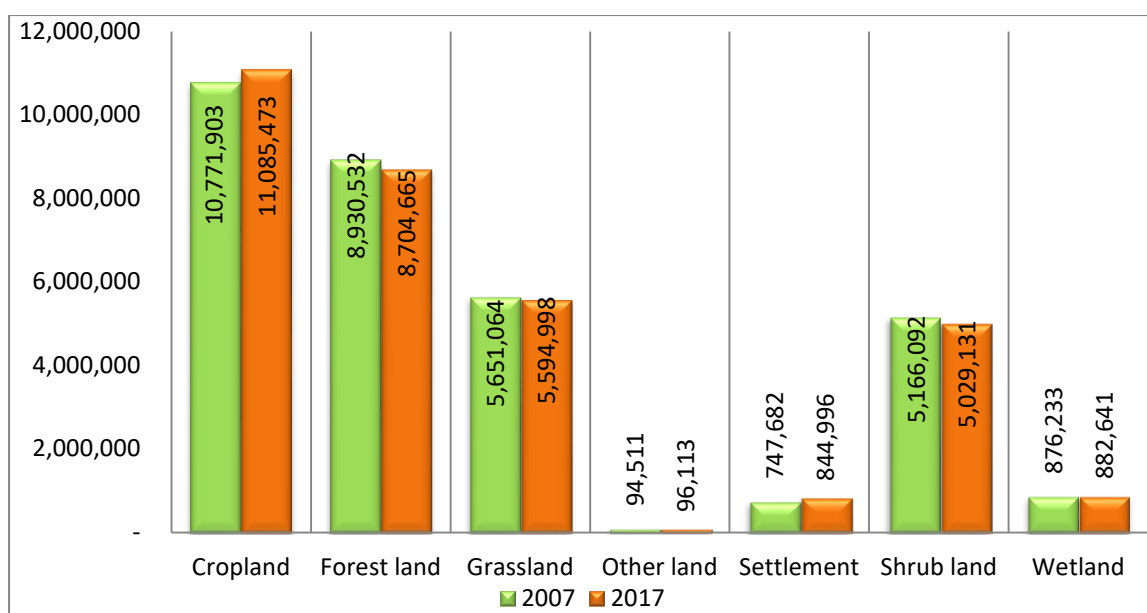
Figure 8  Oromia Regional level Land use Land cover extent detected between 2007 and 2017

### 3.1.2   LULC Activity Data (AD) between 2007 – 2017

Based on regional level area based estimation of deforestation analysis from 2007 to 2017 respective LULC classes; cropland, other land, settlement and wetland showed an increment in in positive direction (gain for the class) with 313,570 ha (2.83%) for cropland, 1,602 (1.67%) ha for other land, 97315 ha (11.5%) for settlement and 6,408 ha (0.7%) for Wetland by 2017 respectively. On the other hand, forest land, grassland and shrub land showed reduction with 225,866 ha (2.6%) for forest class, 136,962 ha (2.7%) for shrub land class and 56,066 ha (1%) for Grassland classes respectively.

*Table 1 Oromia National Regional State transition matrix of Land Use Land Cover Changes between base year 2007 and year 2017 in hectares*

| Row Labels | 2007 LULC | | | | | | | Total |
| | Cropland | Forest land | Grassland | O/ land | Settlement | Shrub land | Wetland | |
|---|---|---|---|---|---|---|---|---|
| Cropland | 10,604,906 | 234,677 | 103,322 | 400 | 6,808 | 131,355 | 4,005 | **11,085,473** |
| Forest land | 48,457 | 8,605,749 | 14,017 | 400 | 801 | 34,841 | 400 | **8,704,665** |
| Grassland | 20,024 | 48,858 | 5,491,276 | - | 400 | 34,040 | 400 | **5,594,998** |
| Other land | 801 | 400 | 1,201 | 91,708 | 400 | 1,201 | 400 | **96,113** |
| Settlement | 79,294 | 10,412 | 15,218 | 400 | 730,862 | 6,808 | 2,002 | **844,996** |
| Shrub land | 15,218 | 29,234 | 25,230 | 1,201 | 400 | 4,957,446 | 400 | **5,029,131** |
| Wetland | 3,204 | 1,201 | 801 | 400 | 8,009 | 400 | 868,624 | **882,641** |
| Grand Total | **10,771,903** | **8,930,532** | **5,651,064** | **94,511** | **747,682** | **5,166,092** | **876,233** | **32,238,018** |

The transition matrix indicated above showed that from **8,930,532** ha estimated as forest cover class in 2007, about 8,889 ha was converted to other land cover classes between the two monitoring period, where 234, 677 ha, 48,858 ha, 400 ha, 10,000 ha, 29,234 ha and 1,201 ha has been converted in to cropland, Grassland, other land, settlement, shrub land and wetland respectively. Detailed information about each class and change class activity data is presented in (Table 1).

### 3.1.3 Uncertainty Estimates

The uncertainty of measurements can come from various sources such including the reference measurement device used to perform the measurement, the environmental conditions, and the person performing the measurements, the procedure, and other sources. When estimating the area change from satellite imagery, different definitions and deficiencies in sampling design at the time of the measurements introduce uncertainty (Hirata et al., 2012). When Permanent Sample Plots (PSPs) are used for estimating deforestation and carbon stocks, the uncertainty depends largely on how many plots are established and where they are established. Accordingly, Figure below showed the uncertainty of land use land cover area estimation with 95% confidence interval. Statistical error value was calculated both for land remaining land classes and land use change categories.

Accordingly, the statistical error for land remaining land classes is low compared to that of change classes. From land remaining land classes, the statistical error for cropland is low compared to others (0.5%), followed by forest land (0.58%), Grassland (0.78%), shrub land (0.83%), settlement (2.31%) and for other land is 6.6% out of the total area of each class estimated from area proportion of sample points. On the other hand, the statistical error of land use land cover change classes ranges from smallest for cropland to forest (4.12%), cropland to grassland (5.51%), cropland to other land (6.22%), cropland to settlement (7.1%), cropland to shrub land and cropland to wetland each having 9% error. However, some change classes has very low statistical accuracy like settlement to wetland, shrub land to cropland shrub land to forest, shrub land to grassland, shrub land to other land and other change classes. Similarly 95% confidence Interval presented in table (*Table 2*) also showed high margin of error for change classes than land remaining land classes. The high error obtained for other land in land remaining land class and other change classes might be attributed to less number of sample points were covered during sampling, while it was higher for these classes with high less uncertainty (*Table 2*, *Figure 9* and *Figure 10*).

Table 2 Area estimates for the change and stable LULC classes with 95% confidence Interval uncertainty estimates.

| No | LULC subcategory | Area (ha) | CI (ha) | No | LULC subcategory | Area (ha) | CI (ha) |
|---|---|---|---|---|---|---|---|
| 1 | Cropland-Cropland | 10,604,906 | 104,634 | 25 | Other land-Settlement | 400 | 785 |
| 2 | Cropland-Forest land | 48,457 | 8,628 | 26 | Other land-Shrub land | 1,201 | 1,360 |
| 3 | Cropland-Grassland | 20,024 | 5,549 | 27 | Other land-Wetland | 400 | 785 |
| 4 | Cropland-Other land | 801 | 1,110 | 28 | Settlement-Cropland | 6,808 | 3,236 |
| 5 | Cropland-Settlement | 79,294 | 11,031 | 29 | Settlement-Forest land | 801 | 1,110 |
| 6 | Cropland-Shrub land | 15,218 | 4,837 | 30 | Settlement-Grassland | 400 | 785 |
| 7 | Cropland-Wetland | 3,204 | 2,220 | 31 | Settlement-Other land | 400 | 785 |
| 8 | Forest land-Cropland | 234,677 | 18,932 | 32 | Settlement-Settlement | 730,862 | 33,150 |
| 9 | Forest land-Forest land | 8,605,749 | 98,516 | 33 | Settlement-Shrub land | 400 | 785 |
| 10 | Forest land-Grassland | 48,858 | 8,663 | 34 | Settlement-Wetland | 8,009 | 3,510 |
| 11 | Forest land-Other land | 400 | 785 | 35 | Shrub land-Cropland | 131,355 | 14,187 |
| 12 | Forest land-Settlement | 10,412 | 4,002 | 36 | Shrub land-Forest land | 34,841 | 7,317 |
| 13 | Forest land-Shrub land | 29,234 | 6,703 | 37 | Shrub land-Grassland | 34,040 | 7,233 |
| 14 | Forest land-Wetland | 1,201 | 1,360 | 38 | Shrub land-Other land | 1,201 | 1,360 |
| 15 | Grassland-Cropland | 103,322 | 12,588 | 39 | Shrub land-Settlement | 6,808 | 3,236 |
| 16 | Grassland-Forest land | 14,017 | 4,643 | 40 | Shrub land-Shrub land | 4,957,446 | 80,337 |
| 17 | Grassland-Grassland | 5,491,276 | 83,721 | 41 | Shrub land-Wetland | 400 | 785 |

| 18 | Grassland-Other land | 1,201 | 1,360 | | 42 | Wetland-Cropland | 4,005 | 2,482 |
|---|---|---|---|---|---|---|---|---|
| 19 | Grassland-Settlement | 15,218 | 4,837 | | 43 | Wetland-Forest land | 400 | 785 |
| 20 | Grassland-Shrub land | 25,230 | 6,228 | | 44 | Wetland-Grassland | 400 | 785 |
| 21 | Grassland-Wetland | 801 | 1,110 | | 45 | Wetland-Other land | 400 | 785 |
| 22 | Other land-Cropland | 400 | 785 | | 46 | Wetland-Settlement | 2,002 | 1,755 |
| 23 | Other land-Forest land | 400 | 785 | | 47 | Wetland-Shrub land | 400 | 785 |
| 24 | Other land-Other land | 91,708 | 11,861 | | 48 | Wetland-Wetland | 868,624 | 36,060 |
| Total | | | | | | | **32,238,018** | |
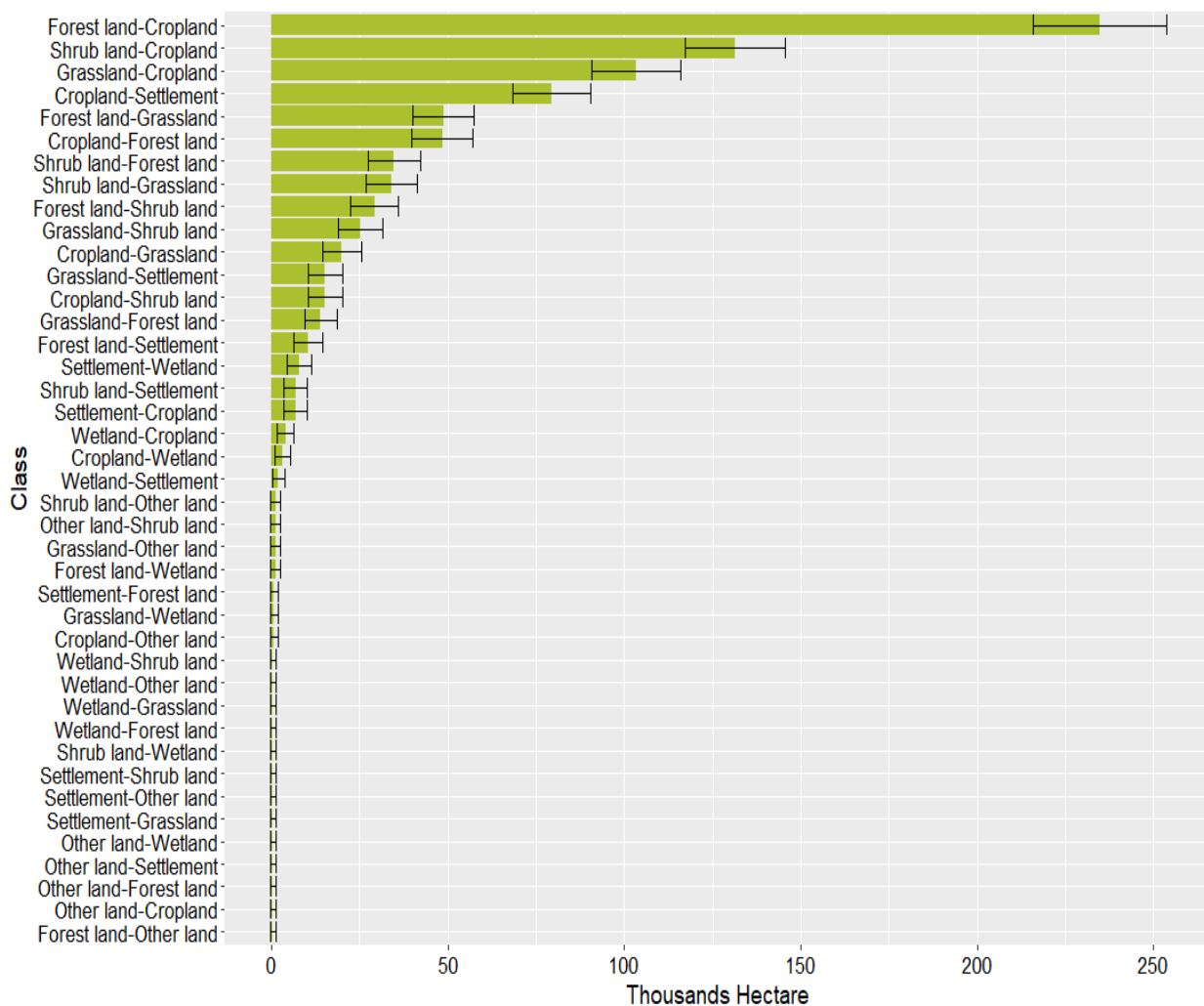


Figure 9 Area estimates for the 41 LULC change and stable classes with uncertainty
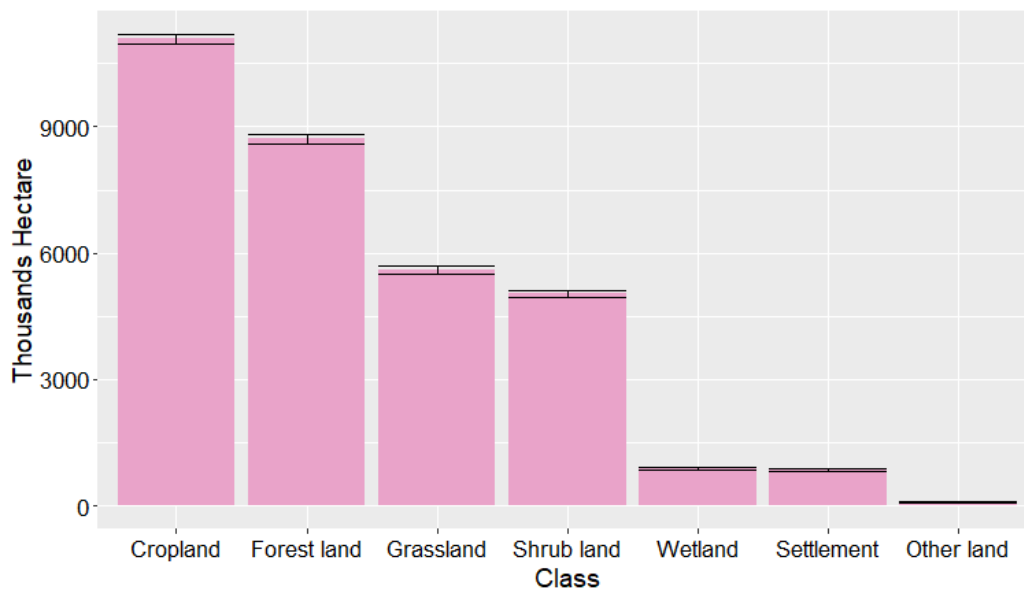
Figure 10 Area estimates for the LULC classes for the year 2017 with uncertainty estimates

### 3.1.4 Regional rate of Deforestation and other Land use change rates

Cascading Original sample points to 32,238,018 ha regional boundary used for Emission Reduction Program Document preparation (ISFL, 2019), the present assessment found 80500 sample points. Based on assessment conducted for those sample points about 8,930,531.7 ha was identified as forest in 2007, while the extent of forest cover in 2017 is reduced to 8,704,665.33 ha, with cumulative net deforestation of 225,866.4 ha between the two periods. Accordingly, standardized Annual net deforestation for the region is estimated to be 22,847.9 ha with 0.26% annual change rate. In consistent with forest class shrub land and Grassland showed reduction with 13862.35 ha (0.23%) and 5631.8 ha (0.1%) annual change rate respectively. On the other hand, cropland, settlement and other land sowed increment in extent with annual change rate of 30953.64 ha (0.29%), 9204.46 ha (1.22%) and 158.98 ha (0.17%) respectively. The relative contribution forest class to net GHG emissions during the monitoring period is more than 8,419,448.61 tCo2e per year.

*Table 3 Oromia Regional State 2007-2017 LULC classes' extent and associated changes in percentt and hectares per year*

| LUL Class | 2007 LULC Area (Ha) | 2017 LULC Area (ha) | Net change 2007-2017[a] | Annual Change (%)[b] | Annual Change Per year (ha)[c] | CI (ha) |
|---|---|---|---|---|---|---|
| Cropland | 10771903.21 | 11085473.00 | 313569.8 | 0.287 | 30953.64 | 105784 |
| Forest land | 8930531.69 | 8704665.33 | -225866.4 | -0.256 | -22847.89 | 98873 |
| Grassland | 5651064.25 | 5594998.13 | -56066.1 | -0.100 | -5631.80 | 84344 |
| Other land | 94511.46 | 96113.35 | 1601.9 | 0.168 | 158.98 | 12142 |
| Settlement | 747681.73 | 844996.50 | 97314.8 | 1.224 | 9204.46 | 35580 |
| Shrub land | 5166092.33 | 5029130.81 | -136961.5 | -0.269 | -13862.35 | 80810 |
| Wetland | 876233.33 | 882640.89 | 6407.6 | 0.073 | 638.66 | 36342 |
| Total | 32238018.00 | 32238018.00 | | | | |

The above table shows the net LULC change between 2007 and 2017 (a), annual change per year in percent (b) and Annual Change of each class per year in hectares (c). Positive values showed increment trend and negative values indicate reduction trend during the baseline analysis (2007-2017).

### 3.1.5   Quality Assurance and Quality Control (QA and QC)

Out of the 29,589 samples (32%) extracted for the for the forest class and randomly re-interpreted and labeled by data collectors for QA/QC, 3882 sample (13%) were found to be misinterpreted as forest land but they were non-forest (Figure 11). These samples were corrected and replaced the old version for final analysis.
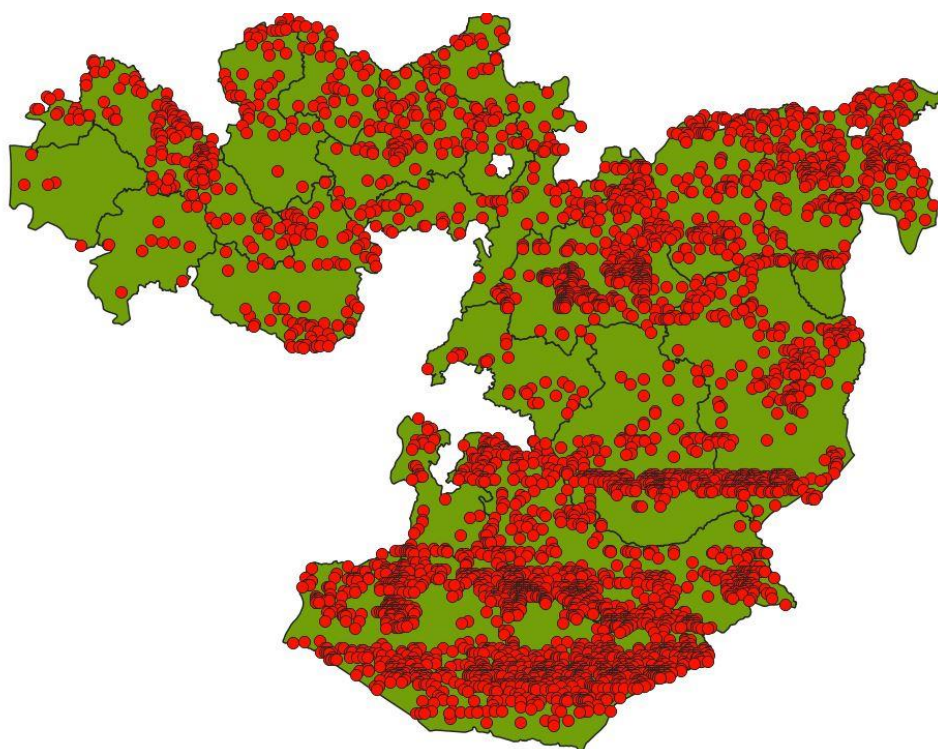


*Figure 11 Misinterpreted sample points and corrected after quality assessment*

## 3.2     Zonal Level Activity Data Estimation

Regional level 92,820 sample points were cascaded to zonal level boundary and all information related to each sample plots land use land cover and change information were used to estimate area proportion of each land use land cover classes. The total number of sample points used within each zone varies based on their area extent (Figure 35).   Overall, each 21 Oromia Zones deforestation baseline for phase one Emission Reduction Result Based Payment was calculated and presented below.

### 3.2.1   Zonal Level Forest area Estimate for two monitoring Periods

Baseline data estimated for showed that forest cover distribution across Zones has Variations, from 10,634,961.93 ha and 10,396,167.28 ha total regional forest cover in 2007 and 2017 respectively. Accordingly, the top five forest covered areas of the region are Borena, East Bale, Bale, Guji and Ilu Ababaora Zones, contributing more than 60% of the region. Borena Zone has highest forest cover extent

above 2.2 million hectares (20.9% in 2007 and 21.3% in 2017), followed by East Bale with above 1.63 and 1.61 million ha (15.5% in 2007 and 15.4% in 2017), Bale above 0.98 and 0.96 million ha (9.3% in 2007 and 9.2% in 2017), Guji Zone with 0.87 and 0.82 million ha (8.2% in 2007 and 7.9 % in 2017) and Ilu Ababaora with about 7.4 million ha in both years (7.1% in 2007 and 7% in 2017). Forest cover in Borena, East Bale and Eastern part of Guji Zone are primarily arid and semi-arid dry woodland forests, while most part of Ilu Ababora, Bale and Western part of Guji Zone are high Afroalpine forests.

Next to the top five forest covered Zones, Jimma, Kellem Wollega, East Wollega, East Hararge, West Wollega are ranked from 6th to 10th forest covered Zones, totally contributing 23% of the region. Jimma contributes about 6.3 and 6.1% in 2007 and 2017, Kellem Wollega and East Wollega each contribute 4.8% in both years, East Harerge has about 3.9% in both years and West Wollega contribute 3.4% in 2007 and 3.2% in 2017. While the rest eleven Zones totally contribute about 17% of regional forest cover in both monitoring periods (*Figure 12*).
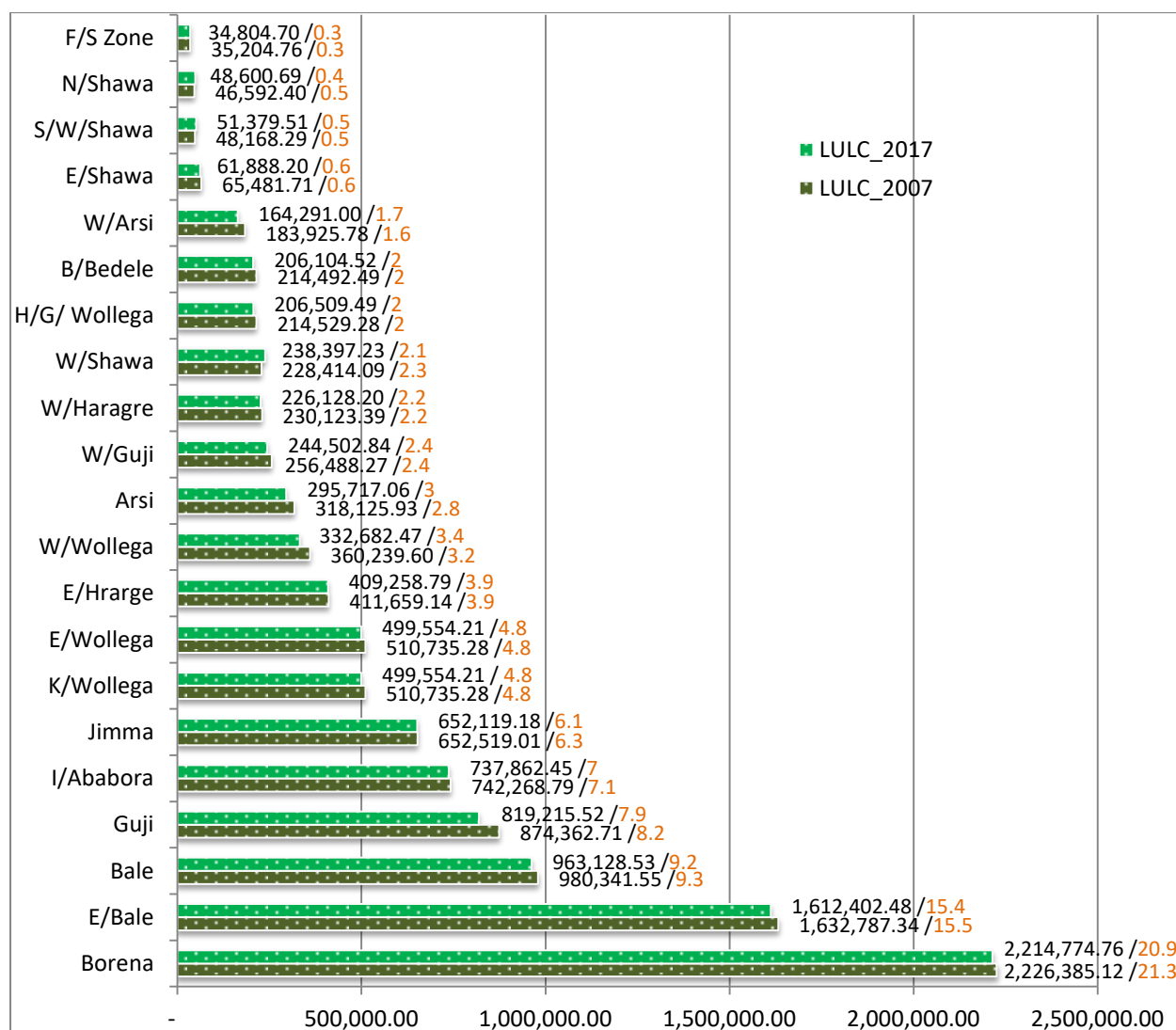


Figure 12 *Oromia Regional State 2007 and 2017 Forest cover extent and total regional share per Zones.*

The Values indicated on the bar are forest cover extent in hectares and forest cover of each zone in percent during monitoring periods. Every Zone has forest cover ranging from 2.2 million ha in Borana to the smallest about 35 thousand hectares in Surrounding Finfinnee Special Zone.

*Table 4   Forest area estimates, AD and rate of deforestation per zone*

| No | Zone | Forest cover in 2007 (ha) | Forest cover in 2017 (ha) | Total Forest loss (ha) | Total Forest gain (ha) | Net Deforestation | 95 % CI (ha)[a] | Rate of deforestation (%/year)[b] | Rate of deforestation (ha/year)[c] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | East Wollega | 360,240 | 332,682 | 32,350 | 4,793 | 27,557 | 19,815 | -0.80 | **2,855.53** |
| 2 | H/G/ Wollega | 214,529 | 206,509 | 15,238 | 7,218 | 8,020 | 15,445 | -0.38 | 815.82 |
| 3 | West Shewa | 238,397 | 228,414 | 18,369 | 8,386 | 9,983 | 17,451 | -0.43 | 1,017.64 |
| 4 | North Shewa | 46,592 | 48,601 | 6,427 | 8,435 | -2,008 | 8,445 | 0.42 | -197.11 |
| 5 | East Harerge | 411,659 | 409,259 | 6,801 | 4,401 | 2,400 | 23,100 | -0.06 | 240.63 |
| 6 | West Harerge | 230,123 | 226,128 | 5,993 | 1,998 | 3,995 | 17,399 | -0.18 | 402.66 |
| 7 | Kelem Wollega | 510,735 | 499,554 | 16,772 | 5,591 | 11,181 | 20,451 | -0.22 | **1,129.27** |
| 8 | East Shewa | 65,482 | 61,888 | 5,191 | 1,597 | 3,594 | 9,461 | -0.56 | 368.60 |
| 9 | S/West Shewa | 51,380 | 48,168 | 3,211 | 0 | 3,211 | 8,493 | -0.65 | 330.53 |
| 10 | Ilu Aba Bora | 742,269 | 737,862 | 10,816 | 6,409 | 4,407 | 20,221 | -0.06 | 441.88 |
| 11 | Guji | 874,363 | 819,216 | 56,746 | 1,598 | 55,148 | 30,605 | -0.65 | **5,677.79** |
| 12 | West Guji | 256,488 | 244,503 | 12,784 | 799 | 11,985 | 16,913 | -0.48 | **1,224.47** |
| 13 | Borena | 2,226,385 | 2,214,775 | 28,826 | 17215 | 11,611 | 45,306 | -0.05 | **1,163.73** |
| 14 | Bale | 980,342 | 963,129 | 20,816 | 3,603 | 17,213 | 31,696 | -0.18 | **1,735.05** |
| 15 | East Bale | 1,632,787 | 1,612,402 | 22,783 | 2,398 | 20,385 | 37,440 | -0.13 | **2,050.03** |
| 16 | West Arsi | 183,926 | 164,291 | 20,035 | 401 | 19,634 | 14,849 | -1.13 | **2,064.74** |
| 17 | Arsi | 318,126 | 295,717 | 26,010 | 3,601 | 22,409 | 19,737 | -0.73 | **2,315.27** |
| 18 | West Wollega | 389,808 | 388,610 | 15,576 | 14,378 | 1,198 | 20,562 | -0.03 | **119.98** |
| 19 | Buno Bedele | 214,492 | 206,105 | 11,184 | 2,796 | 8,388 | 14,468 | -0.40 | 853.83 |
| 20 | O/S/Z/S Finfinee | 35,205 | 34,805 | 3,200 | 2,800 | 400 | 7,029 | -0.11 | 40.21 |
| 21 | Jimma | 652,519 | 652,119 | 6,397 | 5,997 | 400 | 25,498 | -0.01 | 40.01 |
|  | Total | 10,601,098 | 10,394,737 | 345,525 | 104,414 | 241,111 | 130904.7* | 0.23** | 24,690.59 |

NB: Total Forest cover estimated in this table is based on 92820 sample points distributed to each zones (Figure 35) with cumulative area coverage of 37,127,169 ha as spatial data obtained from  Oromia Planning and Development Commission. Gross Deforestation per year is **34,553** ha/year. Negative signs under [a] and [c] respectively showed forest net forest gain than forest loss and rate of forest development in hectares per year, while –ve value under [b] showed rate of forest loss and +ve value showed rate of forest gain in percent.

In Oromia, top 7 zones are responsible for 60% of forest cover loss between 2007 and 2017. Guji had the most deforestation rate compared to others with gross deforestation rate of 56,746 ha (16.4% of the region) during the monitoring periods, with standardized annual deforestation rate of 5,678 ha (0.65%) forest loss per year. East Wollega, Borena, Arsi, East Bale, Bale and West Arsi are respectively shares 32350 ha (9.4% share), 28826 ha (8.3% share), 26010 ha (7.5% share), 22785 ha (6.6% share), 20816 ha (6% share) and 20035 ha (5.8% share) of gross deforestation rate between the monitoring periods. Their annual standardized deforestation rate per year in hectares and percent ranges are 2856 ha (0.8%) for East Wollega, 2315 ha (0.73%) for Arsi, 2064 ha (1.13%) for West Arsi, 2050 ha (0.13%) for East Bale, 1735 ha (0.18%) for Bale, and 1163 ha (0.05%) for Borena. The rest 14 zones cumulatively account for 40% of gross total deforestation in the region (Figure 13 and Table 4)
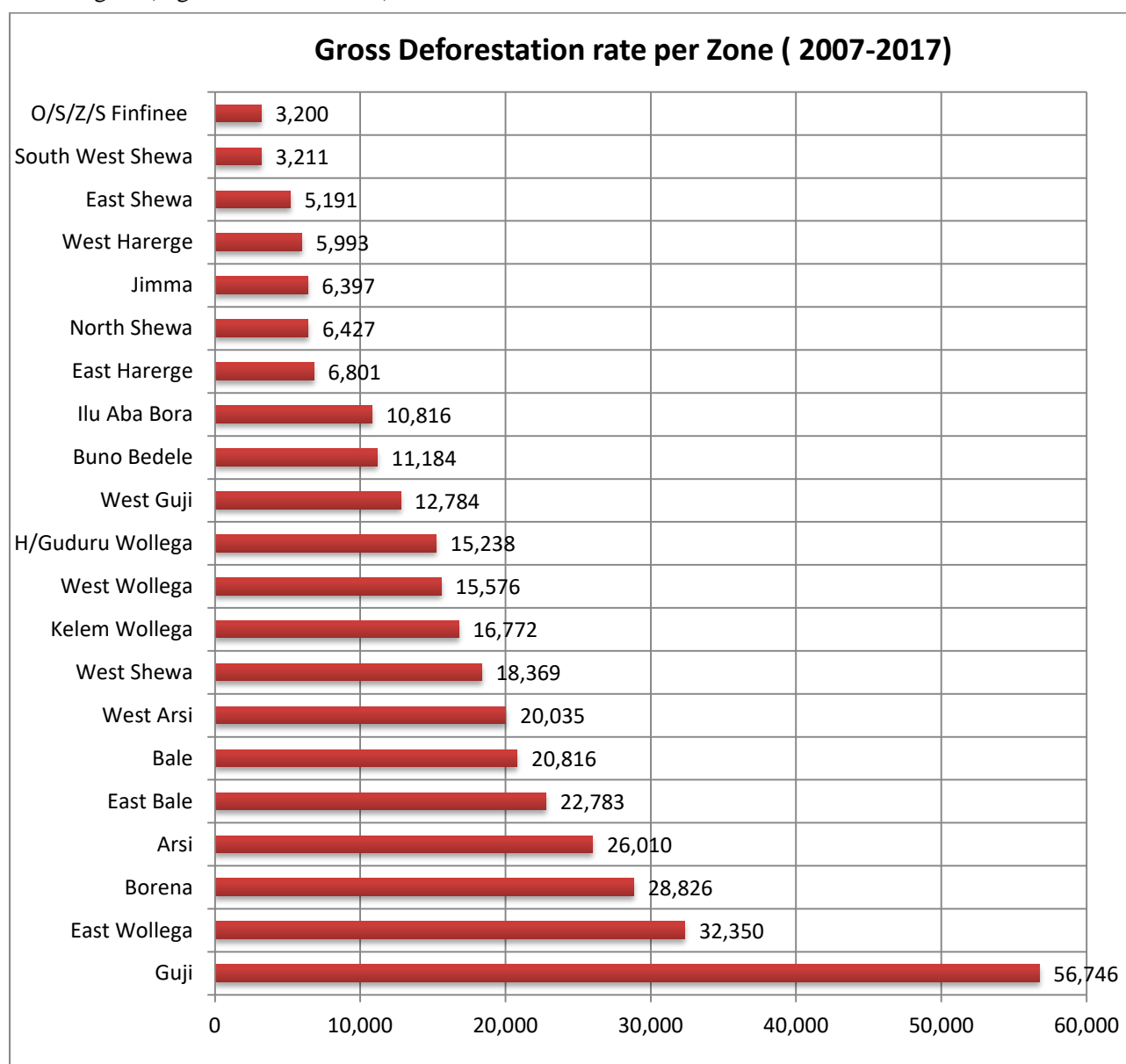


*Figure 13 Gross Deforestation estimated for each Zone between 2007 and 2017.*

22

### 3.2.2 Zonal Level LULC Change (AD) transition Matrix between 2007 – 2017 with Uncertainty Estimate

Zonal level area based estimation of land use land cover and its change analysis from 2007 to 2017 respective to each Zone per each LULC classes are presented in *Table 5*. The transition matrix of all Zones showed significant land use change from 2007 to 2017 in all Zones, specifically high magnitude of change is observed in cropland, forest, shrub land, grassland and settlement land use land cover classes. Specific result of each zone Land use land cover and activity data is presented in *Table 5*, while its description and discussion including uncertainty analysis and rate of AFOLU changes baseline assessment for each Zone is consequently presented underneath.

Table 5 Zonal Level Land Use Land cover and change transition Matrix from 2007-2017

| 1. East Wollega | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2017 LULC | 2007 LULC | | | | | | Total 2017 |
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | Total 2017 |
| Cropland | 774794.71 | 27157.75 | 10383.85 | 0.00 | 798.76 | 26758.37 | 798.76 | **840692.20** |
| Forest land | 3195.03 | 327889.93 | 798.76 | 0.00 | 0.00 | 798.76 | 0.00 | **332682.47** |
| Grassland | 798.76 | 1996.89 | 79476.36 | 0.00 | 0.00 | 2795.65 | 0.00 | **85067.67** |
| Other land | 0.00 | 0.00 | 0.00 | 1597.51 | 0.00 | 0.00 | 0.00 | **1597.51** |
| Settlement | 1198.14 | 399.38 | 798.76 | 0.00 | 51519.85 | 798.76 | 0.00 | **54714.88** |
| Shrub land | 1597.51 | 2795.65 | 1198.14 | 0.00 | 0.00 | 88662.08 | 0.00 | **94253.38** |
| Wetland | 399.38 | 0.00 | 0.00 | 0.00 | 1597.51 | 0.00 | 29554.0 | **31550.92** |
| **Total 2007** | **781983.5** | **360239.6** | **92655.9** | **1597.51** | **53916.13** | **119813.61** | **30352.8** | **1440559** |

| 2. Horo Guduru Wollega | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2017 LULC | 2007 LULC | | | | | | Total 2017 |
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | Total 2017 |
| Cropland | 374123 | 10827 | 4812 | 401 | 1203 | 14837 | 401 | **406603** |
| Forest land | 3208 | 199292 | 802 | 0 | 0 | 2807 | 401 | **206509** |
| Grassland | 401 | 1203 | 39698 | 0 | 0 | 4411 | 0 | **45713** |
| Other land | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| Settlement | 2005 | 0 | 0 | 0 | 18846 | 0 | 802 | **21653** |
| Shrub land | 1203 | 2807 | 401 | 0 | 0 | 71777 | 0 | **76188** |
| Wetland | 401 | 401 | 0 | 0 | 2406 | 0 | 64559 | **67767** |
| **Total 2007** | **381341** | **214529** | **45713** | **401** | **22455** | **93831** | **66163** | **824434** |

| 3. West Shawa | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2017 LULC | 2007 LULC | | | | | | Total 2017 |
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | Total 2017 |
| Cropland | 878,515.7 | 13,976.39 | 798.65 | - | - | 5,590.55 | 798.65 | **899,680** |
| Forest land | 3,194.60 | 220,028.26 | 1,597.30 | - | - | 3,593.93 | - | **228,414** |
| Grassland | 1,197.98 | 798.65 | 68,284.63 | - | - | 399.33 | - | **70,680.6** |
| Other land | - | - | - | 798.65 | 399.33 | - | - | **1,198** |
| Settlement | 1,597.30 | - | - | - | 55,506.22 | - | 399.33 | **57,502.9** |
| Shrub land | 1,597.30 | 3,593.93 | - | - | - | 120,196.93 | 99.33 | **125,787.5** |
| Wetland | - | - | - | - | 1,197.98 | 399.33 | 37,936 | **39,533** |
| **Total 2007** | **886,103** | **238,397.23** | **70,680.58** | **798.65** | **57,103.52** | **30,180.06** | **39,533** | **1,422,796.2** |

| 4. North Shawa | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2017 LULC | 2007 LULC | | | | | | |

|  | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| Cropland | 671573 | 2410 | 1607 | 0 | 0 | 5623 | 402 | **681615** |
| Forest land | 3213 | 40166 | 1607 | 0 | 0 | 3615 | 0 | **48601** |
| Grassland | 1205 | 0 | 38158 | 0 | 0 | 402 | 0 | **39764** |
| Other land | 0 | 0 | 0 | 7632 | 0 | 402 | 0 | **8033** |
| Settlement | 803 | 0 | 0 | 0 | 36149 | 0 | 0 | **36953** |
| Shrub land | 2008 | 4017 | 1205 | 803 | 0 | 123309 | 0 | **131342** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 36149 | **36149** |
| **Total 2007** | **678803** | **46592** | **42576** | **8435** | **36149** | **133351** | **36551** | **982457** |

### 5. East Hararge

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
|  | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland |  |
| Cropland | 670096 | 2000 | 2400 | 0 | 0 | 1600 | 0 | **676097** |
| Forest land | 1600 | 404858 | 2000 | 0 | 0 | 800 | 0 | **409259** |
| Grassland | 2800 | 4001 | 942935 | 0 | 400 | 3601 | 0 | **953737** |
| Other land | 0 | 0 | 0 | 400 | 0 | 0 | 0 | **400** |
| Settlement | 4001 | 0 | 800 | 0 | 34005 | 0 | 0 | **38806** |
| Shrub land | 400 | 800 | 3200 | 0 | 0 | 599686 | 0 | **604087** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 14002 | **14002** |
| **Total 2007** | **678898** | **411659** | **951337** | **400** | **34405** | **605687** | **14002** | **2696387** |

### 6. West Hararge

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
|  | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland |  |
| Cropland | 624049.9 | 2796.64 | 4394.72 | 0.00 | 0.00 | 7191.36 | 0.00 | 638432.6 |
| Forest land | 1997.60 | 224130.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 226128.2 |
| Grassland | 1598.08 | 1198.56 | 416299.6 | 0.00 | 0.00 | 5193.76 | 0.00 | 424290 |
| Other land | 0.00 | 0.00 | 0.00 | 1198.6 | 0.00 | 0.00 | 0.00 | 1198.56 |
| Settlement | 399.52 | 0.00 | 0.00 | 0.00 | 23172.2 | 799.04 | 0.00 | 24370.7 |
| Shrub land | 2397.12 | 1997.60 | 2796.64 | 0.00 | 399.52 | 436275.60 | 0.00 | 443866.5 |
| Wetland | 0.00 | 0.00 | 0.00 | 0.00 | 399.52 | 0.00 | 8389.9 | 8789.4 |
| **Total 2007** | 630442.2 | 230123.39 | 423490.97 | 1198.56 | 23971.2 | 449459.8 | 8389.9 | **1767076** |

### 7. Kellem Wollega

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
|  | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland |  |
| Cropland | 319060 | 15574 | 4792 | 0 | 399 | 5191 | 399 | **345415** |
| Forest land | 2396 | 493964 | 399 | 0 | 0 | 2795 | 0 | **499554** |
| Grassland | 1198 | 799 | 133774 | 0 | 0 | 0 | 0 | **135770** |
| Other land | 0 | 0 | 399 | 1198 | 0 | 0 | 0 | **1597** |
| Settlement | 8785 | 0 | 399 | 0 | 28352 | 799 | 0 | **38335** |
| Shrub land | 799 | 399 | 399 | 0 | 0 | 52311 | 0 | **53909** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 24758 | **24758** |
| **Total 2007** | **332237** | **510735** | **140163** | **1198** | **28751** | **61097** | **25157** | **1099339** |

### 8. East Shawa

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
|  | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland |  |
| Cropland | 592929 | 3194 | 7986 | 0 | 399 | 1996 | 0 | **606504** |
| Forest land | 1198 | 60291 | 0 | 0 | 0 | 399 | 0 | **61888** |
| Grassland | 1198 | 1198 | 161309 | 0 | 0 | 1996 | 0 | **165701** |
| Other land | 0 | 399 | 0 | 2795 | 0 | 399 | 0 | **3594** |

| Settlement | 13176 | 399 | 1198 | 0 | 33539 | 399 | 0 | **48712** |
|---|---|---|---|---|---|---|---|---|
| Shrub land | 0 | 0 | 399 | 0 | 0 | 91834 | 0 | **92233** |
| Wetland | 1597 | 0 | 799 | 0 | 0 | 399 | 95827 | **98622** |
| **Total 2007** | **610098** | **65482** | **171690** | **2795** | **33939** | **97424** | **95827** | **1077254** |

### 9. South West Shawa

| 2017 LULC | 2007 LULC | | | | | | | **Total 2017** |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 431909 | 2810 | 1204 | 0 | 0 | 803 | 0 | **436726** |
| Forest land | 0 | 48168 | 0 | 0 | 0 | 0 | 0 | **48168** |
| Grassland | 1606 | 401 | 26091 | 0 | 0 | 0 | 0 | **28098** |
| Other land | 0 | 0 | 0 | 1606 | 0 | 0 | 0 | **1606** |
| Settlement | 803 | 0 | 0 | 0 | 22077 | 0 | 0 | **22880** |
| Shrub land | 0 | 0 | 401 | 0 | 0 | 26493 | 0 | **26894** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 5218 | **5218** |
| **Total 2007** | **434317** | **51380** | **27697** | **1606** | **22077** | **27295** | **5218** | **569590** |

### 10. Ilu Ababora

| 2017 LULC | 2007 LULC | | | | | | | **Total 2017** |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 245553.6 | 10014.42 | 3204.61 | 0.00 | 400.58 | 2804.04 | 0.00 | **261977.22** |
| Forest land | 4806.92 | 731453.22 | 0.00 | 0.00 | 0.00 | 1602.31 | 0.00 | **737862.45** |
| Grassland | 400.58 | 400.58 | 56080.75 | 0.00 | 0.00 | 0.00 | 0.00 | **56881.90** |
| Other land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| Settlement | 6809.81 | 400.58 | 0.00 | 0.00 | 15622.49 | 0.00 | 0.00 | **22832.88** |
| Shrub land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50072.10 | 0.00 | **50072.10** |
| Wetland | 0.00 | 0.00 | 0.00 | 0.00 | 400.58 | 0.00 | 22832.9 | **23233.45** |
| **Total 2007** | **257570.9** | **742268.79** | **59285.36** | **0.00** | **16423.65** | **54478.44** | **22832.9** | **1152860.0** |

### 11. Guji

| 2017 LULC | 2007 LULC | | | | | | | **Total 2017** |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 397619 | 47554 | 8792 | 0 | 0 | 9990 | 0 | **463956** |
| Forest land | 400 | 817617 | 400 | 0 | 0 | 799 | 0 | **819216** |
| Grassland | 799 | 6394 | 591034 | 0 | 0 | 1598 | 0 | **599826** |
| Other land | 0 | 0 | 0 | 799 | 0 | 0 | 0 | **799** |
| Settlement | 799 | 1598 | 1199 | 0 | 19581 | 400 | 799 | **24377** |
| Shrub land | 1199 | 1199 | 400 | 0 | 0 | 1263990 | 0 | **1266787** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 33568 | **33568** |
| **Total 2007** | **400816** | **874363** | **601824** | **799** | **19581** | **1276777** | **34367** | **3208528** |

### 12. West Guji

| 2017 LULC | 2007 LULC | | | | | | | **Total 2017** |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 304430 | 9189 | 11186 | 0 | 0 | 7191 | 400 | **332396** |
| Forest land | 0 | 243704 | 400 | 0 | 0 | 400 | 0 | **244503** |
| Grassland | 400 | 3196 | 221331 | 0 | 0 | 400 | 0 | **225326** |
| Other land | 0 | 0 | 0 | 799 | 0 | 0 | 0 | **799** |
| Settlement | 1998 | 0 | 1199 | 0 | 13583 | 1199 | 0 | **17978** |
| Shrub land | 400 | 0 | 2397 | 0 | 0 | 112264 | 0 | **115060** |
| Wetland | 0 | 400 | 0 | 0 | 0 | 0 | 90690 | **91089** |
| **Total 2007** | **307227** | **256488** | **236513** | **799** | **13583** | **121452** | **91089** | **1027152** |

### 13. Borena LULC

| 2017 LULC | 2007 LULC | **Total 2017** |
|---|---|---|

| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
|---|---|---|---|---|---|---|---|---|
| Cropland | 90,080 | 9,609 | 11,210 | - | - | ,808 | - | **119,707** |
| Forest land | 400 | 2,197,559 | 4,404 | - | - | | - | **2,214,775** |
| Grassland | 801 | 6,005 | 1,484,924 | - | - | 8,808 | - | **1,500,538** |
| Other land | - | - | 1,201 | 34,030 | - | 1,601 | - | **36,833** |
| Settlement | 400 | 2,002 | 2,402 | 400 | 7,607 | 801 | - | **13,612** |
| Shrub land | 1,201 | 10,810 | 9,609 | 400 | - | 1,594,221 | - | **1,616,241** |
| Wetland | - | 400 | - | 400 | 400 | - | 69,662 | **70,863** |
| **Total 2007** | **92,883** | **2,226,385** | **1,513,750** | **35,231** | **8,007** | **1,626,650** | **69,662** | **5,572,569** |

**14. Bale**

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 519593 | 18414 | 6405 | 0 | 0 | 12009 | 0 | **556421** |
| Forest land | 2002 | 959526 | 0 | 0 | 400 | 1201 | 0 | **963129** |
| Grassland | 0 | 1601 | 507184 | 0 | 0 | 3202 | 0 | **511987** |
| Other land | 0 | 0 | 0 | 37228 | 0 | 0 | 0 | **37228** |
| Settlement | 400 | 801 | 801 | 0 | 19215 | 400 | 0 | **21616** |
| Shrub land | 0 | 0 | 1201 | 0 | 0 | 873461 | 0 | **874662** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 28021 | **28021** |
| **Total 2007** | **521995** | **980342** | **515590** | **37228** | **19615** | **890273** | **28021** | **2993064** |

**15. East Bale**

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 266602 | 15189 | 2398 | 0 | 0 | 10792 | 0 | **294981** |
| Forest land | 1199 | 1610004 | 799 | 0 | 0 | 400 | 0 | **1612402** |
| Grassland | 799 | 5196 | 852567 | 0 | 0 | 799 | 0 | **859362** |
| Other land | 0 | 0 | 0 | 1599 | 0 | 0 | 0 | **1599** |
| Settlement | 400 | 400 | 799 | 0 | 13990 | 0 | 0 | **15588** |
| Shrub land | 400 | 1999 | 400 | 0 | 0 | 898133 | 0 | **900931** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 17987 | **17987** |
| **Total 2007** | **269400** | **1632787** | **856964** | **1599** | **13990** | **910124** | **17987** | **3702850** |

**16. West Arsi**

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 601,465 | 12,021 | 9,617 | 0 | 1,202 | 801 | 801 | **625,909** |
| Forest land | 401 | 163,890 | 0 | 0 | 0 | 0 | 0 | **164,291** |
| Grassland | 401 | 7,213 | 203,561 | 0 | 0 | 0 | 401 | **211,575** |
| Other land | 0 | 0 | 0 | 11,621 | 0 | 0 | 0 | **11,621** |
| Settlement | 13,223 | 801 | 4,809 | 0 | 102,181 | 0 | 0 | **121,014** |
| Shrub land | 0 | 0 | 0 | 0 | 0 | 50,089 | 0 | **50,089** |
| Wetland | 401 | 0 | 0 | 0 | 401 | 0 | 94,167 | **94,968** |
| **Total 2007** | **615,891** | **183,926** | **217,986** | **11,621** | **103,784** | **50,890** | **95,369** | **1,279,466** |

**17. Arsi**

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 1092432 | 16406 | 9204 | 0 | 2001 | 4402 | 0 | **1124445** |
| Forest land | 2801 | 292116 | 400 | 0 | 0 | 400 | 0 | **295717** |
| Grassland | 1200 | 7603 | 262904 | 0 | 0 | 2001 | 0 | **273708** |
| Other land | 400 | 0 | 400 | 2001 | 0 | 0 | 0 | **2801** |
| Settlement | 6803 | 1601 | 1200 | 0 | 66826 | 800 | 0 | **77231** |

| Shrub land | 0 | 400 | 400 | 0 | 0 | 250899 | 0 | **251700** |
|---|---|---|---|---|---|---|---|---|
| Wetland | 0 | 0 | 0 | 0 | 400 | 0 | 38015 | **38415** |
| **Total 2007** | **1103637** | **318126** | **274509** | **2001** | **69227** | **258502** | **38015** | **2064017** |

### 18. West Wollega

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 550763.4 | 7588.5 | 798.8 | 0.0 | 5990.9 | 3195.1 | 0.0 | 568336.7 |
| Forest land | 10783.6 | 374231.5 | 1198.2 | 0.0 | 798.8 | 1597.6 | 0.0 | 388609.7 |
| Grassland | 6390.3 | 1597.6 | 118220.4 | 0.0 | 399.4 | 798.8 | 0.0 | 127406.5 |
| Other land | 0.0 | 0.0 | 0.0 | 1997.0 | 0.0 | 0.0 | 0.0 | 1997.0 |
| Settlement | 399.4 | 399.4 | 0.0 | 0.0 | 47128.4 | 0.0 | 0.0 | 47927.2 |
| Shrub land | 7987.9 | 5990.9 | 399.4 | 0.0 | 399.4 | 87467.1 | 0.0 | 102244.7 |
| Wetland | 0.0 | 0.0 | 0.0 | 399.4 | 0.0 | 0.0 | 92260 | 92659.3 |
| **Total 2007** | 576324.6 | 389807.9 | 120616.8 | 2396.4 | 54716.9 | 93058.6 | 92260 | **1329181** |

### 19. Buno Bedele

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 304364 | 8787 | 799 | 0 | 0 | 1198 | 0 | **315148** |
| Forest land | 1997 | 203309 | 0 | 0 | 0 | 799 | 0 | **206105** |
| Grassland | 1198 | 1598 | 24764 | 0 | 0 | 0 | 0 | **27560** |
| Other land | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| Settlement | 1997 | 399 | 0 | 0 | 11983 | 0 | 0 | **14379** |
| Shrub land | 399 | 399 | 0 | 0 | 0 | 17974 | 0 | **18773** |
| Wetland | 0 | 0 | 0 | 0 | 0 | 0 | 26762 | **26762** |
| **Total 2007** | **309956** | **214492** | **25563** | **0** | **11983** | **19971** | **26762** | **608727** |

### 20. Oromia Special Zone Surrounding Finfinnee

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 302841 | 1200 | 800 | 0 | 400 | 800 | 0 | **306041** |
| Forest land | 2800 | 32004 | 0 | 0 | 0 | 0 | 0 | **34805** |
| Grassland | 1200 | 400 | 40005 | 0 | 0 | 0 | 0 | **41606** |
| Other land | 400 | 0 | 0 | 2000 | 0 | 0 | 0 | **2400** |
| Settlement | 4801 | 1200 | 0 | 0 | 29204 | 0 | 0 | **35205** |
| Shrub land | 0 | 400 | 0 | 0 | 0 | 16802 | 0 | **17202** |
| Wetland | 400 | 0 | 0 | 0 | 400 | 0 | 13202 | **14002** |
| **Total 2007** | **312442** | **35205** | **40806** | **2000** | **30004** | **17602** | **13202** | **451261** |

### 21. Jimma

| 2017 LULC | 2007 LULC | | | | | | | Total 2017 |
|---|---|---|---|---|---|---|---|---|
| | Cropland | Forest land | Grassland | Other land | Settlement | Shrub land | Wetland | |
| Cropland | 847635 | 5997 | 1199 | 0 | 0 | 1199 | 400 | **856431** |
| Forest land | 4798 | 646122 | 0 | 400 | 0 | 800 | 0 | **652119** |
| Grassland | 800 | 0 | 107154 | 0 | 0 | 1199 | 0 | **109153** |
| Other land | 0 | 0 | 0 | 400 | 0 | 0 | 0 | **400** |
| Settlement | 5598 | 400 | 400 | 0 | 98358 | 400 | 0 | **105155** |
| Shrub land | 0 | 0 | 1199 | 0 | 0 | 61174 | 0 | **62373** |
| Wetland | 0 | 0 | 0 | 0 | 800 | 0 | 71169 | **71969** |
| **Total 2007** | **858830** | **652519** | **109953** | **800** | **99157** | **64772** | **71569** | **1857600** |

### 3.2.2.1    *East Wollega Zone*

LULC extent of East Wollega Zone showed that Cropland, forest, shrub land and Grassland shares more than 94% of the total area in both monitoring periods. Cropland accounts about 54.28% in 2007 and 58.4% in 2017, followed by forest land which covers 25% in 2007 and 23% in 2017; shrub land covers 8.3% in 2007 and 6.5% ibn 2017, and Grassland Covers 6.43% in 2007 and 5.91% in 2017. Settlement contributes more than 3.7% and wetland shared only 2.1 % of the total Zonal area coverage, with insignificant proportion of other land areas in both years.

This transition matrix of LULC for East Wollega Zone shows significant change from 2007 up to 2017. The results further revealed that cropland, forest land, grassland, settlement, shrub land and Wetland showed significant changes. Cropland and settlement showed positive increment; while forest, grassland, shrub land and wetland classes showed negative sign of change. Copland claimed about 65,897 ha gross (58709 ha net gain) from other land uses classes mainly about 27,157.7 ha from forest, 26,758 ha from shrub land and about 10,384 ha from Grassland between 2007 and 2017. Similarly, settlement increased by 3195 ha gross increment mainly claiming about 1198 ha of cropland, 399 ha of forest land and 798 ha from each shrub land and grassland (Table 6).

*Table 6 East Wollega Zone LULC Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 781984 | 54 | 840692 | 58 | 7189 | 65897 | 58709 | 0.72 | 5681.47 |
| Forest land | 360240 | 25 | 332682 | 23 | 32350 | 4793 | -27557 | -0.8 | -2855.44 |
| Grassland | 92656 | 6 | 85068 | 6 | 13179 | 5591 | -7588 | -0.85 | -788.33 |
| Other land | 1598 | 0 | 1598 | 0 | 0 | 0 | 0 | 0 | 0 |
| Settlement | 53916 | 4 | 54715 | 4 | 2396 | 3195 | 799 | 0.15 | 79.35 |
| Shrub land | 119814 | 8 | 94253 | 7 | 31152 | 5591 | -25560 | -2.4 | -2840.72 |
| Wetland | 30353 | 2 | 31551 | 2 | 799 | 1997 | -1198 | 0.39 | 117.74 |
| Total | 1440559 | 100 | 1440559 | 100 | | | | | |

Positives values under Gross, annual change in percent and annual change in per year in hectares showed gain/increment, while –ve vales indicate reduction in land cover extent related to base year 2007.

On the other hand Forest land, shrub land, and Grassland showed significant reduction in extent. Forest land showed 32349.7 ha gross (27557 net) reductions, while shrub land showed 31151.5 ha gross (25560 ha net) reductions, and grassland decreased with 13179 ha gross (7588 ha net) changes between the two monitoring periods. Reduction of those land cover classes is mainly attributed to conversion to cropland, where about 27157.7 ha of forest, 26758 ha of shrub land and 10, 384 ha of grassland were converted to forest land during the baseline assessment period. Although about 799 ha of wasteland were converted to cropland in the period, other land classes showed insignificant change *Table 5* (1). Related to other LULC classes the uncertainty of cropland is minimal with +/- 23178.7.
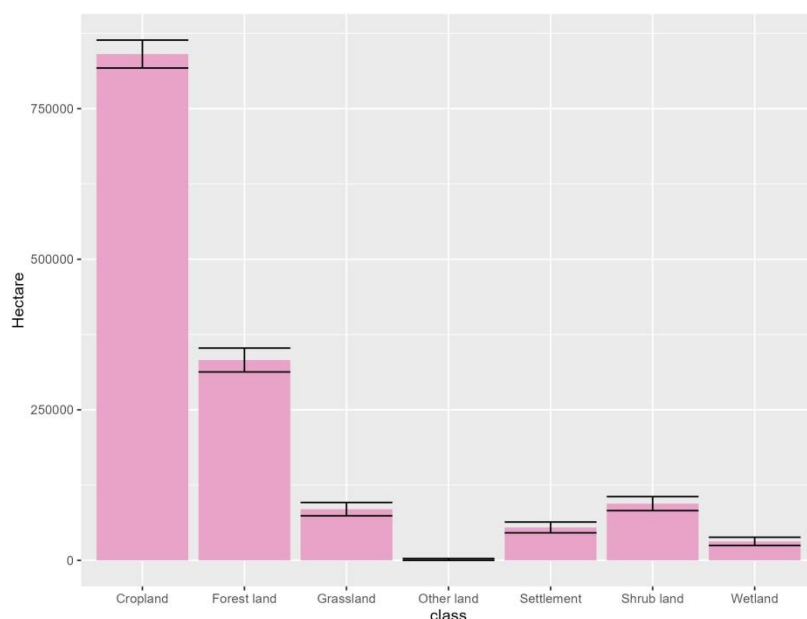
***Figure 14  East Wollega Land Use Land Cover of 2017 with 95% confidence interval (CI)***

### 3.2.2.2    *Horo Guduru  Wollega  Zone*

Horo Guduru Wollega Zone covers an area of 824,434 ha, from which Cropland covers 381341 (46.25%) in 2007 and 406603 ha (49.32%) in 2017, followed by forest land covering 214529 ha (26%) in 2007 and 206509 ha (25%) in 2017. Subsequently, the extent of Shrub land, wetland, and Grassland are 11.4, 8.03, and 5.54 percent in 2007 and 9.24, 8.22, and 5.54 percent in 2017 respectively. Settlement contributes more than 2.5% in both years and the proportion of other land class is insignificant.

*Table 7 Horo Guduru  Wollega Zone LULC Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 381341 | 46 | 406603 | 49 | 7218 | 32480 | 25262 | 0.64 | 2453.94 |
| Forest land | 214529 | 26 | 206509 | 25 | 15238 | 7218 | -8020 | -0.38 | -815.8 |
| Grassland | 45713 | 6 | 45713 | 6 | 6015 | 6015 | 0 | 0 | 0 |
| Other land | 401 | 0 | 0 | 0 | 401 | 0 | 401 | 0 | 0 |
| Settlement | 22455 | 3 | 21653 | 3 | 3609 | 2807 | 802 | 0.36 | 81.52 |
| Shrub land | 93831 | 11 | 76188 | 9 | 22054 | 4411 | -17644 | -2.08 | -1934.27 |
| Wetland | 66163 | 8 | 67767 | 8 | 1604 | 3208 | 1604 | 0.24 | 158.67 |
| Total | 824434 | 100 | 824434 | 100 | | | | | |
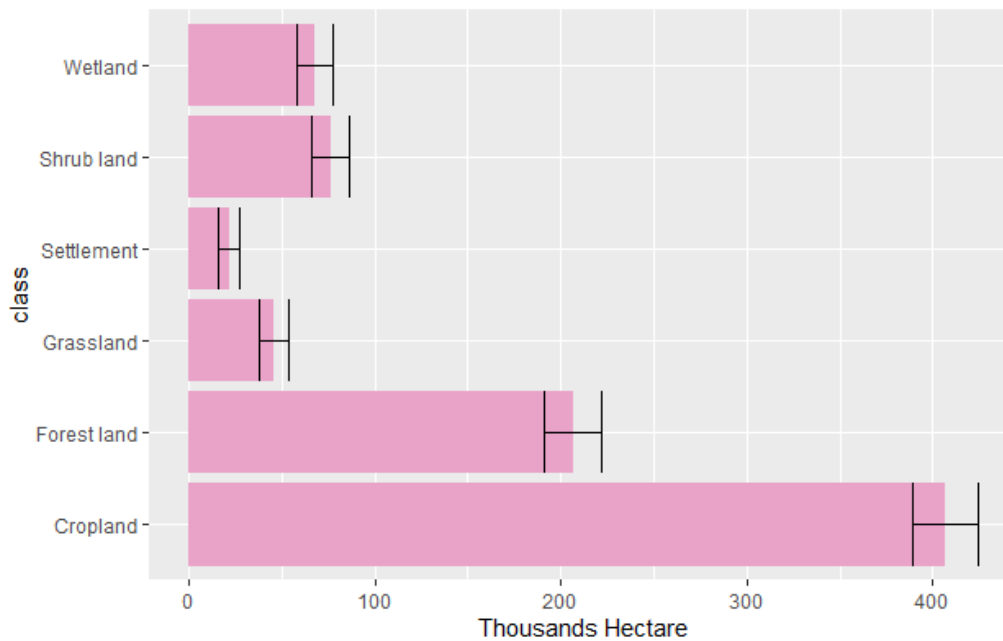
*Figure 15 Horo Guduru Wollega Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)*

LULC change classes for Horo Gududuru Wollega Zone also showed significant change for cropland, forest, shrub land and settlement classes. Transition matrix result *Table 5* (2) showed that cropland increased from 381341 ha to 406603 ha with net gain of 25262 ha mainly from shrub land (14837 ha), forest land (10827 ha) and Grassland (4812 ha). On the other hand forest land decreased from 214519 ha in 2007 to 206509 ha in 2017 with net gross deforestation of 8020 ha. In consistent with forest land Scrubland also showed reduction from 93831 ha to 76188 ha with net loss of 17644 ha within the monitoring periods. However, the net change for grassland and other land is insignificant or minimal. Uncertainty analysis for each LULC analysis for 2017 showed that there is +/- 95% confidence Interval for cropland 17821 ha, Forest 15444 ha, Grassland 8157 ha, settlement with 5700 ha, shrub land with 10323 ha and wetland with 9790 ha (Figure 15).

### 3.2.2.3    West Shawa Zone

In 2007, cropland shares the largest part (63.23%) and followed by forest land (16%), shrub land (8.84%), Grassland (4.97%) and settlement with 4% of total area of West shawa Zone. Wetland and other land shares the smallest accounting 2.78% and 0.06% during 2007. Attributed to 2017 Land use land cover information of West shawa, largest part (62.3%) of the total land mass is covered by cropland (with 95% confidence and +/-30,000ha). Forest land is the next largest LULC class holding 16.8% of the zone and followed by shrub land, grass land, and settlement covering 9.1, 5.0 and 4.0 % respectively. Wetland and other land are the smallest LULC class encompassing 2.8 and 0.056 % of the land mass respectively Table 8. Overlying with Biome class 70.6 % of West Shewa zone is found in Dry Afromotane biom and the remaining 29.4% of the zone is found in Combretum-Terminalia.

*Table 8 West Shawa Zone LULC Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 886103 | 62 | 899680 | 63 | 7587 | 21164 | 13577 | 0.15 | 1367.02 |
| Forest land | 238397 | 17 | 228414 | 16 | 18369 | 8386 | -9983 | -0.43 | -979.21 |
| Grassland | 70681 | 5 | 70681 | 5 | 2396 | 2396 | 0 | 0 | 0 |
| Other land | 799 | 0 | 1198 | 0 | 0 | 399 | 399 | 4.05 | 47.6 |
| Settlement | 57104 | 4 | 57503 | 4 | 1597 | 1997 | 399 | 0.07 | 40.06 |
| Shrub land | 130180 | 9 | 125787 | 9 | 9983 | 5591 | -4393 | -0.34 | -432.5 |
| Wetland | 39533 | 3 | 39533 | 3 | 1597 | 1597 | 0 | 0 | 0 |
| Total | 1422796 | 100 | 1422796 | 100 | | | | | |

Attributed to transition of LULC class's cropland, forest, shrub land showed significant changes compared to other classes. Cropland increased from 886,102.92 ha to 899,679.98 ha with net increment of 13577 mainly obtained from forest (13976 .4 ha), shrub land (5590.55 ha), from Grassland and wetland each contributing 798 ha to cropland classes during baseline assessment period. Compared to 2007, other land and settlement covered areas also showed increment with about 399 ha in 2017. On the other hand, Forest land showed large reduction from 238,397.23 ha in 2007 to 228,414.09 ha in 2017 with net gross deforestation of 9983 ha. In consistent with forest land Scrubland also showed reduction from 130,180.06 ha to 125,787.48 ha with net loss of 4393 ha within the monitoring periods. However, the net change for grassland and wetland classes is insignificant or minimal.

Attributed to Uncertainty analysis of 2017 LULC the finding showed that there is +/- 95% confidence Interval for cropland 22647 ha, Forest 17450 ha, Grassland 10152 ha, other land with1106 ha, settlement with 9171 ha, shrub land with 13471 ha and wetland with 7679 ha (Figure 16).



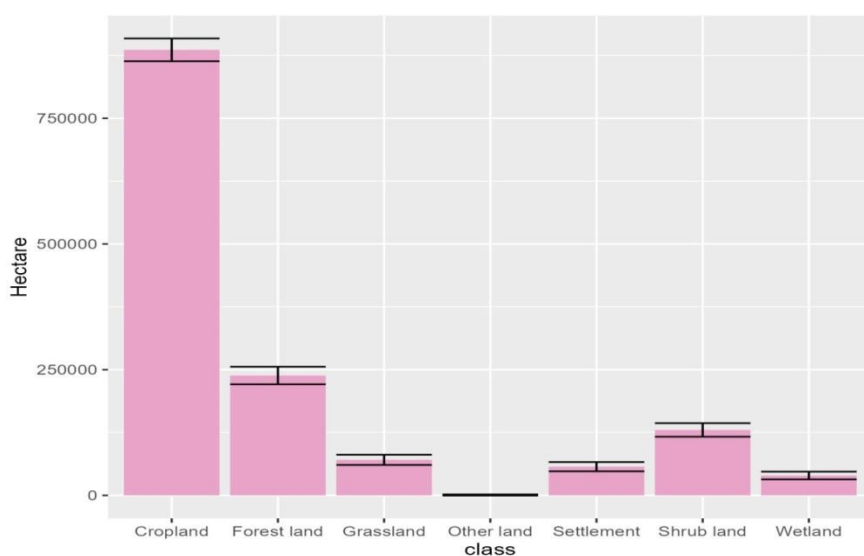*Figure 16 West Shawa Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)*

### 3.2.2.4    North Shawa Zone

Form 982457 ha total of North Shawa Zone, cropland shares the largest part 678,803 ha in 2007 and 681,615 ha in 2017, where both nearly shares about 69% of the total area, followed by shrub land accounting 133,351 ha in 207 and 131,342 ha in 2017 nearly contributing about 13.5% of the total area in both monitoring periods. The next land use land covers accounting less than 5% share are Forest land, Grassland, Wetland and Settlement classes accounting 4.74 and 4,94, 4.33 and 4.05, 3.72 and 3,68, 3.68 and 3.76 percent of the total area in 2007 and 2017 consequently. Still, the contribution of other land to the total area of this specific Zone is minimal (0.86%) for 2007 (Table 9).

*Table 9 North Shawa Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 678803 | 69 | 681615 | 69 | 7230 | 10041 | 2812 | 0.04 | 280.64 |
| Forest land | 46592 | 5 | 48601 | 5 | 6427 | 8435 | 2008 | 0.42 | 197.04 |
| Grassland | 42576 | 4 | 39764 | 4 | 4418 | 1607 | -2812 | -0.68 | -289.88 |
| Other land | 8435 | 1 | 8033 | 0 | 803 | 402 | 402 | 0.49 | 41.05 |
| Settlement | 36149 | 4 | 36953 | 4 | 0 | 803 | 803 | 0.22 | 79.54 |
| Shrub land | 133351 | 14 | 131342 | 13 | 10041 | 8033 | -2008 | -0.15 | -202.2 |
| Wetland | 36551 | 4 | 36149 | 4 | 402 | 0 | -402 | -0.11 | -40.37 |
| Total | 982457 | 100 | 982457 | 100 | | | | | |

Attributed to transition of LULC class's cropland, forest, settlement showed increment in extent, while Grassland, shrub land, wetland and other land classes showed reduction. Cropland increased with 2811 net gain mainly obtained from forest, Grassland and shrub land classes. This is followed by forest land which showed an increment with about 2008 ha net gain obtained mainly from cropland and shrub land through forest development and restoration activities- surprisingly net forest increment is uncommon for other Zones. On the other hand, there was net reduction of Grassland with 2811 ha, shrub with about 2008 ha, wetland and other land with about 400 ha. Still, the net change for other land class is minimal *Table 5* (4).
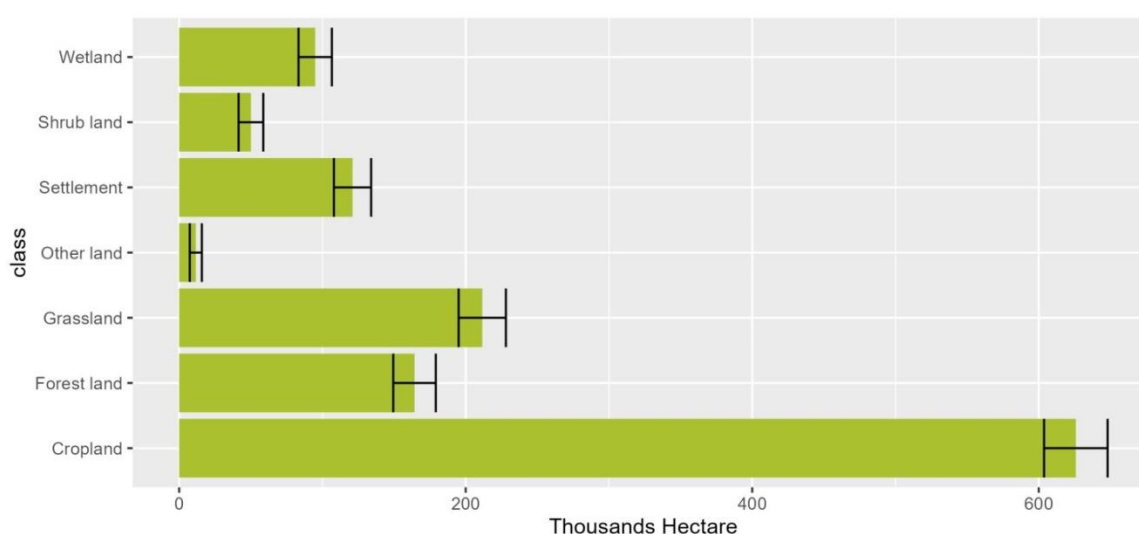
Attributed to Uncertainty analysis of 2017 LULC the finding showed that there is +/- 95% confidence Interval for cropland 17950 ha, Forest 8444 ha, Grassland 7674 ha, other land with 3506 ha, settlement with 7409 ha, shrub land with 13252 ha and wetland with 7331 ha (Figure 17).

### 3.2.2.5    *East Hararge Zone*

Form 2,696,387 ha total area of East Hararge Zone cropland shares the largest part about 25%, followed by grassland contributing 35%, shrub land accounting about 22%, forest land nearly contributing about 15% of the total area in both monitoring periods. Settlement contributed about 1.28 in 2007 and 1.44% in 2017, wetland covers 0.5 ha in both years and other land class contribution is insignificant. Attributed to transition of LULC class's grassland and settlement showed increment, while cropland, forest and shrub land showed reduction in land cover extent. Settlement showed net increment by 4400.6 ha followed by grassland with 2400 ha compared to 2007 land cover extent. On the other hand extent of cropland is decreased with 2800 ha net reduction followed by 2400 ha forestland, and 1600 ha shrub land. Other land and wetland classes showed no change during the monitoring periods *Table 5* (5).

*Table 10 East Hararge Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 678898 | 25 | 676097 | 25 | 8801 | 6001 | -2800 | -0.04 | -280.56 |
| Forest land | 411659 | 15 | 409259 | 15 | 6801 | 4401 | -2400 | -0.06 | -240.67 |
| Grassland | 951337 | 35 | 953737 | 35 | 8401 | 10802 | 2400 | 0.03 | 239.76 |
| Other land | 400 | 0 | 400 | 0 | 0 | 0 | 0 | 0 | 0 |
| Settlement | 34405 | 1 | 38806 | 1 | 400 | 4801 | 4401 | 1.2 | 416.61 |
| Shrub land | 605687 | 22 | 604087 | 22 | 6001 | 4401 | -1600 | -0.03 | -160.21 |
| Wetland | 14002 | 1 | 14002 | 1 | 0 | 0 | 0 | 0 | 0 |
| Total | 2696387 | 100 | 2696387 | 100 | | | | | |

Attributed to transition of LULC class's cropland showed 8801 ha gross reduction with 280 ha per year, forest land with 4401 ha with annual reduction rate of 240 ha per year, and shrub land showed 4401 ha gross reduction with 160 ha loss per year. On the other hand Grassland and settlement classes are showing an increment with 10802 ha and 4801 ha with annual increment rate of 239 ha and 416 ha per year *Table 5* (1) and Table 10.
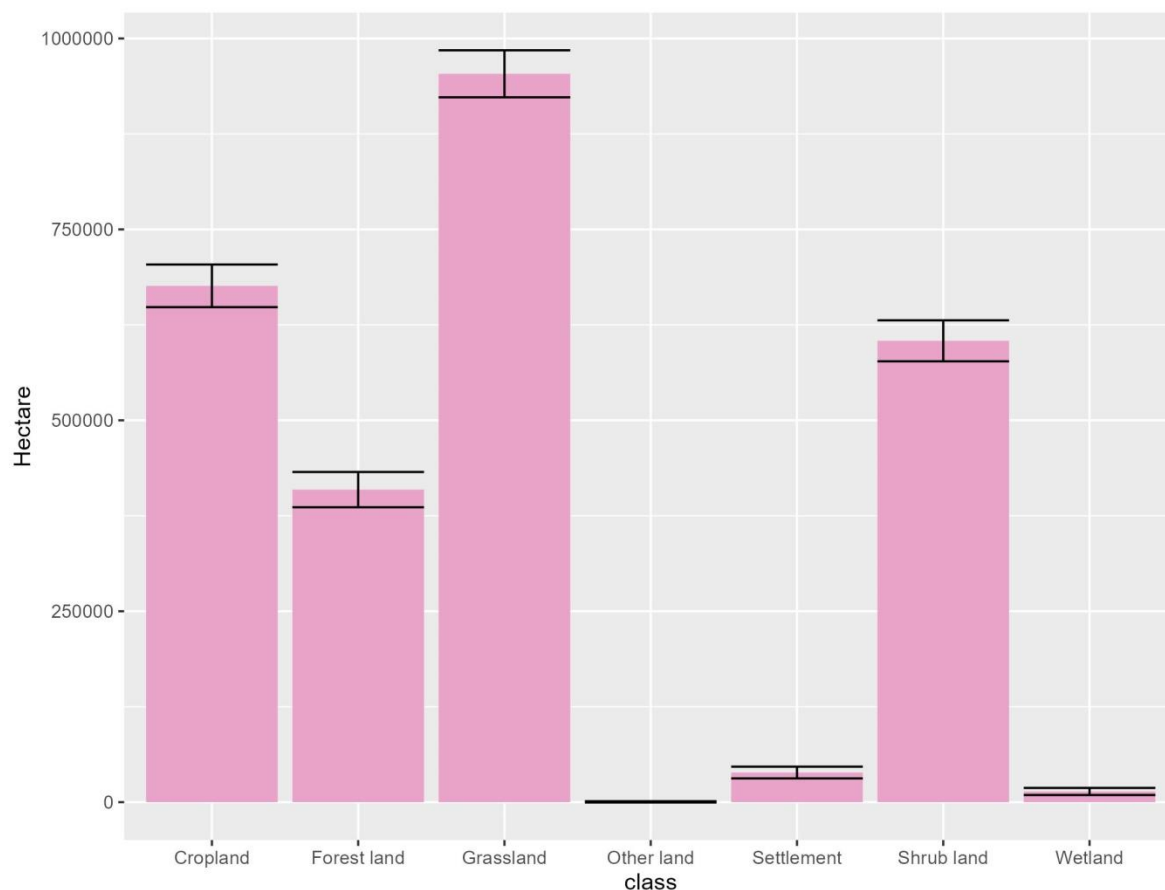
*Figure 18 East Hararge Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)*

Uncertainty analysis of 2017 main LULC OF East Hararge Zone finding showed that there is +/- 95% confidence Interval for cropland 27904 ha, Forest 23099 ha, Grassland 30780 ha, other land with 784 ha, settlement with 7667 ha, shrub land with 26842 ha and wetland with 4627 ha (Figure 18).

### 3.2.2.6    *West Hararge Zone*

Like other zones of Oromia, west Hararge zone have different land use land cover types such as cropland, Grassland, Other land, Settlement, Shrub land and Wetland. Based on the activity data conducted between 2007 and 2017 Zonal deforestation baseline assessment presented on *Table 5* (6) the following summery was produced. From the total area of the 1,767,076 ha areal extent of West Harage Zone cropland, shrub land, Grassland and forest classes shares largest land cover extent consecutively accounting 630442.2 ha (35.7%), 449459.76 ha (25.44%), 423490.97 ha (23.97%) and 230123.39 ha (13%) in 2007 and 638432.61 ha (36.13%), 443866.48 (25.12%), 424290.01 (24%), and 226128.20 ha (12.8%) in 2017 respectively. Settlement has about 1.34% share during the monitoring periods with 399 ha increment and wetland shared 0.5% of the total area, while other land cover class has less contribution. Transition matrix on *Table 5* (6) and Table 11 showed that Forest land and Shrub land classes has been reduced with 5992.80 ha and 13184.15 ha with net reduction of 3995.20 ha and 5593.28 ha respectively. On the other hand cropland, Grassland and settlement showed gross increment with about 6392 ha, 7191 ha, 799 ha with net gain of 7990 ha, 799 ha and 399 ha respectively.

*Table 11 West Hararge Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 630442 | 36 | 638433 | 36 | 6392 | 14383 | 7990 | 0.13 | 794.52 |
| Forest land | 230123 | 13 | 226128 | 13 | 5993 | 1998 | -3995 | -0.18 | -402.68 |
| Grassland | 423491 | 24 | 424290 | 24 | 7191 | 7990 | 799 | 0.02 | 79.84 |
| Other land | 1199 | 0 | 1199 | 0 | 0 | 0 | 0 | 0 | 0 |
| Settlement | 23971 | 1 | 24371 | 1 | 799 | 1199 | 400 | 0.17 | 39.66 |
| Shrub land | 449460 | 25 | 443866 | 25 | 13184 | 7591 | -5593 | -0.13 | -562.48 |
| Wetland | 8390 | 0 | 8789 | 0 | 0 | 400 | 400 | 0.47 | 39.12 |
| Total | 1767076 | 100 | 1767076 | 100 | | | | | |
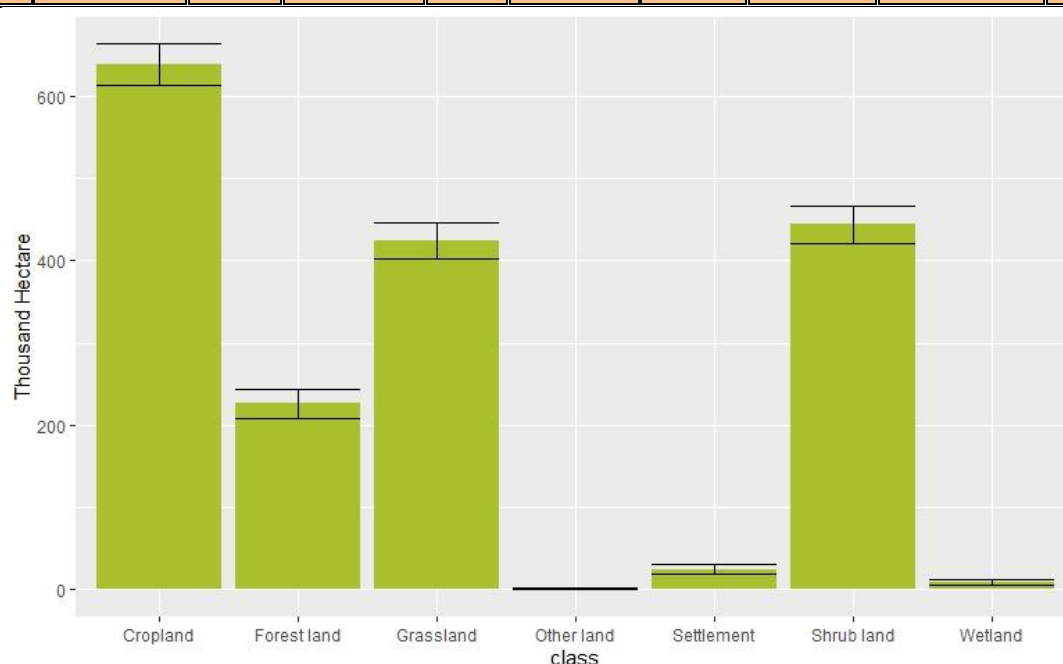


*Figure 19 West Hararge Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)*

Attributed to transition of LULC class's forest land with 5993 ha gross (3995 net) reduction has 402 ha (0.18%) annual reduction rate and shrub land showed 13184 ha gross (5593 ha net) reduction with 562 ha loss per year. On the other hand cropland showed 14383 ha gross increment (7990 net gain) with 794 ha (0.13%) change per year, settlement showed 1199 ha gross (400 ha net) increment with 39 ha annual increment rate per year. Rate of increment in grassland class is 79 ha per year compared to base year respective land cover information. Other land class has insignificant contribution on change compared to the base year. Uncertainty analysis of 2017 main LULC OF West Hararge Zone finding showed that there is +/- 95% confidence Interval for cropland 25019 ha, Forest 17398 ha, Grassland 22247 ha, other land with 1355 ha, settlement with 6074 ha, shrub land with 22588 ha and wetland with 3664 ha (Figure 19).

### 3.2.2.7    *Kellem Wollega Zone*

Kellem Wollega is one of the zones of the Oromia Region in Ethiopia which located in western part Oromia. This summary describes the activity data of Kelem Wollega Zone which was analyzed based on Sample based area estimation from 2007-2017. As indicated below the total area of Kelem wollega zone is **1099338.72 hectares** and the total sample point collected from this area is **2753.** From the total area of Kelem Wollega Zone Forest land accounts 510,735 ha (44.46%) followed by cropland 332237 ha (30.22%), Grassland 140163 ha (12.75%), shrub land 61,097 ha (5.56%) and wetland 25157 ha (2.29%) in 2007. Similarly, area extent of those land cover in 2017 are 499554 (35.44%) for forest, cropland with 345415 ha (31.42%), grassland with 135770 ha (12.35%), shrub land with 53909 ha (4.90%) and wetland with 24758 ha (2.25%).  Related to transition of those LULC classes cropland, Settlement and other land showed increment with  net gain of 13177 ha, 9584 ha and  399 ha respectively during monitoring period.  However, there is reduction in forest, shrub land and Grass land with gross reduction of 16771.6 ha (11181 ha net), 8785 ha (7184 ha net), 6389 ha (4393 ha net) changes between the two monitoring periods (*Table 12*).

Table 12 Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods for Kellem Wollega Zone

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 332237 | 30.22 | 345415 | 31.42 | 13177.7 | 26355 | 13177.7 | 0.39 | 1294.82 |
| Forest land | 510735 | 46.46 | 499554 | 45.44 | 16771.6 | 5591 | -11181.1 | -0.22 | -1129.28 |
| Grassland | 140163 | 12.75 | 135770 | 12.35 | 6389.2 | 1997 | -4392.6 | -0.32 | -445.58 |
| Other land | 1198 | 0.11 | 1597 | 0.00 | 0.00 | 399 | 399.3 | 2.88 | 34.96 |
| Settlement | 28751 | 2.62 | 38335 | 3.49 | 399.3 | 9983 | 9583.8 | 2.88 | 839.14 |
| Shrub land | 61097 | 5.56 | 53909 | 4.90 | 8785.1 | 1597 | -7187.8 | -1.25 | -759.94 |
| Wetland | 25157 | 2.29 | 24758 | 2.25 | 399.3 | 0 | -399.3 | -0.16 | -40.22 |
| Total | 1099339 | 100 | 1099339 | 100 | | | | | |

Positives values under Gross, annual change in percent and annual change in per year in hectares showed gain, while –ve vales indicate reduction in land cover extent related to base year 2007.

Result showed that cropland is increasing with 0.39 standardized annual changes in percent which contribute for 1294.8 hectares annual change per year. Consistently, settlement and other land showed 2.9% annual change in percent contributing 839 ha and 35 ha annual growth in land cover extent respectively. On the other hand, forest land, shrub land, Grassland and wetland showed annual reduction rate in percent of 0.22, 1.25, 0.32 and 0.16 which directly contribute for annual change in hectares of 1129, 759, 446 and 40 per year.

This graph indicated on **Figure 20** showed that Land Use Land Cover of 2017 with bias corrected 95% confidence interval.  Attributed to each Land use land cover class estimated for of Kellem Wollega Zone, standard error and confidence interval was calculated to see the uncertainty behind estimation of each land use land cover information. Accordingly, based on their proportion of area share *Table 5* and *Table 12*  the confidence interval (CI) or margin of error  (MOE) of  those land cover classes are +/- 20451 ha  for forest

land, +/- 19066.3 ha for cropland, +/- 13513.7ha for Grassland, +/- 8869.7 ha for shrub land, +/- 7535 ha for settlement, +/- 6094 ha for wetland and +/- 1564 ha for other land classes.
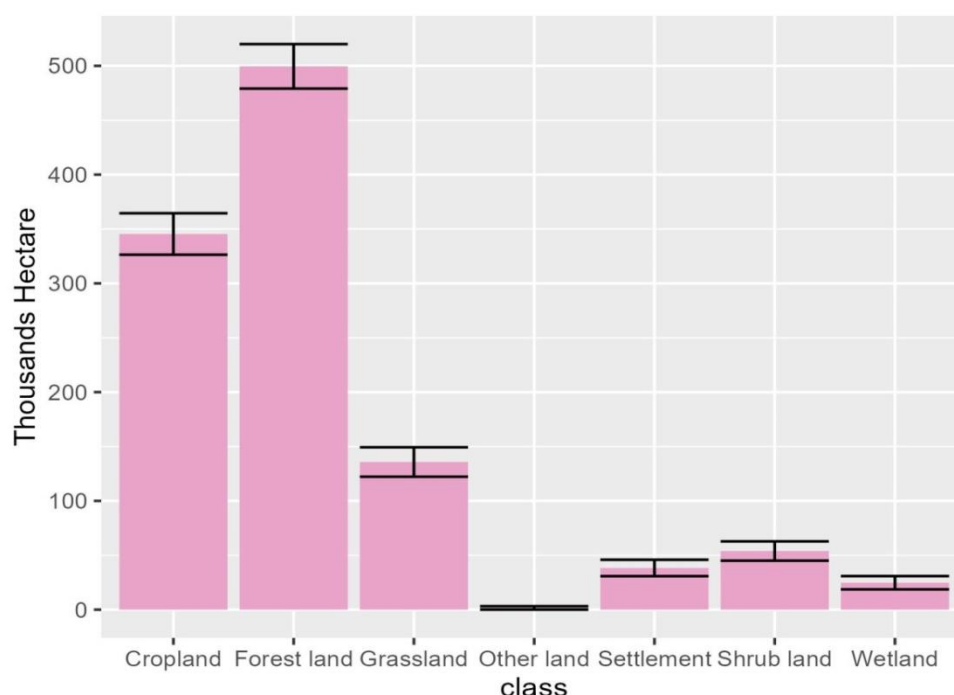


*Figure 20  Kelem Wollega Land Use Land Cover of 2017 with 95% confidence interval (CI)*

### *3.2.2.8    East Shawa Zone*

This summary describes the activity data of East Shawa Zone located in central part of Oromia, based area estimation from 2007-2017. As indicated below the total area of East Shawa zone is 1,077,254 **hectares** and the total sample point collected from this area is 2698**.** From the total area of Zone cropland accounts 610,098 ha (57%), followed by Grassland accounting 171,690 ha (16%) in 2007. Shrub land and wetland independently cover about 8% and forest land covers about 65,482 ha (6%) of total area.  Similarly, cropland covers about 56% in 2017, followed by Grassland accounting 165,701 ha (15%) , shrub land and wetland each accounting 9%,  forest land  contributing 16,888 ha (6%) of the total area. Settlement shared 3% and 5% in 2007 and 2017 respectively. The contribution of other land is minimal and less than 0.5% in both monitoring periods *Table 5* (8) and Table 13.

*Table 13  East Shawa Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 610098 | 57 | 606504 | 56 | 17169 | 13575 | 3594 | 0.06 | 360 |
| Forest land | 65482 | 6 | 61888 | 6 | 5191 | 1597 | -3594 | -0.56 | -369 |
| Grassland | 171690 | 16 | 165701 | 15 | 10381 | 4392 | -5989 | -0.36 | -609 |
| Other land | 2795 | 0 | 3594 | 0 | 0.00 | 799 | 799 | 2.51 | 71 |
| Settlement | 33939 | 3 | 48712 | 5 | 399 | 15173 | 14773 | 3.61 | 1249 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shrub land | 97424 | 9 | 92233 | 9 | 5590 | 399 | -5191 | -0.55 | -532 |
| Wetland | 95827 | 9 | 98622 | 9 | 0.00 | 2795 | -2795 | -0.29 | 276 |
| Total | 1077254 | 100 | 1077254 | 100 | | | | | |

Referring to transition of one LULC class in to other classes cropland has gross reduction of about 17169 ha (3594 ha net reduction), followed by Grassland, shrub land and forest lands where each showed gross reduction with 10381 ha (5989 ha net change), 5590 ha (5191 ha net change) and 5191 ha (3594 ha net change) during the monitoring periods. However, there is net increment with settlement with 14773 ha, followed by wetland with 2795 ha and other land with about 799 ha. Standardized annual change in percent is higher for settlement, followed by other land contributing 1249 ha and 71 hectares of land annual increment per year. On the other hand, forest, shrub land and grassland are decreasing with 369 ha (0.56%), 532 ha (0.55%), 609 ha (0.36%) annual change per year in hectares.
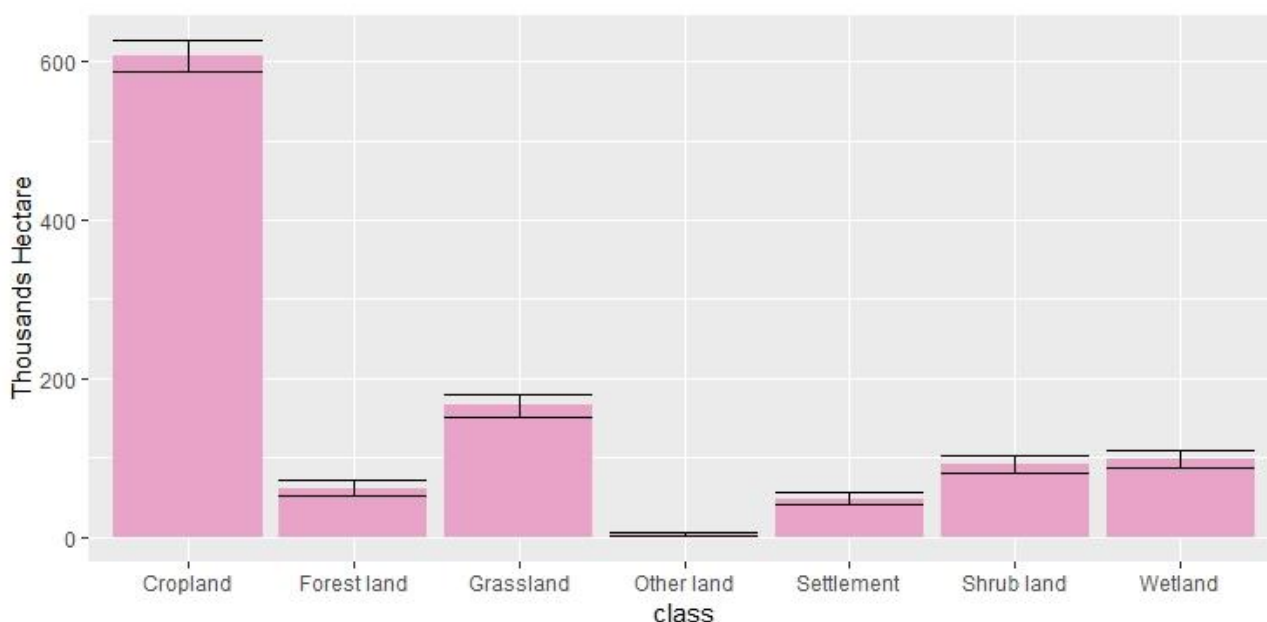


*Figure 21* **East Shawa Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)**

Pertinent to East Shawa zone uncertainity analysis, bias corrected confidence Interval or error of Margine showed classes are +/- 20,166.36 ha for forest land, +/- 14667.93 ha for grassland, +/- 11724.97433 ha for wetland, +/- 11375.81 ha for shrub land, +/- 9460.8 ha for forest land, +/- 8447.8 ha for settlement, +/- 2344 ha for other land classes compared to total area of each class. High marginal error attributed to other land is due to small number of sample points respected to the class.

### 3.2.2.9     South West Shawa Zone

South West shawa Zone is located in central part of oromia region of Ethiopia covering 569,590 ha total area. The land use land cover (LULC) of this zone in 2007 is mainly covered by cropland sharing 434,317.4 ha (76.3%). Forest land is the next largest LULC class holding 51,379.5 ha (9%), followed by Grassland accounting 27697 ha (4.9%), Shrub land accounts 27295.4 ha (4.8%), settlement covers 22077.1 ha (3.9%)

. Wetland and Other land each covers less than 1% of the total area. For year 2017 land use land cover (LULC) cropland covered the largest share accounting 436725.9 ha (76.7%) with 95% confidence of +/- 12616 ha. Forest land is the next largest LULC class holding 48168.3 ha (8.4%) with 95% confidence of +/- 8493 ha, followed by Grassland accounting 28098.2 ha (4.9%) with +/- 6376.6 ha CI, Shrub land accounts 26894.0 ha (4.7%) with +/- 6332.5 ha CI, settlement covers 22879.9 ha (%) with +/- 5722 ha CI. Wetland and Other land each covers less than 1% of the total area . Mainly the CI for wetland and other land is high due to the number of sample point covered for those classes is low, 13 sample points and 4 sample points respectively.

*Table 14 South West Shawa Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 434317 | 76.3 | 436726 | 76.7 | 2408.4 | 4817 | 2408.4 | 0.06 | 241 |
| Forest land | 51379.5 | 9.0 | 48168.3 | 8.5 | 3211.2 | 0.0 | -3211.2 | -0.65 | -312 |
| Grassland | 27696.8 | 4.9 | 28098.2 | 4.9 | 1605.6 | 2007 | 401.4 | 0.14 | 40 |
| Other land | 1605.6 | 0.3 | 1605.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 0 |
| Settlement | 22077.1 | 3.9 | 22879.9 | 4.0 | 0.0 | 802.8 | 802.8 | 0.36 | 82 |
| Shrub land | 27295.4 | 4.8 | 26894.0 | 4.7 | 802.8 | 401.4 | -401.4 | -0.15 | -40 |
| Wetland | 5218.2 | 0.9 | 5218.2 | 0.9 | 0.0 | 0.0 | 0.0 | 0.00 | 0 |
| Total | 569590 | 100 | 569590 | 100 | | | | | |
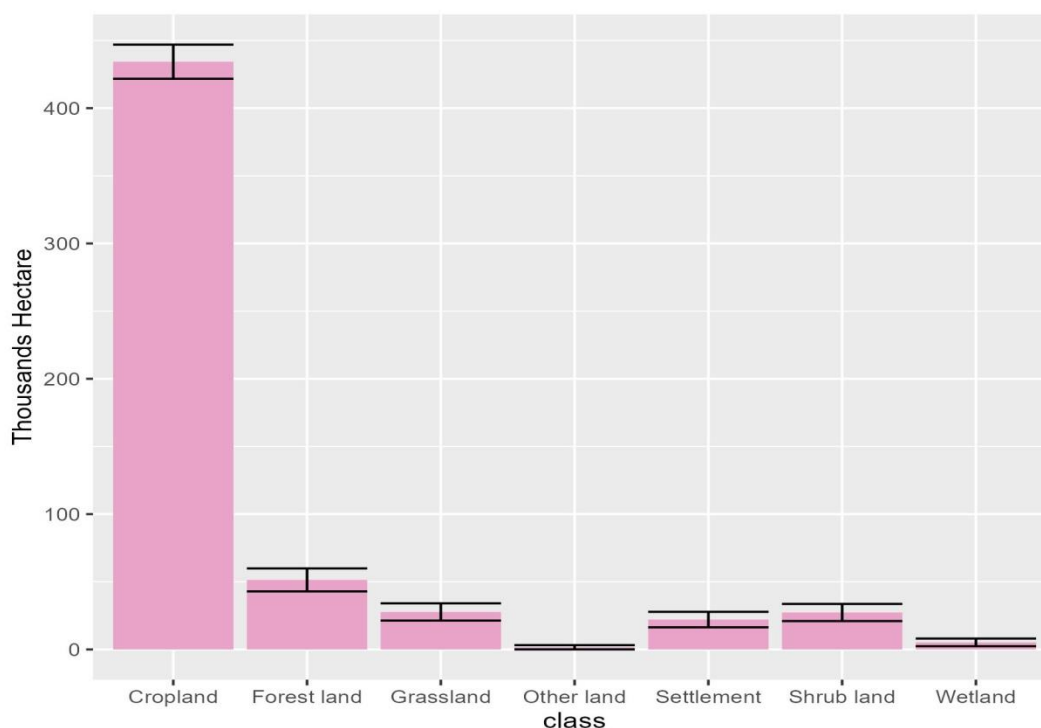


Figure 22 Soth West Shawa Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Referring to transition of LULC class in to other classes cropland has gross increment of about 4817 ha (2408.4 ha net increment) with 241 ha (0.06%) annual change per year in hectares, followed by Grassland showing net increment of 401.4 ha (40 ha (0.14%)) annual change per year and 802.8 ha for settlement classes with 82 ha (0.36%) increment per year. On the other hand Forest land showed gross and net reduction of 3211.2 ha, with 312 ha annual change (0.65%) per year, followed by shrub land which has shown net reduction of 401 ha with standardized 40 ha (0.15%) loss per year Table 14 and Figure 22.

### 3.2.2.10    Ilu Ababora Zone

Ilu Ababora Zone is located in Western part of oromia region of Ethiopia covering 1,152,860 ha total area. In 2007 the land use land cover (LULC) of this zone is mainly covered by Forest land sharing 742269 ha (64%) of total land mass, followed by cropland accounting 257,571 (22%). Grassland and Shrub land each accounts 5% of the total land mass independently covering 59285 ha and 54478 ha respectively. Consistently with 2017, Forest land accounts 737862 ha (64%) of the total land mass with 95% confidence Interval off +/- 20220.72 ha, followed by cropland accounting 261,977 (23%) with +/- confidence interval of 17653.39 ha, Grassland covering 56882 (5%) with +/- 17653.39 ha CI and Shrub land covering 50072 ha (4%) with 8586.7 ha confidence interval.  Settlement accounts 1% in 2007 and 2% of the total area in 2017 with +/- 5869.6 CI, while other land coverage is not detected in this Zone in both monitoring periods (Table 15).

*Table 15 Ilu Ababora Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 257571 | 22 | 261977 | 23 | 12017 | 16424 | 4406 | 0.2 | 437.3 |
| Forest land | 742269 | 64 | 737862 | 64 | 10816 | 6409 | -4406 | -0.1 | -441.8 |
| Grassland | 59285 | 5 | 56882 | 5 | 3205 | 801 | -2403 | -0.4 | -244.9 |
| Other land | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Settlement | 16424 | 1 | 22833 | 2 | 801 | 7210 | 6409 | 3.3 | 550.1 |
| Shrub land | 54478 | 5 | 50072 | 4 | 4406 | 0 | -4406 | -0.8 | -457.6 |
| Wetland | 22833 | 2 | 23233 | 2 | 0.0 | 401 | 401 | 0.2 | 39.7 |
| Total | 1152860 | 100 | 1152860 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland, settlement and wetland showed increment, where cropland has gross increment of about 4406 ha (4406 ha net increment) with 437 ha (0.2%) annual change per year in hectares. This was mainly gained from Grassland, shrub land and forest classes. Settlement class has net gained of 6409 ha mainly from cropland and forest classes with annual change of 550 ha (3.3%) per year.  On the other hand Forest land, Grassland and shrub land showed reduction in extent, where forest land showed 10816 gross reduction (4406 ha net change) with 442 ha (0.1%) annual change per year, shrub land showed 4406 ha gross and net change with 457 ha (0.8%) annual change and Grassland showed 3205 ha gross reduction (2403 ha net change) with 245 ha (0.4%) annual change rate per year (*Table 5* (10) and Table 15).

Figure 23 **Ilu Ababora Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)**

### 3.2.2.11 Guji Zone

Guji Zone is located in South Eastern part of oromia region of Ethiopia covering 3,208,528 ha total area nand the number of sample points within this Zone are 8029. In 2007 the land use land cover (LULC) of this zone is mainly covered by shrub land sharing 1,276,777 ha (40%) of total land mass, followed by accounting 874363 (27%). Grassland and Cropland respectively account 874363 (19%) and 400816 ha (12.5%). With similar trend in 2017, shrub land accounts 1266787 ha (40%) of the total land mass with 95% confidence Interval off +/- 34308.35 ha, followed by forest land accounting 599826 (25.5%) with +/- confidence interval of 45306.39 ha, Grassland covering 599826 (19%) with +/- 41067.34895 ha CI and crop land covering 463956 ha (14.5%) with 13422.6 ha confidence interval. Settlement accounts 0.6% in 2007 and 0.8% of the total area in 2017 with +/- 6094.5 CI, while other land coverage is not minimal around 799 ha which is less than 0.5% with high confidence interval (1107.6) during year 2017 (Table 16).

*Table 16 Guji Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 400816 | 12.5 | 463956 | 14.5 | 3197 | 66336 | 63140 | 1.5 | 5906.5 |
| Forest land | 874363 | 27.3 | 819216 | 25.5 | 56746 | 1598 | -55147 | -0.7 | -5677.8 |
| Grassland | 601824 | 18.8 | 599826 | 18.7 | 10790 | 8792 | -1998 | -0.0 | -200.1 |
| Other land | 799 | 0.0 | 799 | 0.0 | 0 | 0 | 0 | 0.0 | 0.0 |
| Settlement | 19581 | 0.6 | 24377 | 0.8 | 0 | 4795 | 4795 | 2.2 | 433.7 |
| Shrub land | 1276777 | 39.8 | 1266787 | 39.5 | 12788 | 2797 | -9990 | -0.1 | -1002.6 |
| Wetland | 34367 | 1.1 | 33568 | 1.0 | 799 | 0 | -799 | -0.2 | -80.8 |
| Total | 3208527.5 | 100 | 3208527.5 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland and settlement showed increment, where cropland has gross increment of about 66336 ha (63140 ha net increment) with 5907 ha (1.5%) annual change per year in hectares. This is mainly attributed to conversation of forest land, shrub land and grassland classes to cropland with 47,554 ha, 9990 ha, and 8792 ha respectively during the monitoring period. The other land cover class increasing with 2.2% annual change rate is settlement having 434 ha annual change per year, mainly from forest (1598 ha), grassland (1199 ha) and cropland (799 ha) classes. On the other hand Forest land, shrub land, Grassland and wetland showed reduction in extent, where gross forest land reduction is 56746 ha (55147 ha net change) with 5677.8 ha (0.7%) annual change per year, wetland showed 799 ha net reduction with 81% ha (0.2% annual change Table 15).
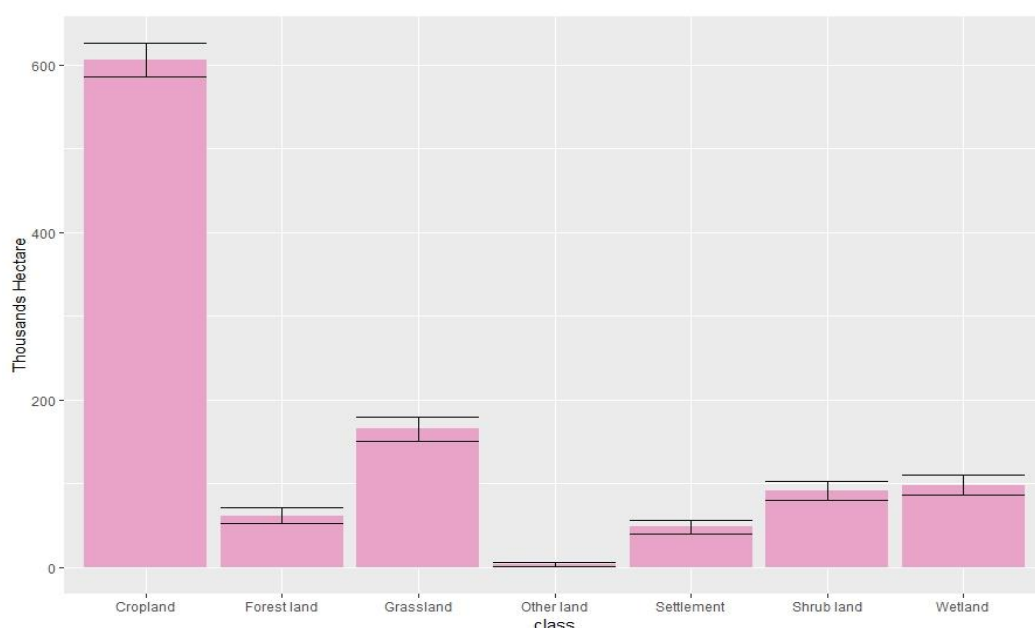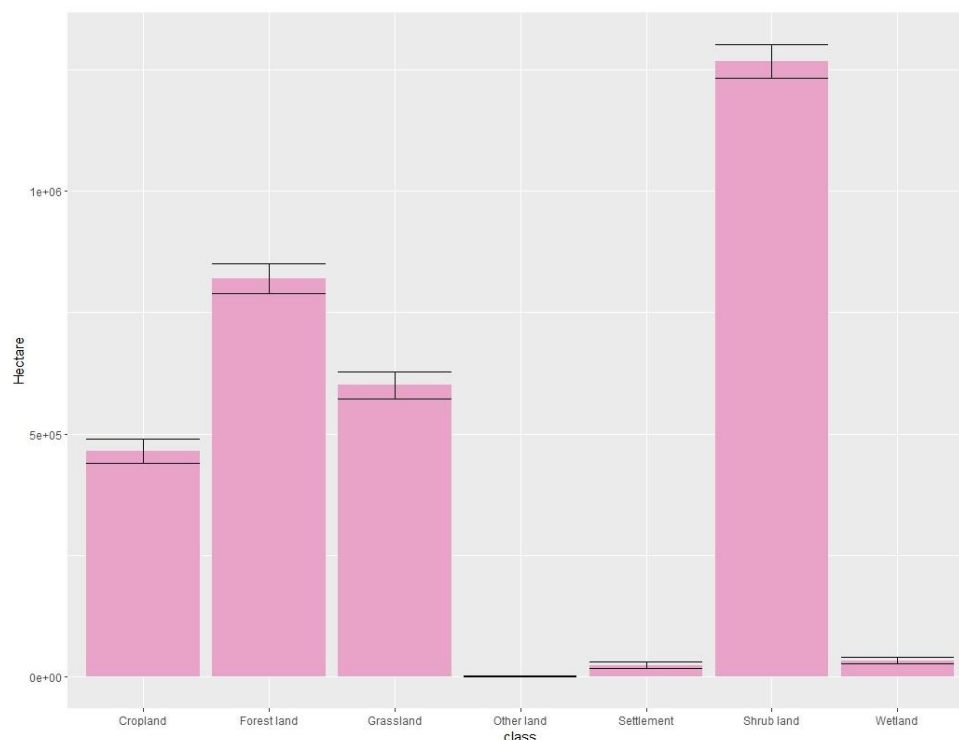


Figure 24 **Guji Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)**

### 3.2.2.12    *West Guji*

West Guji Zone is located in South Eastern part of oromia region of Ethiopia covering 1,027,151.64 ha total area and the number of sample points within this Zone are 2571. In 2007 the land use land cover (LULC) of this zone is mainly covered by cropland land sharing 307227 ha (30%) of total land mass, followed by forest accounting 256488 (25%). Grassland and Shrub land   respectively accounts 23% and 13% of the total land area 5 respectively.   Consistently with 2017, but with some area extent variation cropland forest land grassland and shrub land accounts the largest share 32.4 % for cropland (with 95% confidence Interval off +/- 18579.4 ha), 24% for forest land (with 95% confidence Interval off +/- 16912.7ha), 22% for grassland (with 95% confidence Interval off +/- 16433.69 ha) and followed by shrub land accounting 11.2 with +/- confidence interval of 12524.8 ha. Wetland accounts about 9% of the total area, while Settlement and other

land accounts accounts the smallest extent compared to other land covers, less than 2%  for settlement and around 0.5%  (799 ha) for other land classes during both years (Table 17).

*Table 17 West Guji Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Gross Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 307227 | 29.9 | 332396 | 32.4 | 2797 | 27966 | 25169 | 0.79 | 2428.7 |
| Forest land | 256488 | 25 | 244503 | 23.8 | 12784 | 799 | -11985 | -0.48 | -1224.5 |
| Grassland | 236513 | 23 | 225326 | 21.9 | 15182 | 3995 | -11186 | -0.48 | -1143.2 |
| Other land | 799 | 0.08 | 799 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0.0 |
| Settlement | 13583 | 1.32 | 17978 | 1.8 | 0.0 | 4395 | 4395 | 2.8 | 386.1 |
| Shrub land | 121452 | 11.8 | 115060 | 11.2 | 9189 | 2797 | -6392 | -0.54 | -654.9 |
| Wetland | 91089 | 8.87 | 91089 | 8.9 | 400 | 400 | 0.0 | 0 | 0.0 |
| Total | 1099339 | 100 | 1099339 | 100 | | | | | |
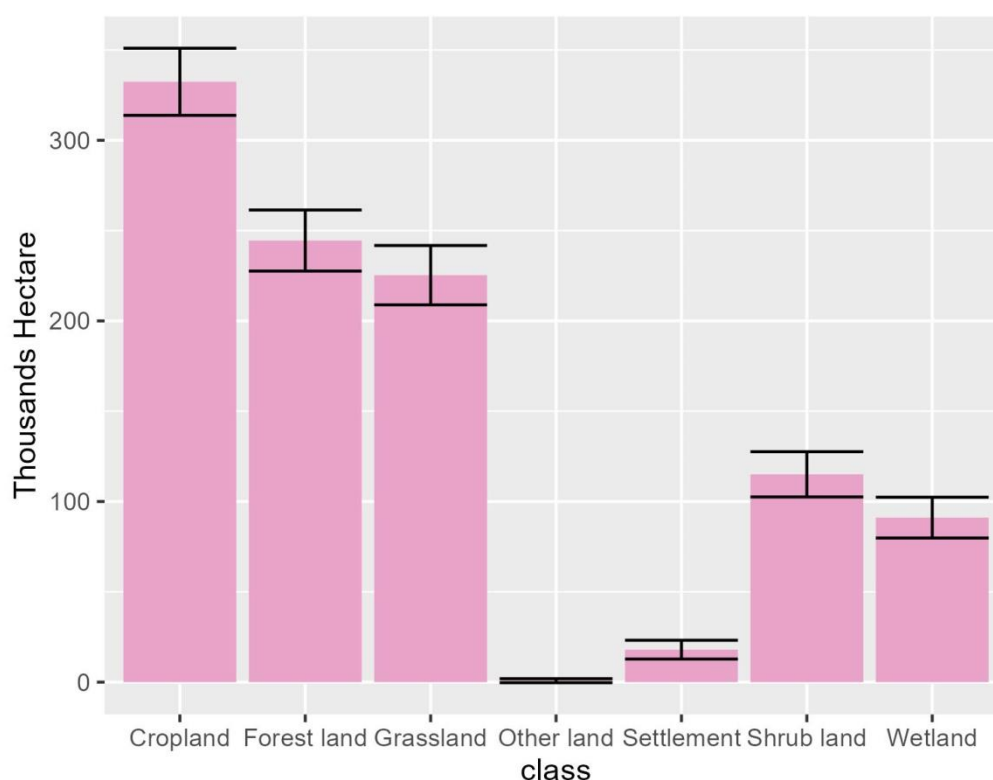


Figure 25  West Guji Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Referring to transition of LULC class, annual change in percent and per year cropland and settlement showed increment, where cropland has gross increment of about 27966 ha (25169 ha net increment) with 2429 ha (0.8%) annual change per year in hectares. This was mainly gained from

forest (9189 ha), Grassland (11186 ha) and shrub land (7191 ha) classes. Settlement class has net gained of 4395 ha mainly from cropland (1998 ha), Grassland (1199 ha) and shrub land (1199 ha) classes with annual change of 386 ha (2.8%) per year.  On the other hand Forest land, Grassland and shrub land showed reduction in extent, where forest land showed 12784 ha gross reduction (11985 ha net change) with 1225 ha (0.48%) annual change per year, Grassland showed 15182 ha gross (11186 ha net) change with 1143 ha (0.48%) annual change and shrub land showed 9189 ha gross reduction (6392 ha net change) with 655 ha (0.54%) annual change rate per year (*Table 5* (12)

### 3.2.2.13    Borena

Borena Zone is located in South Eastern part of oromia region of Ethiopia covering 5,572,568.68 ha total area and the number of sample points within this Zone are 13919. In 2007 the land use land cover (LULC) of this zone is mainly covered by Forest land sharing 2226385 ha (40%) of total land mass, followed by shrub land accounting 1,626,650 (29.2%), Grassland accounting 1513750 ha (27%) of the total area. The extent of cropland and wetland is relatively small which is 92883 ha (1.7%) and 69662 (1.3%) respectively. Other land class covers about 0.6% of the total area.  Similarly, Forest land accounts 2214775 ha (40%) of the total land mass with 95% confidence Interval off +/- 45306.3 ha, followed by shrub land accounting 1616241 (29%) with +/- confidence interval of 42011.3 ha, Grassland covering 1,500,538 (40%) with +/- 41067.3 ha CI and cropland covering 119707ha (2.1%) with 13422.68 ha confidence interval in 2017.   Settlement accounts still accounts 1.3% of the total area in 2017 with +/- 4570 CI, while the extent of other land class minimal less than 0.5% (Table 18).

*Table 18 Borena Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 92883 | 1.7 | 119707 | 2.1 | 2802.5 | 29626 | 26824 | 2.54 | 2387 |
| Forest land | 2226385 | 40.0 | 2214775 | 39.7 | 28825.7 | 17215 | -11610 | -0.05 | -1164 |
| Grassland | 1513750 | 27.2 | 1500538 | 26.9 | 28825.7 | 15614 | -13212 | -0.09 | -1326 |
| Other land | 35231 | 0.6 | 36833 | 0.0 | 1201.1 | 2802 | -1601 | -0.44 | -157 |
| Settlement | 8007 | 0.1 | 13612 | 0.2 | 400.4 | 6005 | 5605 | 5.31 | 436 |
| Shrub land | 1626650 | 29.2 | 1616241 | 29.0 | 32428.9 | 22020 | -10409 | -0.06 | -1044 |
| Wetland | 69662 | 1.3 | 70863 | 1.3 | 0.0 | 1201 | 1201 | 0.17 | 119 |
| Total | 5,572,568 | 100 | 5,572,568 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland, settlement and wetland showed increment, where cropland has gross increment of about 29626 ha (26824 ha net increment) with 2387 ha (2.54%) annual change per year in hectares, showing transition of the local community to sedentary life. This was mainly gained from Grassland, forest and shrub land classes each contributing 11,210 ha, 9,609 ha and 8,808 ha respectively. Settlement class has net gained of 5605 ha mainly from forest, grassland and shrub land classes with annual change of 436 ha (5.3%) per year.  On the other hand

Forest land, Grassland and shrub land showed reduction in extent, where forest land showed 28825.7 ha gross reduction n (11610 ha net change) with 1164 ha (0.05%) annual change per year, Grassland showed 28825.7ha gross (13212 ha net) change with 1326 ha (0.09%) annual change and shrub land showed 32428.9 ha gross reduction (10409 ha net change) with 1044 ha (0.06%) annual change rate per year (*Table 5* (13) and Table 18).



Figure 26 Borena Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

### *3.2.2.14    Bale Zone*

Bale Zone is located in Eastern part of oromia region of Ethiopia covering 2,993,064 ha total area and the number of sample points within this Zone are 7477. In 2007 the land use land cover (LULC) of this zone is mainly covered by Forest land sharing 980,342 ha (33%) of total land mass, followed by shrub land accounting 890,273 (30%), cropland covering 521995 ha (17.4%), Grassland accounting 515590 ha (17.2%) of the total area. The extent of other land is about 1.2%, while settlement and wetland shares the smalles with less than 1% each. Other land class covers about 1.2% of the total area.  In 2017 forest land kept it largest share with 963129 ha (32.1%) of the total land mass with 95% confidence Interval off +/- 31696 ha, followed by shrub land  accounting 874662 (29%) with +/- confidence interval of 30856.4 ha, Cropland covers 556421 ha (18.6%) with +/- 26394.8 ha CI, Grassland covering 511987 ha (17.1%) with +/- 25548.8 ha.  Settlement and wetland shares 0.7% and o.9% respectively, relatively with high confidence interval, +/- 5745 ha error margin for settlement and +/- 6534 error margin for wetland due to low number of sample points involved during area estimation, which is similar for other land class (*Table 5* (14) and Table 19) and Figure 27.

*Table 19 Bale Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 521995 | 17.4 | 556421 | 18.6 | 2401.8 | 36828 | 34426 | 0.64 | 3344.51 |
| Forest land | 980342 | 32.7 | 963129 | 32.2 | 20815.7 | 3602.7 | -17213 | -0.18 | -1735.06 |
| Grassland | 515590 | 17.2 | 511987 | 17.1 | 8406.4 | 4803.6 | -3602.7 | -0.07 | -361.41 |
| Other land | 37228 | 1.24 | 37228 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| Settlement | 19615 | 0.66 | 21616 | 0.7 | 400.3 | 2401.8 | 2001.5 | 0.97 | 191.51 |
| Shrub land | 890273 | 29.7 | 874662 | 29.2 | 16812.7 | 1200.9 | -15612 | -0.18 | -1573.64 |
| Wetland | 28021 | 0.94 | 28021 | 0.9 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| Total | 2993064 | 100 | 2993064 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland and settlement classes showed increment, where cropland has gross increment of about 36828 ha (34426 ha net increment) with 3344 ha (0.64%) annual change per year in hectares. This was mainly gained from forest shrub and Grassland, land classes each contributing 18,414 ha, 12,009ha and 6,405 ha respectively. Settlement class has net gained of 2001.5 ha mainly from forest, grassland, shrub and cropland land classes with annual change of 191 ha (1%) per year. On the other hand Forest land, Grassland and shrub land showed reduction in extent, where forest land showed 20815.7 ha gross reduction (17213 ha net change) with 1735 ha (0.18%) annual change per year, Grassland showed 8406.4 gross (3602.7 ha net) change with 361 ha (0.07%) annual change and shrub land showed 16812.7 ha gross reduction (15622 ha net change) with 1573 ha (0.08%) annual change rate per year. Wetland and other land have no significant changes between the two monitoring periods (Table 19).
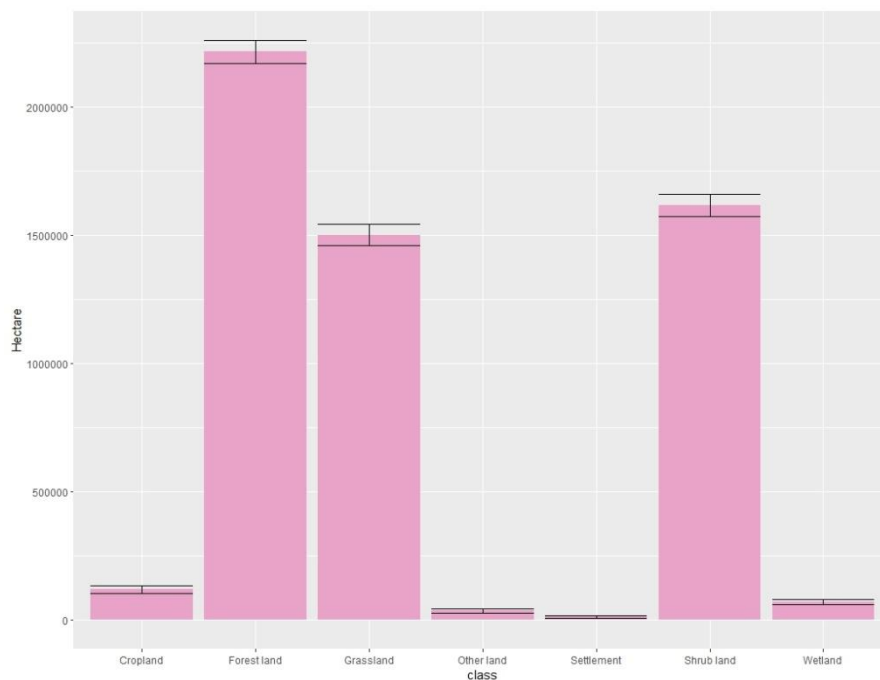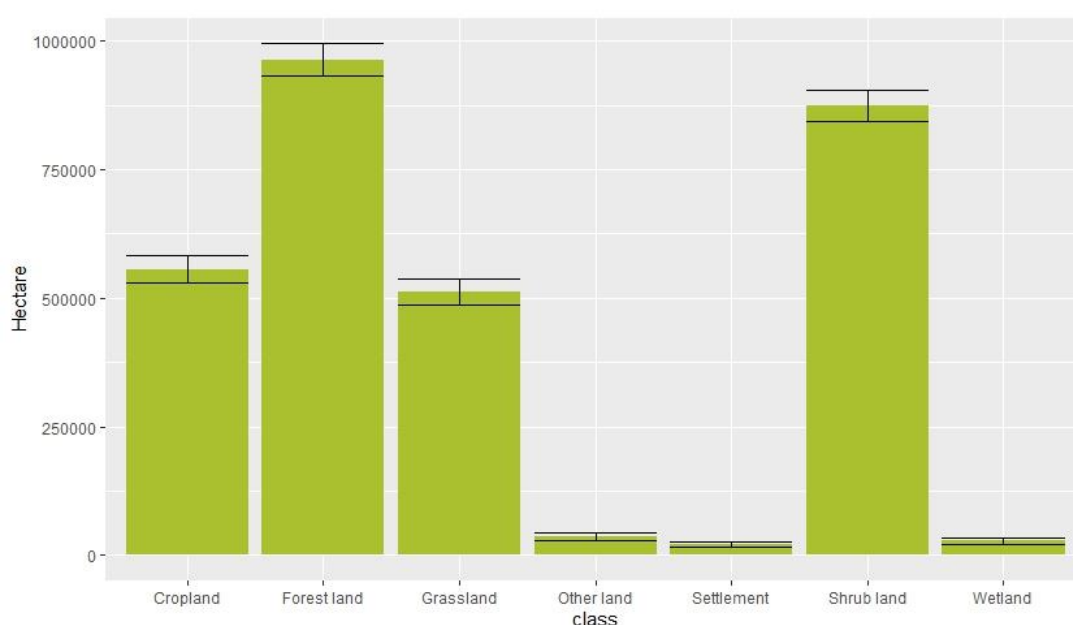
Figure 27 Bale Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

### 3.2.2.15 *East Bale Zone*

East Bale Zone is located in Eastern part of oromia region of Ethiopia covering 3,702,849.9 ha total area and the number of sample points within this Zone are 9264. In 2007 the land use land cover (LULC) of this zone is mainly covered by Forest land sharing 1632787 ha (44%) of total land mass, followed by shrub land accounting 910,124 (25%), Grassland accounting 856964 ha (23%) of the total area. The extent of cropland is 269,400 (7.3%), while the area share of settlement, other land and wetland classes is relatively small each contributing less than 0.5% of the total area (Table 20) . Following similar trend, Forest land accounts 1612402 ha (43.5%) of the total land mass with 95% confidence Interval off +/- 37440 ha, followed by shrub land accounting 900931 (24.3%) with +/- confidence interval of 32467.1 ha, Grassland covering 859362 (23.2%) with +/- 31803.1 ha CI and cropland covering 294981 ha (8%) with +/- 19585.9 ha confidence interval in 2017. Settlement, wetland and other land still accounts small contribution to the total land cover, with high margin of error (+/- 4626 ha for settlement, 5243 ha for wetland and 1566 ha for other land) due to less number of sample points involved during area estimation (Table 20 and Figure 28).

*Table 20 East Bale Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 269400 | 7.28 | 294981 | 7.97 | 2797.92 | 28379 | 25581 | 0.91 | 2454.94 |
| Forest land | 1632787 | 44.10 | 1612402 | 43.5 | 22783.1 | 2398 | -20385 | -0.13 | -2050.03 |
| Grassland | 856964 | 23.14 | 859362 | 23.2 | 4396.73 | 6795 | 2398.2 | 0.03 | 239.52 |
| Other land | 1599 | 0.04 | 1599 | 0.00 | 0.00 | 0 | 0.00 | 0 | 0 |
| Settlement | 13990 | 0.38 | 15588 | 0.42 | 0.00 | 1599 | 1598.8 | 1.08 | 152.21 |
| Shrub land | 910124 | 24.58 | 900931 | 24.3 | 11991.1 | 2798 | -9193.2 | -0.1 | -923.52 |
| Wetland | 17987 | 0.49 | 17987 | 0.49 | 0.00 | 0 | 0.00 | 0 | 0 |
| Total | 3702849.9 | 100 | 3702849.9 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland, settlement and wetland showed increment, where cropland has gross increment of about 28379 ha (25581 ha net increment) with 2455 ha (0.91%) annual change per year in hectares. This was mainly gained from forest land, shrub land and grassland classes each contributing 15,189 ha, 10,792 ha and 2,398 ha respectively. Settlement class has net gained of 1598.8 ha mainly from Grassland (799 ha), forest (400 ha) and cropland (400 ha) land classes with annual change of 152 ha (1.1%) per year. On the other hand Forest land, shrub land and Grassland classes showed reduction in extent, where forest land showed 22783.1 ha gross reduction (20385 ha net change) with 2050 ha (0.13%) annual change per year, shrub land showed 11991.1 ha gross (9193.2 ha net) change with 923 ha (0.1%) annual change and Grassland showed 4396.73 ha gross reduction (2398.2 ha net change) with 239 ha (0.03%) annual change rate per year (*Table 5* (15) and Table 20).

Figure 28 East Bale Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

### 3.2.2.16 West Arsi Zone

West Arsi Zone is located in eastern part of main rift Valley in oromia region of Ethiopia covering 1,279,466 ha total area and the number of sample points used within this Zone are 3193. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 615891 ha (48.14%) of total land mass, followed by Grassland accounting 217986 (17%), Forest land accounting 183926 ha (14%) of the total area. Other classes include Settlement with 103784 with 8%, wetland covers 95369 (7.45%) and other land class cover 11621 (1%) of the total area. Following similar trend, cropland sharing 625909 ha (48.9%) of total land mass with 95% confidence Interval off +/- 22188 ha, followed by Grassland accounting 211575 ha (16.5%) with +/- 16490 ha CI, Forest land accounting 164291 ha (12.8%) of the total area with 95% confidence Interval off +/- 14849.2 ha, shrub land 50089 ha (4%) with +/- 8608.6 ha 95% CI and wetland contributing 94968 ha (7.4%) with +/- 11635 ha 95% CI. However, the contribution of other land is less compared to base year monitoring period (Table 21 and Figure 29).

Table 21 West Arsi Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 615891 | 48.14 | 625909 | 48.9 | 14425.6 | 24443 | 10018 | 0.16 | 994.5 |
| Forest land | 183926 | 14.38 | 164291 | 12.8 | 20035.5 | 401 | -19635 | -1.13 | -2064.7 |
| Grassland | 217986 | 17.04 | 211575 | 16.5 | 14425.6 | 8014 | -6411.4 | -0.3 | -649.8 |
| Other land | 11621 | 0.91 | 11621 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Settlement | 103784 | 8.11 | 121014 | 9.46 | 1602.8 | 18833 | 17231 | 1.54 | 1606.4 |

| Shrub land | 50890 | 3.98 | 50089 | 3.91 | 801.4 | 0 | -801.4 | -0.16 | -80.7 |
|------------|-------|------|-------|------|-------|-----|--------|-------|-------|
| Wetland | 95369 | 7.45 | 94968 | 7.42 | 1202.1 | 801 | -400.7 | -0.04 | -40.2 |
| Total | 1,279,466 | 100 | 1,279,466 | 100 | | | | | |

Referring to transition of LULC class, annual change in percent and per year cropland and settlement showed increment, where cropland has gross increment of about 24443 ha (10018 ha net increment) with 994 ha (0.16%) annual change per year in hectares. This was mainly gained from forest land, Grassland and shrub land classes each contributing 12,021ha, 9,617 ha and 801 ha respectively. Settlement class has net gained of 17231 ha mainly from cropland 13,223 ha, Grassland (4,809 ha) and forest (800 ha) with annual change of 1606 ha (1.54%) per year. On the other hand Forest land and grassland showed significant reduction in extent, where forest land showed 20035.5 ha gross reduction (19635 ha net change) with 2064 ha (1.13%) annual change per year, grassland showed 14425.6 ha gross (6411.4 ha net) change with 649 ha (0.3%) annual change. While there is minimal annual change rate for shrub land with 0.2% and wetland 0.04% annual change in reduction sign (*Table 5* (16) and Figure 29).
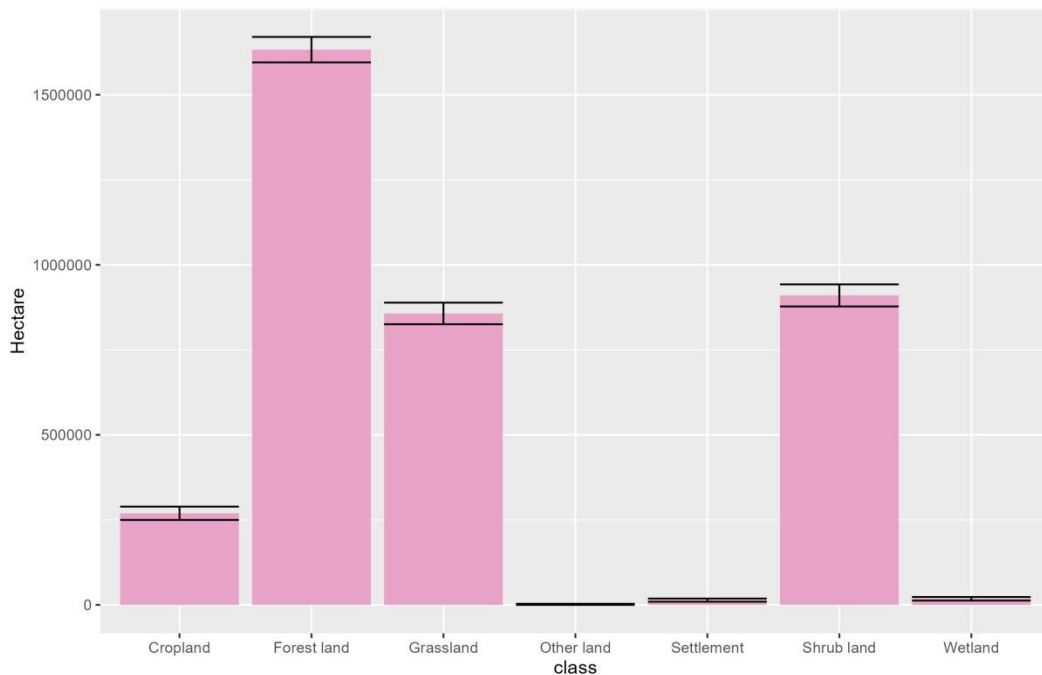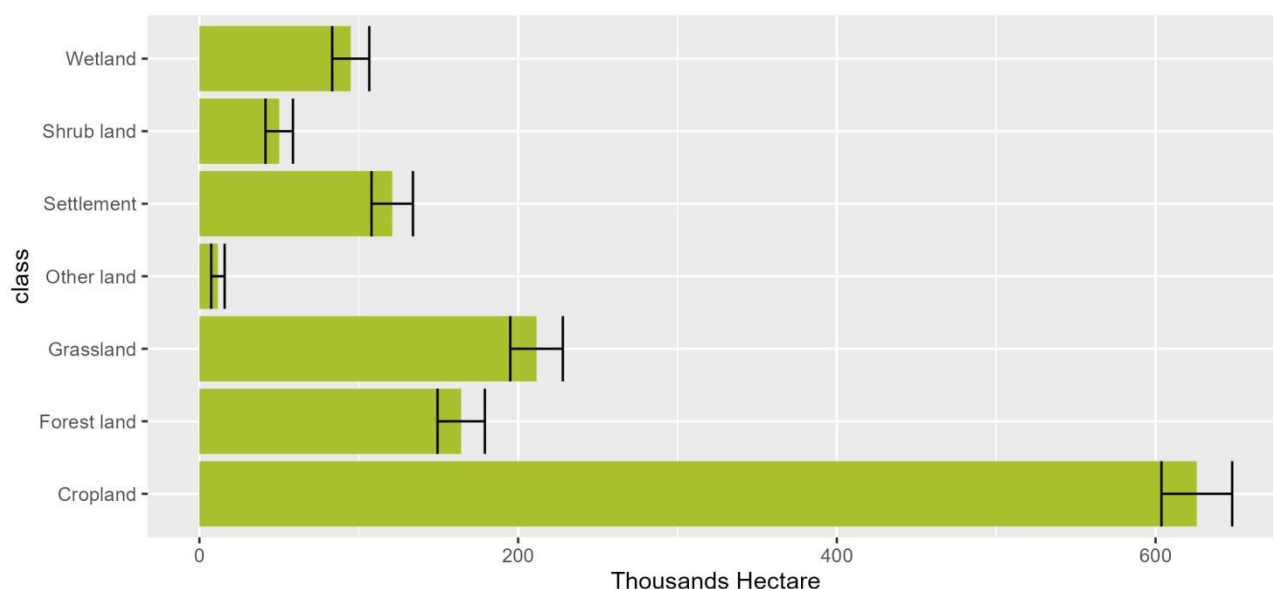


Figure 29 West Arsi Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

### 3.2.2.17    Arsi Zone

West Arsi Zone is located in eastern part of main rift Valley in oromia region of Ethiopia covering 2,064,017 ha total area and the number of sample points used within this Zone are 5158. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 1103637 ha (53.5%) of total land mass, followed by Forest land accounting 318126 (15.4%), Grassland accounting 274509 (13%), shrub land accounting 258502 ha (12.5%) of the total area. Settlement and wetland respectively covers 69227 ha (3.35%) and 38015 (1.84%) of 2007 total land area, while area extent of other land class is insignificant. During 2017,  still cropland shares largest  1124445 ha (54.5%) of total land mass with 95% confidence Interval off +/- 28053.7 ha, followed by Forest land accounting 295,717 ha (14.3%) with +/- 19737 ha CI, Grassland accounting 273708 ha (13.3%) of the total area with 95% confidence Interval off +/- 19105.8 ha,

shrub land covers 251700 ha (12.2%) with +/- 18433.845 ha 95% CI, settlement accounts 77231 ha (about 4%) with +/- 10691.2 ha margin of error and wetland accounts 1.86% with 7613 ha CI. However, the contribution of other land is less compared to base year monitoring period (Figure 30 and Table 22).

*Table 22 Arsi Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 1103637 | 53.5 | 1124445 | 54.5 | 11204.4 | 32013 | 20808 | 0.19 | 2063.38 |
| Forest land | 318126 | 15.4 | 295717 | 14.3 | 26010.3 | 3601 | -22409 | -0.73 | -2315.26 |
| Grassland | 274509 | 13.3 | 273708 | 13.3 | 11604.6 | 10804 | -800.3 | -0.03 | -80.14 |
| Other land | 2001 | 0.10 | 2801 | 0.00 | 0.0 | 800 | 800.3 | 3.36 | 68.47 |
| Settlement | 69227 | 3.35 | 77231 | 3.74 | 2401.0 | 10404 | 8003.2 | 1.09 | 761.5 |
| Shrub land | 258502 | 12.5 | 251700 | 12.2 | 7603.0 | 800 | -6802.7 | -0.27 | -688.46 |
| Wetland | 38015 | 1.84 | 38415 | 1.86 | 0.0 | 400 | 400.2 | 0.1 | 39.83 |
| Total | 2,064,017 | 100 | 2,064,017 | 100 | | | | | |
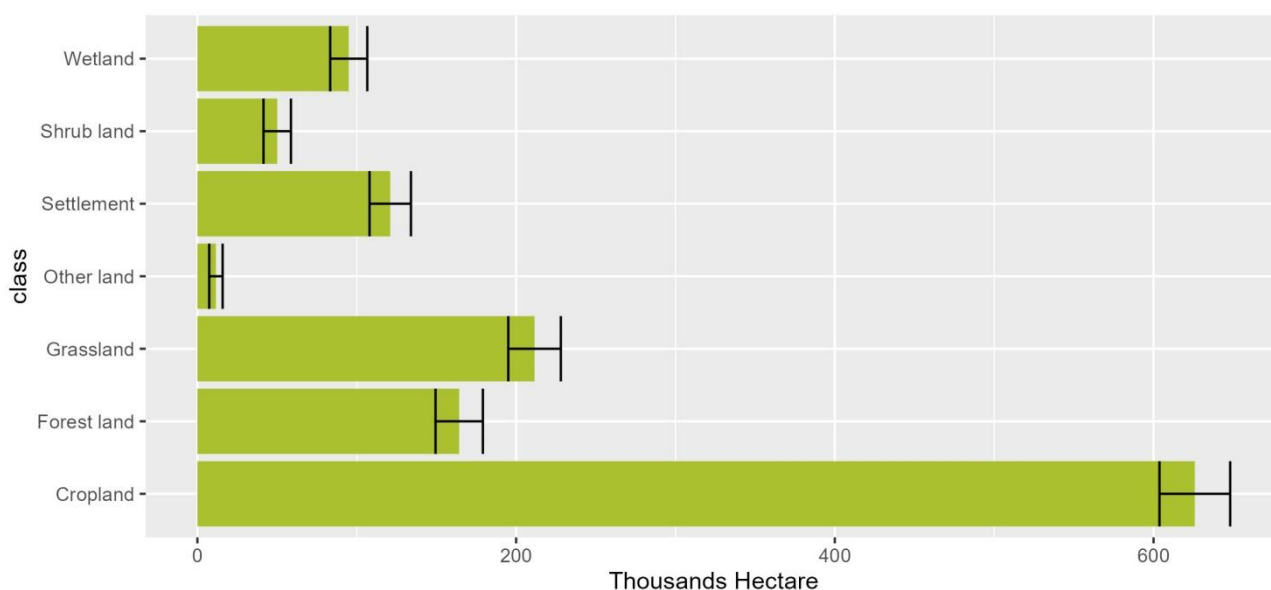


Figure 30 Arsi Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Referring to transition of LULC class, annual change in percent and per year cropland, settlement and other land showed an increment with different extent. Cropland has gross increment of about 32013 ha (20808 ha net increment) with 2063 ha (0.19%) annual change per year in hectares. This was mainly gained from forest land, Grassland and shrub land classes each contributing 16406 ha, 9,204ha and 4402 ha respectively. Settlement class has net gained of 18003.2 ha mainly from cropland 6803 ha, forest 1601 ha, Grassland (1200 ha) and shrub land (800 ha) with annual change of 761 ha (1%) per year. On the other hand Forest land, shrub land and grassland showed significant reduction in extent, where forest land alone showed 26010.3 ha gross reduction (22409 ha net change) with 2315 ha (0.75%) annual change per year, shrub land

showed 7603.0 ha gross (6802.7 ha net) change with 688 ha (0.3%) annual change and Grassland is showed 800 ha net reduction with 80 ha (0.03%) reduction per year compared to base year 2007 monitoring. Other land howed 68 ha annual change with 3.36% per annum, which is higher compared to other Zones in the region  (*Table 5* (17) and Table 22).

### 3.2.2.18    West Wollega

West Wollega Zone is located in eastern part of main rift Valley in oromia region of Ethiopia covering 1,329,181 ha total area and the number of sample points used within this Zone are 3328. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 576325 ha (43%) of total land mass, followed by Forest land accounting 389808 (29.24%), Grassland accounting Grassland (9%), shrub land accounting 93059 ha (7%) and Wetland accounts 92260 ha (7%) of the total area. Settlement covers 54717 ha (4%) and other land cover accounts only about 0.2% of the total land area. During 2017,  still cropland, Forest, Grassland and shrub land shares largest  extent, where cropland  contributes **568337** ha (43%) of total land mass with 95% confidence Interval off +/- 22383.05288 ha, followed by Forest land accounting 388610 ha (29%) with +/- 20562.4 ha CI, Grassland accounting 127406ha (10%) of the total area with 95% confidence Interval off +/- 12973.8 ha, shrub land covers 102245 ha (8%) with +/- 11524.9 ha 95% CI, wetland accounts 92659 ha (about 7%) with +/- 11479 ha margin of error and settlement accounts 4%   with 47927 ha CI. However, the contribution of other land is less compared to base year monitoring period (Figure 30 and Table 22).

*Table 23 West Wollega Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 576325 | 43 | 568337 | 43 | 25561 | 17573 | 7988 | -0.14 | 803.8 |
| Forest land | 389808 | 29 | 388610 | 29 | 15576 | 14378 | -1198 | -0.03 | -119 |
| Grassland | 120617 | 9 | 127406 | 10 | 2396 | 9186 | 6790 | 0.55 | 662.3 |
| Other land | 2396 | 0 | 1997 | 0 | 399 | 0 | --399 | -1.82 | -43.2 |
| Settlement | 54717 | 4 | 47927 | 4 | 7588 | 799 | -6790 | -1.32 | 720.2 |
| Shrub land | 93059 | 7 | 102245 | 8 | 5592 | 14778 | -9186 | 0.94 | -880.2 |
| Wetland | 92260 | 7 | 92659 | 7 | 0 | 399 | -399 | 0.04 | -39.8 |
| Total | 1329181 | 100 | 1329181 | 100 | | | | | |
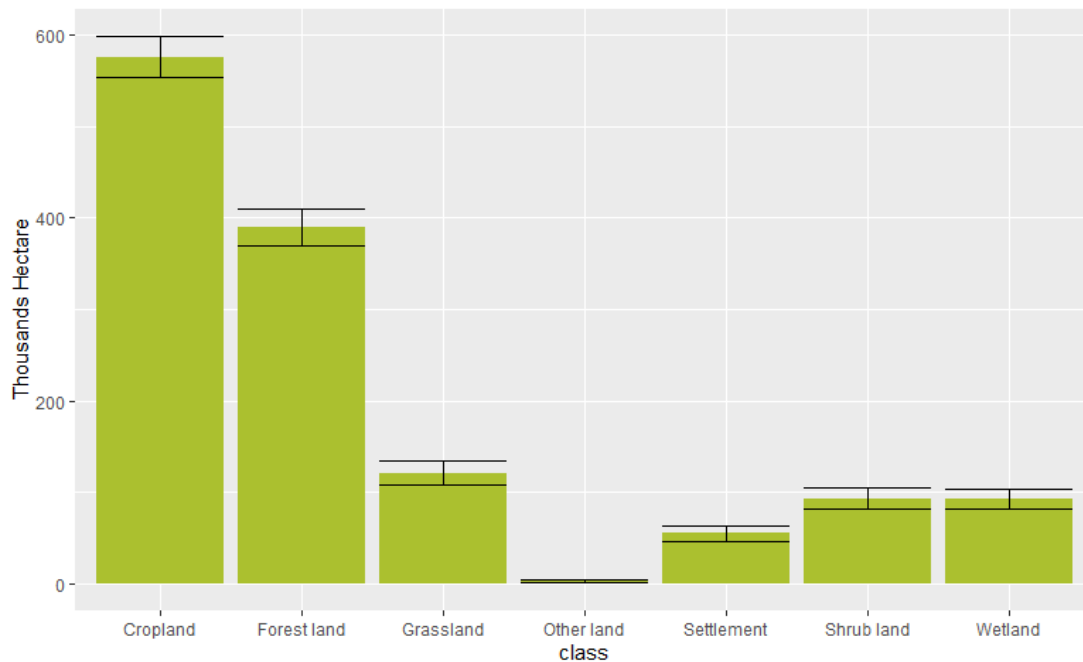
Figure 31 West Wollega Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Transition matrix of LULC classes also revealed that cropland, Forest and settlement showed an increment with different extent. Cropland has gross increment of about 17574.6 ha (7988.3 ha net increment) with 793 ha (0.14%) annual change per year in hectares. This was mainly gained from forest land, shrub land classes. Forest showed land net increment of 1198 ha due to afforestation and reforestation activities with annual increment rate of 119 ha (0.03%) annual gain rate, Settlement classes showed 7589 gross and 6790 ha net gain with 639 ha (1.32%) annual increment rate. Settlement class has net gained of 6790.2 ha mainly from cropland 5991 ha, forest 799 ha and 399 each from Grassland and shrub classes. On the other hand grassland, shrub land and wetland showed significant reduction in extent, where grassland alone was reduced with showed 9186 ha gross reduction (6790 ha net change) with 695 ha (0.55%) annual change per year, shrub land showed 14778.6 ha gross (6790.2 ha net) change with 958 ha (0.94%) annual change and wetland showed 399 ha net reduction with 40 ha (0.04%) reduction per year compared to base year 2007 monitoring (Table 7 (18) and Table 23).

### 3.2.2.19 Buno Bedele

Buno Bedle Zone is among deforestation hotspot Zones located in Western part of oromia region of Ethiopia covering 608,727.3 ha total area and the number of sample points used within this Zone are 1524. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 309,956 ha (51%) of total land mass, followed by Forest land accounting 214492 (35%), wetland accounting 26762 ha (4.4%), Grassland accounting 25563 ha (4.2%), shrub land accounting 19971 ha (3.3%) of the total area. Settlement covers 11983 ha (2%) and area coverage of other land in Buno Bedele Zone is insignificant. During 2017, still cropland and Forest shares the largest area extent with 315148 ha (51.8%) and 206105 ha (33.9%) respectively. The uncertainty or marginal error vale of those land cover classes is +/- 15276 ha for cropland and +/- 14468 ha for forest land compared to the area proportion estimated. Grassland also showed 27560 ha

(4.5%) with 95% CI of +/- 6356.2 ha, wetland has 26762 ha (4.4%) with +/- 6267.7 CI and settlement has 14379 ha with +/- 4642.9 ha CI. On the other hand there is no other land class detected for this Zone during the monitoring period (Table 24 and Figure 32).

*Table 24 Buno Bedele Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 309956 | 50.9 | 315148 | 51.8 | 5592.0 | 10784 | 5192.6 | 0.17 | 515.38 |
| Forest land | 214492 | 35.2 | 206105 | 33.9 | 11184.0 | 2796 | -8388.0 | -0.4 | -853.93 |
| Grassland | 25563 | 4.2 | 27560 | 4.5 | 798.9 | 2796. | 1997.1 | 0.75 | 193.02 |
| Other land | 0.00 | 0.0 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |
| Settlement | 11983 | 2.0 | 14379 | 2.4 | 0.0 | 2397 | 2396.6 | 1.82 | 220.48 |
| Shrub land | 19971 | 3.3 | 18773 | 3.1 | 1997.1 | 799 | -1198.3 | -0.62 | -123.19 |
| Wetland | 26762 | 4.4 | 26762 | 4.4 | 0.0 | 0.0 | 0.0 | 0 | 0.00 |
| Total | 608,727.3 | 100 | 608,727.3 | 100 | | | | | |
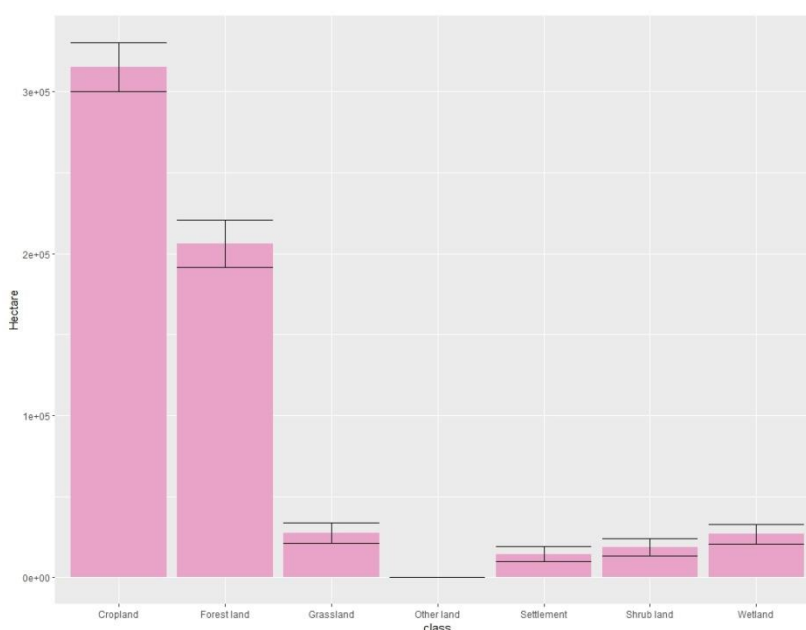


Figure 32 Buno Bedele Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Transition matrix of LULC classes also revealed that cropland, Grassland and settlement showed an increment with different extent. Cropland has gross increment of about 5592.0 ha (5192.6 ha net increment) with 5515 ha (0.17%) annual change per year in hectares. This was mainly gained from forest land, shrub land and Grassland classes each contributing 8787 ha, 1198 ha and 799 ha respectively. Settlement class has net gained of 2397 ha mainly from cropland 1997 ha and forest 399 ha with annual change of 220 ha (1.82%) per year. Grassland showed 2796 ha gross and 1997 ha net gain with annual increment rate of 193 ha

(0.75%) per year. On the other hand Forest land and shrub land showed significant reduction in extent, where forest land alone showed 11184 ha gross reduction (8388 ha net change) with 852 ha (0.4%) annual change per year, shrub land showed 1997 ha gross (1198 ha net) change with 2123 ha (0.62%) annual per year compared to base year 2007 monitoring. Wetland has no significant changes and other land has been not detected in both monitoring periods (Table 5 (19) and Table 24)

### 3.2.2.20 Oromia Special Zone Surrounding Finfinnee

***Oromia Special Zone Surrounding Finfinnee*** is among is specialized zone around Finfinnee in central part of the Oromia Region in Ethiopia with total area of 451,261 ha where the data is analyzed based 1128 sample points. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 312442 ha (69%) of total land mass, followed by Grassland accounting 40806 ha (9%), settlement sharing 30004 ha (7%), shrub land 17602 ha (4%) and wetland covering 13202 ha (3%). During 2017, still cropland, grass land, settlement and forest land accounts 68%, 9%, 8% (for both settlement and Forest land,) classes. The uncertainty or marginal error vale of those land cover classes is +/- 12308 ha for cropland and 7029.06 ha for Grassland, 7065.9 ha for settlement, 504 ha for shrub land classes. On the other hand there is no other land class detected for this Zone during the monitoring period (Table 25 and Figure 33).

Table 25 Oromia Special Zone Surrounding Finfinnee Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 312442 | 69 | 306041 | 68 | 9601 | 3200 | 6401 | 0.21 | 646.07 |
| Forest land | 35205 | 8 | 34805 | 8 | 3200 | 2800 | -400 | -0.11 | -40.21 |
| Grassland | 40806 | 9 | 41606 | 9 | 800 | 1600 | 800 | 0.19 | 79.31 |
| Other land | 2000 | 0 | 2400 | 0 | 0 | 400 | 400 | 1.82 | 36.8 |
| Settlement | 30004 | 7 | 35205 | 8 | 800 | 6001 | 5201 | 1.6 | 483.46 |
| Shrub land | 17602 | 4 | 17202 | 4 | 800 | 400 | 400 | 0.23 | 40.42 |
| Wetland | 13202 | 3 | 14002 | 3 | 0 | 800 | 800 | 0.59 | 77.91 |
| Total | 451261 | 100 | 451261 | 100 | | | | | |

Transition matrix of LULC classes also revealed that cropland, Grassland and settlement showed an increment with different extent. Cropland has gross increment of about 9601 ha (6401 ha net increment) with 647.07 ha with annual change per year in hectares. This was mainly gained forest land, Grassland and settlement. Settlement class has net gain of 5201 ha mainly from cropland 4801 ha and forest 1200 ha with annual change of 483 ha (1.6%) per year. Grassland showed 1600 ha gross and 800 ha net gain with annual increment rate of 36ha (1.82%) per year. Wetland has showed 800 ha net change with 77 ha annual change per year. On the other hand Forest land and shrub land showed reduction in extent, where forest land alone showed 3200 ha gross reduction (400 ha net change) with 40 ha (0.11%) annual change per year, shrub land showed 800 ha gross (400 ha net) change with 40 ha (0.23%) annual per year compared to base year 2007 monitoring (Table 5 (20) and Table 24)
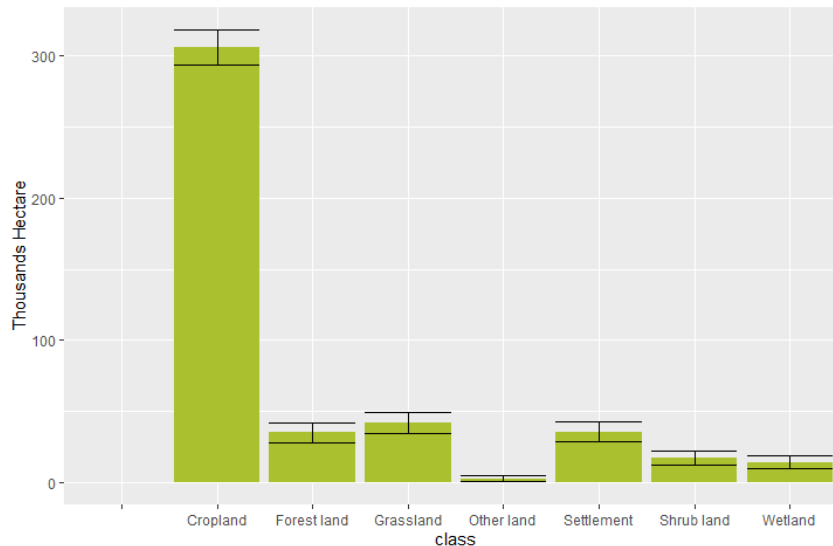
Figure 33 Oromia Special Zone surrounding Finfinnee Land Use Land Cover of 2017 with 95% confidence interval (CI)

### 3.2.2.21   Jimma

**Jimma Zone** is one among Deforestation hotspots and found in Western part of Oromia Region in Ethiopia with total area of 1,857,600 ha where the data is analyzed based 4646 sample points. In 2007 the land use land cover (LULC) of this zone is mainly covered by Cropland sharing 858830 ha (46%) of total land mass, followed by Forest accounting 40806 ha (35%), Grassland covering 109953 (6%),  settlement sharing 99157 ha (5%), wetland accounts 71569 ha (4%) and shrub land 64772 ha (3%) of the total area. Other land covers about 800 ha which is minimal in proportion to total land mass.  Consistent with 2007 trend but with small numerical variation during 2017, cropland, Forest land, grass land, settlement and wetland shares from highest to lowest accounting 46% cropland, 35% forest land, 6% for both settlement and grassland, 4% wetland and 3% shrub land classes. The uncertainty or marginal error vale of those land cover classes is +/-26629.5 ha for cropland, 25498 ha for forest land, 12563.4 ha for grassland, 783 ha for other land, 12345 ha for settlement, 9623 ha shrub land and 10309 ha for wetland classes.  High error was observed other land class might be attributed to low number of sample point used representing this land cover class during data collection.(Figure 34 and Table 26).

*Table 26 Jimma Zone Land use Land cover Extent for Year 2007 and 2017 and area loss and gain between the two monitoring periods.*

| LULC class | LULC Extent | | | | Loss | Gain | Net Change | Annual Change (%) | Annual Change/y (ha) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | % | 2017 | % | | | | | |
| Cropland | 858830 | 46 | 856431 | 46 | 11195 | 8796 | -2399 | -0.03 | -240.2 |
| Forest land | 652519 | 35 | 652119 | 35 | 6397 | 5997 | -400 | -0.01 | -39.99 |
| Grassland | 109953 | 6 | 109153 | 6 | 2799 | 1999 | -800 | -0.07 | -80.23 |
| Other land | 800 | 0 | 400 | 0 | 400 | 0 | -400 | -6.93 | -53.55 |
| Settlement | 99157 | 5 | 105155 | 6 | 800 | 6797 | 5997 | 0.59 | 584.02 |

| Shrub land | 64772 | 3 | 62373 | 3 | 3598 | 1199 | -2399 | -0.38 | -243.99 |
| Wetland | 71569 | 4 | 71969 | 4 | 400 | 800 | 400 | 0.06 | 39.88 |
| Total | 1857600 | 100 | 1857600 | 100 | | | | | |
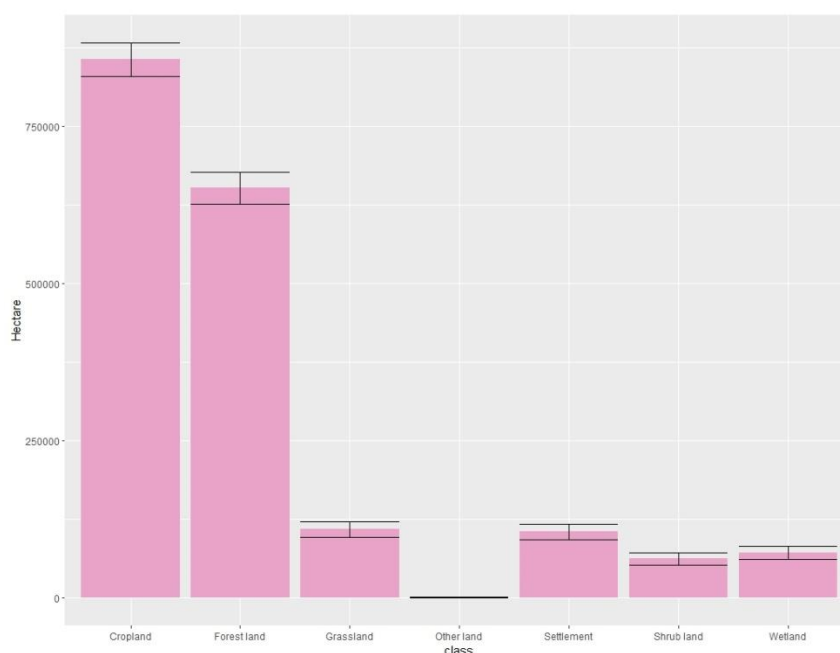


Figure 34 Jimma Zone Land Use Land Cover of 2017 with 95% confidence interval (CI)

Transition matrix of LULC classes also revealed that cropland, Forest land, Grassland, shrub land and other land showed reduction in total extent compared to base year 2007. Extent of reduction varies for each LULC classes. Cropland has gross reduction of about 11195 ha (2399 ha net loss) with 240 ha (0.03%) annual change per year in hectares. This was mainly claimed by settlement with 5598 ha, 4798 by forest land, and 800 by Grassland classes. Forest land and grassland also showed 400 ha and 800 ha minimum reduction respectively with 39 ha and 80 ha loss per annual compared to the base year respectively. The extent of other land class is also showing reduction with 53 ha (6.93%) per year and shrub land showed 243 ha annual loss (0.38%). However Settlement class has net gain of 5997 ha mainly from cropland with 5598 ha and 400 ha from each forest, grass and shrub land during the monitoring periods (Table 7 (21) and Table 26)

### 3.2.3 Zonal rate of Deforestation and Carbon Emission

Based on the activity data generated for each zones and emission and removal factor adopted for this baseline assessment the following Emission and Removal of Greenhouse gas is presented and interpretation is given underneath.

*Table 27 Oromia Regional state Zonal level Deforestation and GHG assessment table from 2007 - 2017*

| No | Zones | Forest_2007 | Forest_2017 | FOREST LOSS | Forest Gain | Emission (t CO2e ha-1) 2007-2017 | Annual | Removal (t CO2e ha-1) 2007-2017 | Annual |
|---|---|---|---|---|---|---|---|---|---|
| 1 | E/Wollega | 360240 | 332682 | 32350 | 4793 | 11920975 | 1192098 | 72494 | 7249 |
| 2 | H/G/ Wollega | **214529** | 206509 | 15238 | 7218 | 5615203 | 561520 | 109172 | 10917 |
| 3 | W/Shawa | 238397 | 228414 | 18369 | 8386 | 6768977 | 676898 | 126838 | 12684 |
| 4 | N/Shawa | 46592 | 48601 | 6427 | 8435 | 2368350 | 236835 | 127579 | 12758 |
| 5 | E/Hrarge | 411659 | 409259 | 6801 | 4401 | 2506169 | 250617 | 66565 | 6657 |
| 6 | W/Haragre | 230123 | 226128 | 5993 | 1998 | 2208421 | 220842 | 30220 | 3022 |
| 7 | K/Wollega | 510735 | 499554 | 16772 | 5591 | 6180482 | 618048 | 84564 | 8456 |
| 8 | E/Shawa | 65482 | 61888 | 5191 | 1597 | 1912884 | 191288 | 24155 | 2415 |
| | S/W/Shawa | 51380 | 48168 | 3211 | 0 | 1183254 | 118325 | 0 | 0 |
| 9 | I/Ababora | 742269 | 737862 | 10816 | 6409 | 3985696 | 398570 | 96936 | 9694 |
| 10 | Guji | 874363 | 819216 | 56746 | 1598 | 20910901 | 2091090 | 24170 | 2417 |
| 11 | W/Guji | 256488 | 244503 | 12784 | 799 | 4710904 | 471090 | 12085 | 1208 |
| 12 | Borena | 2226385 | 2214775 | 28826 | 17215 | 10622270 | 1062227 | 260377 | 26038 |
| 13 | Bale | 980342 | 963129 | 20816 | 3603 | 7670696 | 767070 | 54495 | 5450 |
| 14 | E/Bale | 1632787 | 1612402 | 22783 | 2398 | 8395536 | 839554 | 36270 | 3627 |
| 16 | W/Arsi | 183926 | 164291 | 20035 | 401 | 7382898 | 738290 | 6065 | 607 |
| 17 | Arsi | 318126 | **295717** | 26010 | 3601 | 9584685 | 958469 | 54465 | 5447 |
| 18 | W/Wollega | 389808 | 388610 | 15576 | 14378 | 5739881 | 573988 | 217470 | 21747 |
| 19 | B/Bedele | 214492 | 206105 | 11184 | 2796 | 4121304 | 412130 | 42290 | 4229 |
| 20 | F/S Zone | 35205 | 34805 | 3200 | 2800 | 1179200 | 117920 | 42350 | 4235 |
| 21 | Jimma | 652519 | 652119 | 6397 | 5997 | 2357295 | 235729 | 90705 | 9070 |
| | Total | 10635847 | 10394737 | 345525 | 104414 | 127,325,977 | 12,732,598 | 1,579,264 | 157,926 |

From 2007 to 2017, Oromia lost 345,525 ha forest cover, which is equivalent to about 127 million tCo2e emissions to the atmosphere with about 12.7 million emission levels per year. However, amount of removal estimated is about 1.6 million tCo2e with annual removal rate of 157,926 which is 78 times lower than the emission estimated for the monitoring periods.

In Oromia, the top six zones responsible for about 55% of deforestation and emission of carbon between 2007 and 2017 are Guji accounting about 20.9 million tCo2e (17% of total carbon emission), followed by East Wollega Emitting about 11.8 million (9.45%) tCo2e, Borena contributing about 10.4 million (8.3%), Arsi Zone emitting 9.5 million (7.6%), Bale and East Bale independently Contributing about 7.6 million (6%) tCO2e emissions (Table 27). The next other six Zones contributing high deforestation rate and high carbon emission in oromia are West Arsi, West shewa, Kellem Wollega, West Wollega, Horo Guduru Wollega, and West Guji Zones respectively emitting about 7.4 Mt (5.85%), 6.6 Mt (5.37%), 6 Mt (4.9%), 5.5 Mt ((4.4%), 5 Mt (4%) and 4.7 Mt (3.7%) of of CO₂e emissions. The rest 10 Zones namely according to their emission level are Buno Bedele, Ilu Ababora, East Hararge, North Shawa, Jimma, West Hararge, East Shawa, South West Shawa and oromia Special Zone surrounding Finfinnee totally contributes less than 20 Mt Co2e.
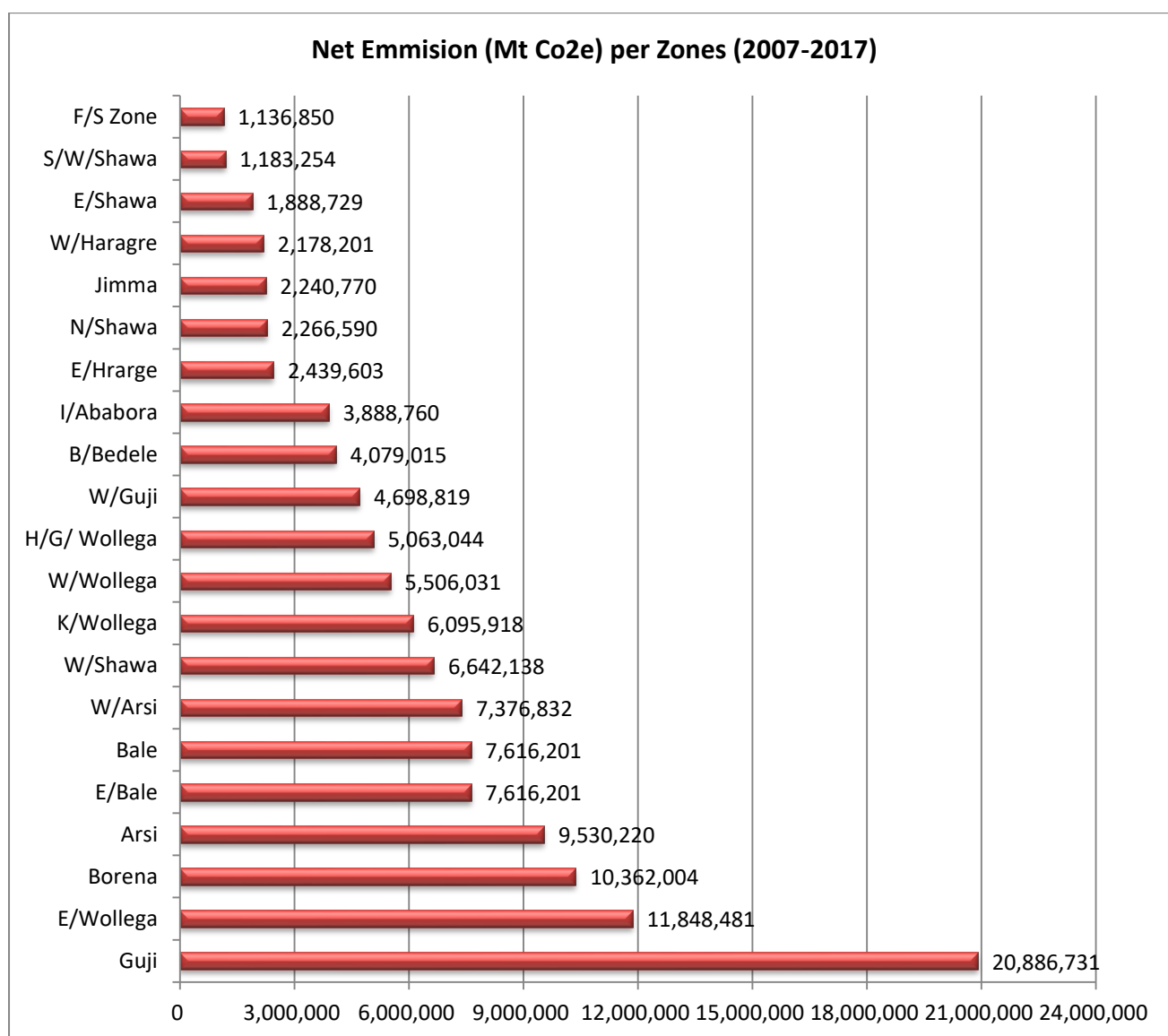
On the other hand, six zone are contributing about 60% of carbon removal from the regional share (1.5 Mt of CO2e) due to forest gain in each Zones according to their contribution are Borena with removal of 260,376 (16%), West Wollega with 217,463 (13.8%), North Shawa with 127579 (8.1%), West Shawa providing about 126,838 (8% each), Horo Guduru Wollega 109,172 (6.9%) and Ilu Ababor Zone contribution 96936 tCO2e (6.1%) removal. The next six regions contributing greater than 25% percent are Jimma, Kellem Wollega, East Wollega, East Hararge, Bale and East Bale, each sharing removal of 5.6%, 5.2%, 4.5%, 4.1%, and 3.4% (Bale and Esst Bale) tCO2e. The rest 9 Zones totally share about 15% of carbon removal.

Overall, the gross emission reduction is 127,325,981 tCO2e, while net emission reduction at regional level is 124,544,391.13 million tCO2e, where the net emission reduction contribution of each zone is presented on the table below Table 27.

4. **Challenges and Actions taken**

Given Ethiopia and the sub-national forest institutions are at early stage of regular forest monitoring and as this is only the first time that the national and sub-national experts in the forest sector pursue a full-fledged analysis following the IPCC good practice guideline, there have been a number of challenges encountered mainly related to technical capacity, institutions and resources, among others.

❖ Technical data related challenges:
   o Particularly difficulty to distinguish the different types of landscapes using existing images with higher resolution.
   o Difficulty to distinguish between similar LULC types (e.g., Grassland vs cropland, Grassland vs wetland, Cropland vs wetland, Shrubland vs forest land…).
   o Absence of commonly accepted regional boundary shapefile with non-topological errors with Zonal boundary, including inconsistency of Zonal boundary administration.

**Actions Taken**

In order to prevail through the challenges and execute the planned activities, the team has devised mechanisms including:

   o Bringing technical assistant from international experts through virtual meetings to build the capacity of the national experts in using different tools for sampling and mapping.
   o Developing national capacities to apply CEO platform for sample based activity data generation which also improves efficiency and provides quicker results.
   o Team work mission is organized at Bishoftu for the national and sub-national experts groups to concentrate and intensively work with better possibility of team discussion and an out of office setting which loosen other regular office duties

o In consultation with OEPA regional officials develop two Activity dat. 1st larger boundaries obtained from Oromia Planning and Development commission was used to designed samples and analysis area stratification at zonal level for ER result based payment. 2nd use sample points collected and extract using the 32 Mha area for ERPD preparation to keep its consistency.

## 5. Conclusions and Recommendations

### 5.1 . Conclusions

The Oromia REDD+ coordination unit at Oromia Environment protection authority in collaboration with Forest Resources Assessment and Monitoring Directorate (FRAMD) of Ethiopian Forestry Development (EFD)) conducted LULC change detection for the period between 2007 and 2017 for developing regional and zonal baseline of AD in Oromia regional state. High resolution imagery (Planet NICFI Level 1) is used for mapping LULC for the current year for the first time at sub-national level. The team has also applied a contemporary state-of-the-art techniques and tools (SEPAL, CEO, RStudio, Microsoft Excel and others) for the monitoring and analysis. Activity data (AD) and emission baseline was produced for regional level and 21 zones which will be utilized for benefit sharing mechanism of emission reduction and removals (ERR) and for updating already developed Emmision Reduction program Document. In addition to sample based area estimation LULC maps of Oromia and 21 zones for the year 2017 were produced. This forest monitoring exercise significantly improved the capacity of the national and regional team of experts. The result showed that gross deforestation stands at 34,553 ha per year between 2007 and 2017, which directly contribute for 12,732,598 t CO2e emission from forest class between the two monitoring periods. Rate of deforestation was estimated to be 0.23 % per year.

Zonal based deforestation estimate also reveal that, top 7 zones are responsible for 60% of forest cover loss between 2007 and 2017, which include ; Guji - 56,746 ha (16.4% ), East Wollega -32350 ha (9.4% ), Borena,-28826 ha (8.3% ), Arsi - 26010 ha (7.5% , East Bale - 22785 ha (6.6% ), and Bale - 20816 ha (6%) and West Arsi shares 20035 ha (5.8%) of gross deforestation rate between the monitoring periods. Similarly, Oromia lost 345,525 ha forest cover, which is equivalent to about 127 million tCo2e emissions to the atmosphere with about 12.7 million emission levels per year. Top six zones responsible for about 55% of emission of carbon between 2007 and 2017 are: Guji with 20.9 million tCo2e (17%), East Wollega with 11.8 million (9.45%), Borena with 10.4 million (8.3%), Arsi Zone with 9.5 million (7.6%), Bale and East Bale independently Contributing about 7.6 milliontCo2e.

It is worth mentioning cropland expansion and commodity driven deforestation would continue to occur and reverse the magnitude unless conservation of forest carbon stocks is implemented through strong commitment and policy support coupled with accelerated investment in forest sector mitigation actions.

## 5.2. Recommendations

In order to improve the overall forest related MRV, EFD needs to develop cost-effective, robust and reliable methods. With the aim of improving the RIP-DD monitoring in, the following points are forwarded based on experiences of the past.

- o Continue provisions of technical assistance through implementing hands-on capacity development for national and regional experts. Consider also upgrading national and subnational experts' skills in remote sensing application on forest monitoring through designing long-term capacity building programs to realize self-reliance in future monitoring.
- o Strengthening collaboration with regional and local institutions (academia, research institutions) for quality assurance and state-of-the art research as well as to collect ground verification data as part of improving regional and local level MRV.
- o Develop and strengthen geo-portal (using the new MRV data center under development) for reliable data storage, processing and sharing.
  - ▪ Strengthen the collaboration with international institutions like FAO and work to share emerging remote sensing technologies.
  - ▪ Improve transparency of forest sector MRV through updating various geo-referenced forest related activities (e.g., REDD+ web-portal and registry, etc.)
- o Awareness raising among stakeholders on the national and international definitions and parameters specifically on IPCC land use categories is required
- o Transforming towards use of high-resolution satellite data for land use land cover monitoring is started. Strengthen the experience and improve the capacity of national and subnational experts in continuous use of high-resolution data along with exerting efforts to comply with IPCC Tier-2 and 3 requirements;
- o Promote and disseminate the generated data and information for a wider use in related policy interventions (e.g., NDC, LT-LEDS and others) as well as to ensure transparency of the forest MRV interventions.

# Appendixes

Appendix **1. Sample point used for area estimation analysis for each Zones in Oromia Region.**
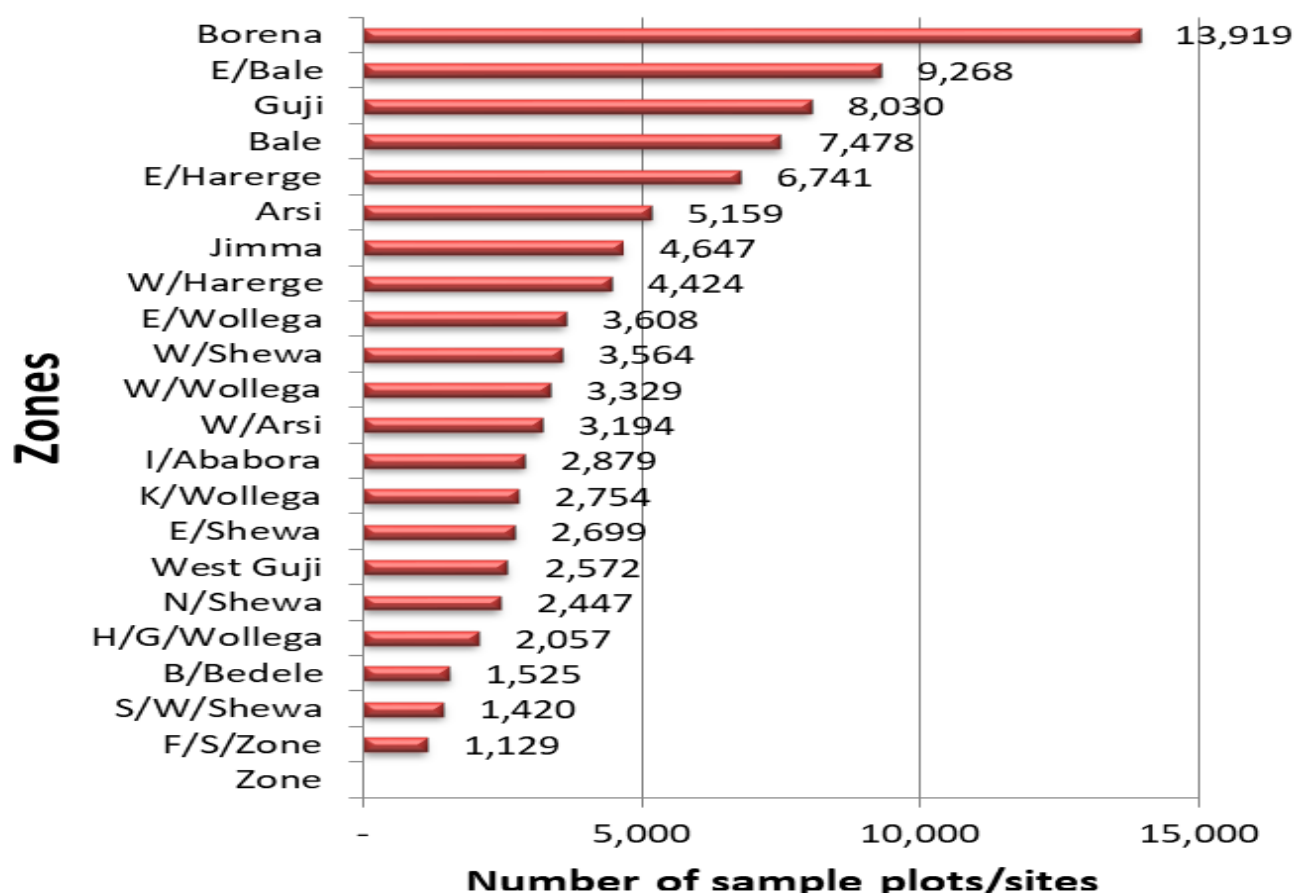


*Figure 35 Distribution of sample points across 21 zones in Oromia Regiona*

Appendix 2. Land Use Land covers area extent; Activity data estimated and related uncertainty (CI) for Zones

| Zone | LULC_Class | LULC 2007 | LULC 2017 | 95% CI |
|---|---|---|---|---|
| East Wollega | Cropland | 781,983.53 | 840692.20 | 23178.70 |
| | Forest land | 360,239.60 | 332682.47 | 19815.45 |
| | Grassland | 92,655.86 | 85067.67 | 11083.42 |
| | Other land | 1,597.51 | 1597.51 | 1564.91 |
| | Settlement | 53,916.13 | 54714.88 | 8987.79 |
| | Shrub land | 119,813.61 | 94253.38 | 11626.89 |
| | Wetland | 30,352.78 | 31550.92 | 6881.86 |
| | Total | 1440559.03 | **1440559.03** | 83139.03 |
| H/G/Wollega | Cropland | 381340.82 | 406603.15 | 17821.15 |
| | Forest land | 214529.28 | 206509.49 | 15445 |
| | Grassland | 45712.78 | 45712.78 | 8157.554 |
| | Other land | 400.99 | 400.99 | |
| | Settlement | 22455.40 | 21653.42 | 5700.486 |
| | Shrub land | 93831.50 | 76187.97 | 10323.23 |
| | Wetland | 66163.23 | 67767.19 | 9790.666 |
| | Total | **824434.00** | 824834.99 | 67238.09 |

| Zone | LULC_Class | LULC 2007 | LULC 2017 | |
|---|---|---|---|---|
| West Shawa | Cropland | 899679.98 | 886102.9192 | 22647.19 |
| | Forest land | 228414.09 | 238397.2252 | 17450.53 |
| | Grassland | 70680.58 | 70680.58436 | 10152.34 |
| | Other land | 1197.98 | 798.6506708 | 1106.72 |
| | Settlement | 57502.85 | 57103.52296 | 9171.01 |
| | Shrub land | 125787.48 | 130180.0593 | 13471.51 |
| | Wetland | 39533.21 | 39533.2082 | 7679.67 |
| | Total | **1422796.17** | 1422796.17 | 81678.96 |
| North Shawa | Cropland | 678803.09 | 681614.70 | 7331.33 |
| | Forest land | 46592.40 | 48600.69 | 2937.78 |
| | Grassland | 42575.82 | 39764.20 | 2357.89 |
| | Other land | 8434.83 | 8033.17 | 787.25 |
| | Settlement | 36149.28 | 36952.59 | 787.25 |
| | Shrub land | 133350.67 | 131342.37 | 12901.74 |
| | Wetland | 36550.94 | 36149.28 | 787.25 |
| | Total | 982457.02 | 982457.02 | 7331.33 |
| East Hararge | Cropland | 678897.53 | 676097.13 | 35221.82 |
| | Forest land | 411659.14 | 409258.79 | 23099.5 |
| | Grassland | 951336.67 | 953737.01 | 30780.65 |
| | Other land | 400.06 | 400.06 | 784.1126 |
| | Settlement | 34404.94 | 38805.57 | 7667.411 |
| | Shrub land | 605687.01 | 604086.78 | 26842.32 |
| | Wetland | 14002.01 | 14002.01 | 4627.156 |
| | Total | 2696387.36 | 2696387.36 | 121705.4 |
| **Zone** | **LULC_Class** | **LULC 2007** | **LULC 2017** | |
| West Harage | Cropland | 630442.22 | 638432.61 | 25019.7 |
| | Forest land | 230123.39 | 226128.20 | 17398.7 |
| | Grassland | 423490.97 | 424290.01 | 22247.5 |
| | Other land | 1198.56 | 1198.56 | 1355.99 |
| | Settlement | 23971.19 | 24370.71 | 6074.25 |
| | Shrub land | 449459.76 | 443866.48 | 22588.5 |
| | Wetland | 8389.92 | 8789.44 | 3664.14 |
| | **Total** | **1767076.00** | **1767076.00** | 98348.9 |
| Kellem Wollega | Cropland | 332237.49 | 345415.18 | 19066.29 |
| | Forest land | 510735.28 | 499554.21 | 20451.29 |
| | Grassland | 140162.69 | 135770.13 | 13513.73 |
| | Other land | 1197.97 | 1597.30 | 1564.50 |
| | Settlement | 28751.32 | 38335.10 | 7535.09 |
| | Shrub land | 61096.56 | 53908.73 | 8869.70 |
| | Wetland | 25157.41 | 24758.08 | 6094.10 |
| | Total | 1099338.72 | 1099338.72 | 77094.71 |
| East Shawa | Cropland | 610097.89 | 606504.38 | 20166.36 |
| | Forest land | 65481.71 | 61888.20 | 9460.864 |
| | Grassland | 171689.85 | 165700.67 | 14667.93 |
| | Other land | 2794.95 | 3593.51 | 2344.274 |
| | Settlement | 33938.69 | 48712.00 | 8447.819 |

| Zone | LULC_Class | LULC 2007 | LULC 2017 | |
|---|---|---|---|---|
| | Shrub land | 97424.01 | 92233.39 | 11375.81 |
| | Wetland | 95826.89 | 98621.85 | 11724.97 |
| | Total | 1077254.00 | 1077254.00 | 78188.03 |
| S/West Shawa | Cropland | 436725.85 | 434317.44 | 12616.14 |
| | Forest land | 51,380 | 48,168 | 8493.10 |
| | Grassland | 28098.17 | 27696.77 | 6376.60 |
| | Other land | 1605.61 | 1605.61 | 1571.83 |
| | Settlement | 22879.94 | 22077.13 | 5722.51 |
| | Shrub land | 26893.96 | 27295.37 | 6332.57 |
| | Wetland | 5218.23 | 5218.23 | 2824.63 |
| | Total | 569590.06 | 569590.06 | 43937.39 |
| Ilu Ababora | Cropland | 257570.88 | 261977.22 | 17653.4 |
| | Forest land | 742268.79 | 737862.45 | 20220.7 |
| | Grassland | 59285.36 | 56881.90 | 9123.8 |
| | Other land | 0 | 0 | 5869.6 |
| | Settlement | 16423.65 | 22832.88 | 8586.8 |
| | Shrub land | 54478.44 | 50072.10 | 5919.8 |
| | Wetland | 22832.88 | 23233.45 | 67374.1 |
| | Total | 1152860.00 | 1152860.00 | 67374.1 |
| **Zone** | **LULC_Class** | **LULC 2007** | **LULC 2017** | |
| Guji | Cropland | 400816.18 | 463955.72 | 24684.71 |
| | Forest land | 874362.71 | 819215.52 | 30604.68 |
| | Grassland | 601823.70 | 599825.61 | 27363.84 |
| | Other land | 799.23 | 799.23 | 1107.614 |
| | Settlement | 19581.25 | 24376.66 | 6094.475 |
| | Shrub land | 1276777.36 | 1266786.93 | 34308.35 |
| | Wetland | 34367.09 | 33567.86 | 7141.399 |
| | Total | 3208527.53 | 3208527.53 | 131305.1 |
| West Guji | Cropland | 307226.61 | 332396.02 | 18579.48 |
| | Forest land | 256488.27 | 244502.84 | 16912.78 |
| | Grassland | 236512.55 | 225326.15 | 16433.70 |
| | Other land | 799.03 | 799.03 | 1107.18 |
| | Settlement | 13583.49 | 17978.15 | 5207.69 |
| | Shrub land | 121452.39 | 115060.16 | 12524.81 |
| | Wetland | 91089.29 | 91089.29 | 11289.52 |
| | Total | 1027151.64 | 1027151.64 | 82055.15 |
| Borena | Cropland | 92882.82 | 119706.73 | 13422.7 |
| | Forest land | 2226385.12 | 2214774.76 | 45306.4 |
| | Grassland | 1513749.71 | 1500537.93 | 41067.3 |
| | Other land | 35231.41 | 36832.84 | 7501.9 |
| | Settlement | 8007.14 | 13612.14 | 4570.1 |
| | Shrub land | 1626650.37 | 1616241.09 | 42011.4 |
| | Wetland | 69662.11 | 70863.18 | 10373.5 |
| | **Total** | **5572568.68** | **5572568.68** | **164253.4** |
| Bale | Cropland | 521994.84 | 556420.89 | 26394.8 |
| | Forest land | 980341.55 | 963128.53 | 31696.0 |

| Zone | LULC_Class | | | |
|------|-----------|-----------|-----------|-----------|
| | Grassland | 515590.00 | 511987.28 | 25548.8 |
| | Other land | 37228.16 | 37228.16 | 7519.6 |
| | Settlement | 19614.84 | 21616.35 | 5745.1 |
| | Shrub land | 890273.42 | 874661.61 | 30856.4 |
| | Wetland | 28021.20 | 28021.20 | 6534.0 |
| | Total | 2993064.00 | 2993064.00 | 134294.9 |
| East Bale | Cropland | 269399.92 | 294980.92 | 19585.9 |
| | Forest land | 1632787.34 | 1612402.48 | 37440.1 |
| | Grassland | 856963.54 | 859361.76 | 31803.2 |
| | Other land | 1598.81 | 1598.81 | 1566.6 |
| | Settlement | 13989.61 | 15588.42 | 4626.3 |
| | Shrub land | 910124.05 | 900930.88 | 32467.2 |
| | Wetland | 17986.64 | 17986.64 | 5242.8 |
| | Total | 3702849.91 | 3702849.91 | 132732.0 |

| Zone | LULC_Class | LULC 2007 | LULC 2017 | |
|------|-----------|-----------|-----------|-----------|
| West Arsi | Cropland | 615890.90 | 625908.64 | 22188.2 |
| | Forest land | 183925.78 | 164291.00 | 14849.2 |
| | Grassland | 217986.11 | 211574.75 | 16489.98 |
| | Other land | 11620.58 | 11620.58 | 4210.87 |
| | Settlement | 103783.83 | 121014.35 | 12989.19 |
| | Shrub land | 50890.14 | 50088.72 | 8608.693 |
| | Wetland | 95368.92 | 94968.21 | 11635.39 |
| | Total | 1279466.26 | 1279466.26 | 90971.52 |
| Arsi | Cropland | 1103636.88 | **1124445.12** | 28053.80 |
| | Forest land | 318125.93 | **295717.06** | 19736.66 |
| | Grassland | 274508.67 | **273708.35** | 19105.81 |
| | Other land | 2000.79 | **2801.11** | 2073.88 |
| | Settlement | 69227.40 | **77230.57** | 10691.23 |
| | Shrub land | 258502.33 | **251699.64** | 18433.84 |
| | Wetland | 38015.05 | **38415.21** | 7613.53 |
| | Total | 2064017.05 | 2064017.05 | 105708.76 |
| West Wollega | Cropland | 568379.5 | 576367.9 | 22383.1 |
| | Forest land | 388638.9 | 389837.2 | 20562.4 |
| | Grassland | 127416.1 | 120625.9 | 12973.8 |
| | Other land | 1997.1 | 2396.5 | 1916.0 |
| | Settlement | 47930.8 | 54721.0 | 8973.3 |
| | Shrub land | 102252.4 | 93065.6 | 11524.9 |
| | Wetland | 92666.2 | 92266.8 | 11479.1 |
| | Total | 1440559.03 | 1440559.03 | 89812.7 |
| Bono Bedele | Cropland | 309955.63 | 315148.19 | 15276.58 |
| | Forest land | 214492.49 | 206104.52 | 14467.69 |
| | Grassland | 25563.35 | 27560.49 | 6356.235 |
| | Other land | 0.00 | 0.00 | 0 |
| | Settlement | 11982.82 | 14379.39 | 4642.978 |
| | Shrub land | 19971.37 | 18773.09 | 5285.464 |

| | | Wetland | 26761.63 | 26761.63 | 6267.742 |
|---|---|---|---|---|---|
| | | Total | 608727.30 | 608727.30 | 52296.68 |
| O/S. Zone Surrounding Finfinnee | | Cropland | 312442.23 | 306041.37 | 12308.3 |
| | | Forest land | 35204.76 | 34804.70 | 7029.1 |
| | | Grassland | 40805.52 | 41605.62 | 7622.2 |
| | | Other land | 2000.27 | 2400.32 | 1916.4 |
| | | Settlement | 30004.06 | 35204.76 | 7066.0 |
| | | Shrub land | 17602.38 | 17202.33 | 5045.0 |
| | | Wetland | 13201.78 | 14001.89 | 4568.3 |
| | | Total | 451261.00 | 451261.00 | 45555.2 |
| Jimma | | Cropland | 858830.16 | 856431.19 | 26629.51 |
| | | Forest land | 652519.01 | 652119.18 | 25498.04 |
| | | Grassland | 109952.65 | 109153.00 | 12563.4 |
| | | Other land | 799.66 | 399.83 | 783.6625 |
| | | Settlement | 99157.30 | 105154.72 | 12345.25 |
| | | Shrub land | 64772.11 | 62373.14 | 9623.248 |
| | | Wetland | 71569.18 | 71969.01 | 10309.36 |
| | | Total | 1857600.06 | 1857600.06 | 97752.48 |

## References

Assessment, F. M. A., & Assessment, A. E. M. A. (2016). A Practical Guide. *FAO: Roma, Italy*, 69.

CARBON, M. F. (2012). COOKBOOK. How to Measure and Monitor Forest Carbon.

Collins, J. (2001). Deforestation. *UWO Envirofacts Index Page*, 1.

FAO. (2002). xpert Meetin g on Harmonizing forest-related definitions for use by various stakeholders. Food and Agricultural Organisation of the United ations (FAO), Rome,

Italy 23-25 January 2002. Available at: http://www.fao.org/forestry/15533-0cb816e82c09c14873ce9226dd13910b9.pdf

FAO. (2005). Grasslands of the World. Available at

http://www.fao.org/docrep/008/y8344e/y8344e05.htm Food and Agricultural Organisation of the United Nation Rome 2005. Food & Agriculture

FAO. (2010). Global forest resource assessment 2010 main report.

Fearnside, P. M. (1993). Deforestation in Brazilian Amazonia: the effect of population and land tenure. *Ambio-Journal of Human Environment Research and Management, 22*(8), 537-545.

Gallego, F. J. (2004). Remote sensing and land cover area estimation. *International Journal of Remote Sensing, 25*(15), 3019-3047.

Hirata, Y., Takao, G., Sato, T., Toriyama, J. J. R. r., development center, f., & forest products research institute, T. (2012). REDD-plus cookbook: How to measure and monitor forest carbon.

IPCC. (2000). xpert Meetin g on Harmonizing forest-related definitions for use by various stakeholders. Food and Agricultural Organisation of the United ations (FAO), Rome,

Italy 23-25 January 2002. Available at: http://www.fao.org/forestry/15533-0cb816e82c09c14873ce9226dd13910b9.pdf

ISFL. (2019). Oromia Forested Landscape Program (OFLP. Initative for Suitanable Forested Landscape Program (ISFL) Emission Reductions (ER) Program Document (PD). https://www.biocarbonfund-isfl.org/sites/isfl/files/2021-09/OFLP-%20Final%20ERPD%20-%20Phase%201-%2027%20May%202021.pdf.

Kaimowitz, D., & Angelsen, A. (1998). Economic Models of Tropical Deforestation A Review Center for International Forestry Research Indonesia.

Mishra, V. N., Rai, P. K., & Mohan, K. (2014). Prediction of land use changes based on land change modeler (LCM) using remote sensing: A case study of Muzaffarpur (Bihar), India. *Journal of the Geographical Institute" Jovan Cvijic", SASA, 64*(1), 111-127.

Munthali, M. G., Botai, J. O., Davis, N., & Adeola, A. M. (2019). Multi-temporal analysis of land use and land cover change detection for Dedza district of Malawi using geospatial techniques.

Nath, D. C., & Mwchahary, D. D. (2012). Population increase and deforestation: a study in Kokrajhar district of Assam, India. *International Journal of Scientific and Research Publications, 2*(10), 1-12.

Puyravaud, J.-P. (2003). Standardizing the calculation of the annual rate of deforestation. *Forest ecology and management, 177*(1-3), 593-596.

Souza, C., Siqueira, J., Ribeiro, J., & Sales, M. (2013). Deforestation and forest degradation in the amazon biome. *Report, IMAZON*.

Additional resources for analysts'

SEPAL documentation: https://docs.sepal.io/en/latest/

Accessing Planet imagery in CEO: https://collect.earth/downloads/CEO_Planet_new_imagery_user_doc.pdf

Data collection manual CEO:

https://collect.earth/downloads/CEO_Manual_DataCollector_EN_20210331.pdf

Link to the Planet Explorer: https://www.planet.com/explorer/#/zoom/2.82

Link to Planet Explorer user guide: https://developers.planet.com/docs/apps/explorer/

NICFI data user page: https://developers.planet.com/nicfi/

FAQ document on the NICFI Planet data: https://assets.planet.com/docs/NICFI_General_FAQs.pdf

A user guide to Level 1 NICFI data: https://assets.planet.com/docs/NICFI_UserGuidesFAQ.pdf

More information on Level 2 NICFI data: https://www.nicfi.no/current/call-for-proposals-nicfi-satellite-data-program-level-2-access/