

## Biophysical characterization: Sustainable Intensification Sites

**Background:** The Sustainable Intensification (SI) research program is being implemented over five African countries with the aim of introducing sustainably intensified farming systems for smallholder farmers and providing pathways out of hunger and poverty. Ethiopia is among the five implementers of this initiative via three members of the CG centre (i.e., Alliance of Bioversity International and CIAT, International Livestock Research Institute (ILRI), and ICARDA) based in Addis Ababa, Ethiopia. This initiative in Ethiopia is implemented under the project of Sustainable intensification of crop-livestock mixed farming systems (SI-MFS). The purpose of the project is to encourage the adoption and innovation of sustainable intensification technologies that improve crop, livestock, and water productivity, and conserve natural resources for smallholder farmers in Ethiopia. To implement the SI-MFS in Ethiopia, three project sites in Basona Worena (of North Shewa Zone of Amhara region), Doyogena (Kembata Timbaro Zone of SNNP), and Lemmo Woreda (Hadiya Zone of SNNP) were selected based on bio-physical and socio-economic criteria set by experts of the above implementing CG centres based in Addis Ababa. Before the actual project is being commenced, project site characterization (i.e., the bio-physical, socio-economic, and farming system characterization) needs to be conducted to identify constraints, options, and opportunities for the ground implementation of SI and to generate baseline data for impact analysis. The objective of this study was to characterize the biophysical features of the project woredas and generate primary benchmark information to establish key monitorable bio-physical indicators.

**Descriptions of the study sites:** Basona Werena is found in North Shewa Zone of Amhara region and geographically located between latitude of  $9^{\circ} 38' - 9^{\circ} 41'00''$  N and longitude of  $39^{\circ} 30' 00'' - 39^{\circ} 32'00''$  E. Doyogena is one of the woreda in Kembta Tembaro Zone of SNN and it lies between between latitude  $7^{\circ}18'25''N - 7^{\circ}21'49''N$  and longitude  $37^{\circ}45'33''E - 37^{\circ}48'51''E$ . Lemo woreda is situated in Hadya zone, in SNNP Region, and located within  $7^{\circ}14'N$  to  $7^{\circ}45'N$  latitude and  $37^{\circ}05'E$  to  $37^{\circ}52'E$  longitude.

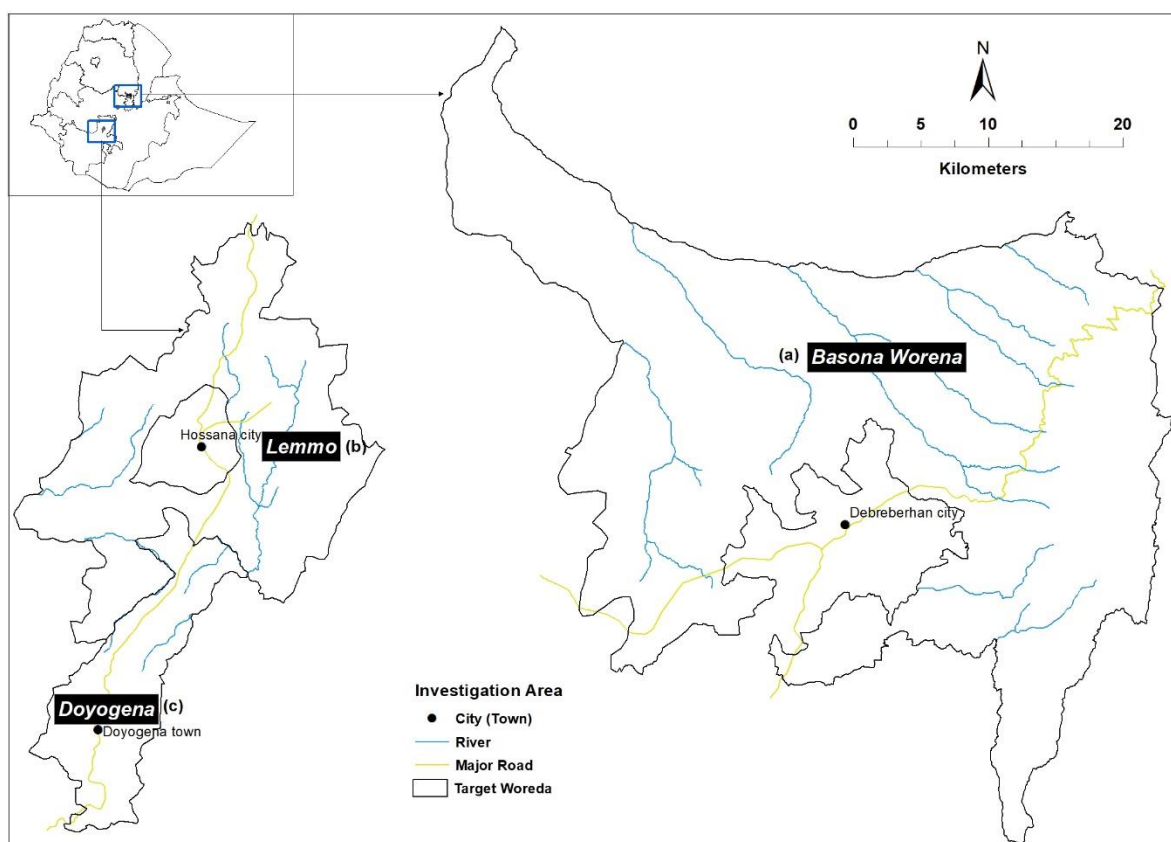


Figure 1. Location map of the study site (a) Basona Worena Woreda (of North Shewa Zone of Amhara region), (b) Doyogena Woreda (Kembata Timbaro Zone of SNNP), and (c) Lemmo Woreda (Hadiya Zone of SNNP)

### Biophysical characteristics

**Topography:** The topography of the study site was characterized based on the elevation and slope topographic parameters. The elevation map of the study site was produced using the DEM (with 30m spatial resolution) obtained from USGS. The DEM were also used to generate the slope maps of the study site using the slope functions in Google Earth Engine (GEE). The slopes were calculated in percentage of slope, and six slope classes (0-3%, 3-8%, 8-15%, 15-30%, 30-50% and >50%) were designated for each site based on the FAO slope classification system.

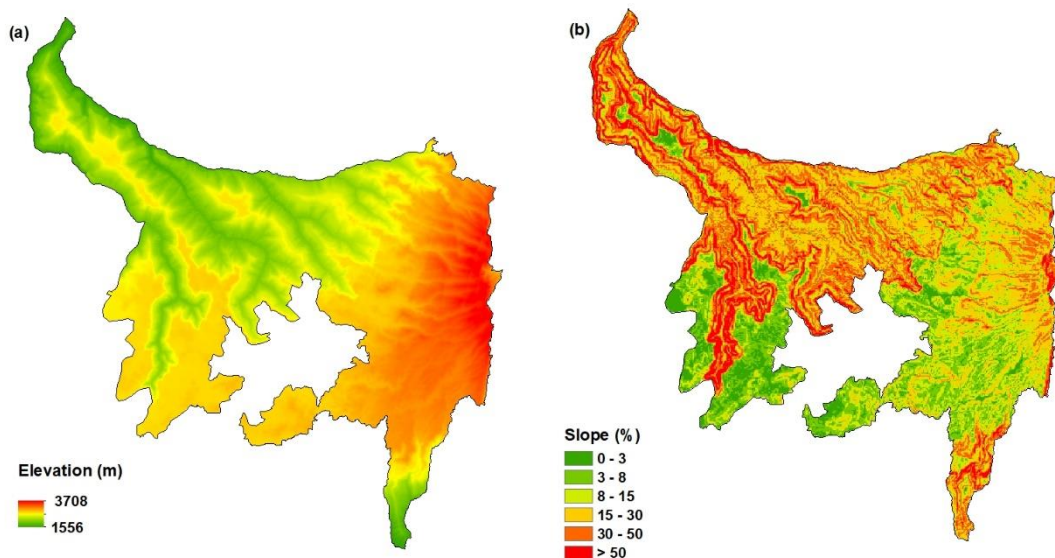


Figure 2. Elevation (a) and slope (b) maps of Basona Worena Woreda. These maps were generated using DEM under the GEE environment.

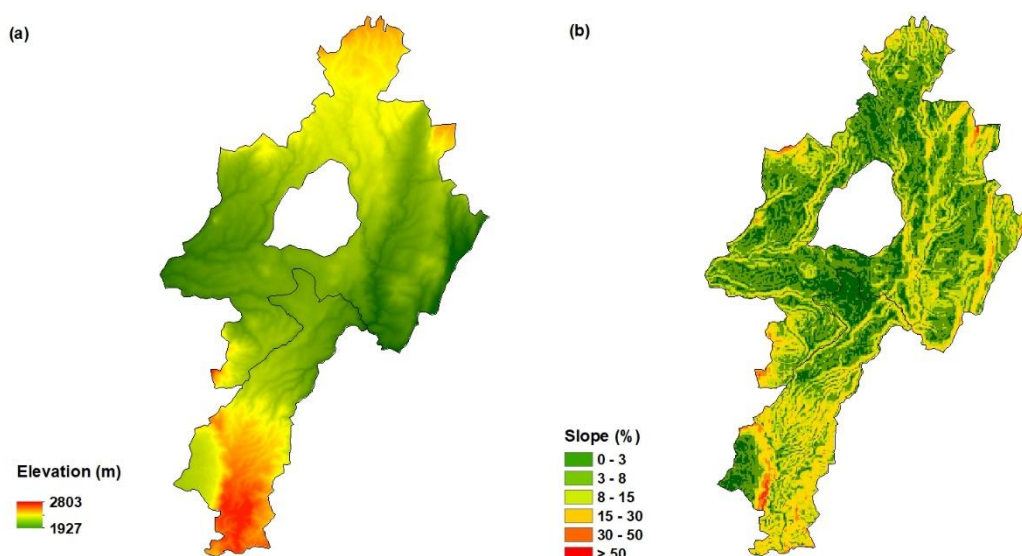


Figure 3. Elevation (a) and slope (b) maps of Doyogena(upper) and Lemo (lower) Woreda. These maps were generated using DEM under the GEE environment.

**Climate.** Rainfall and temperatures are the two most important climate parameters. The climate condition of the study site was characterized using the long-term mean annual rainfall and surface temperature. The CHIRPS and MODIS LST data set, accessed through GEE, were used to analyse the rainfall and temperature conditions of the study area.

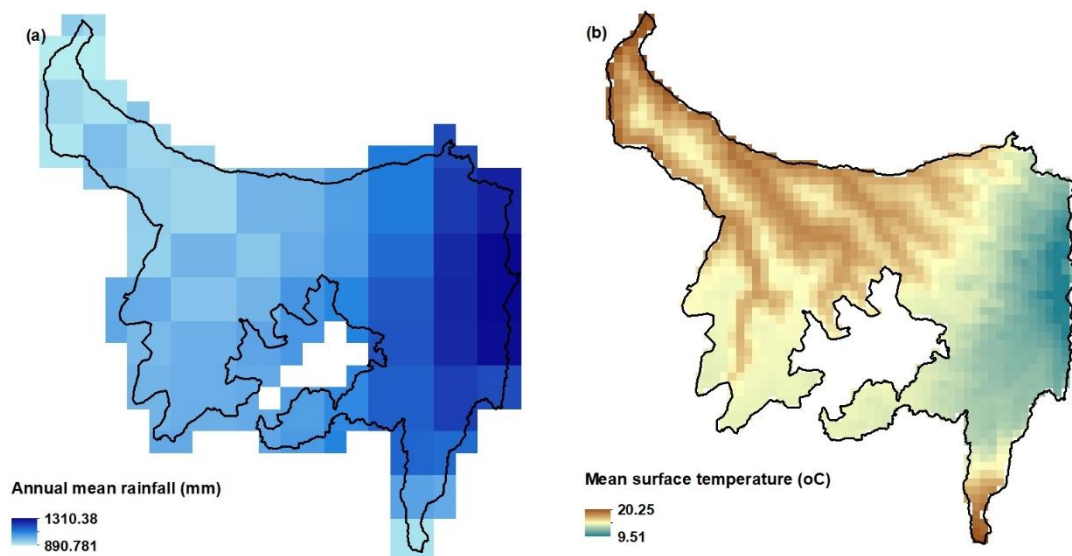


Figure 4. Annual mean rainfall (1981 to 2021) (a) and Mean Surface temperature (2000 to 2021) (b) maps of Basona Worena Woreda.

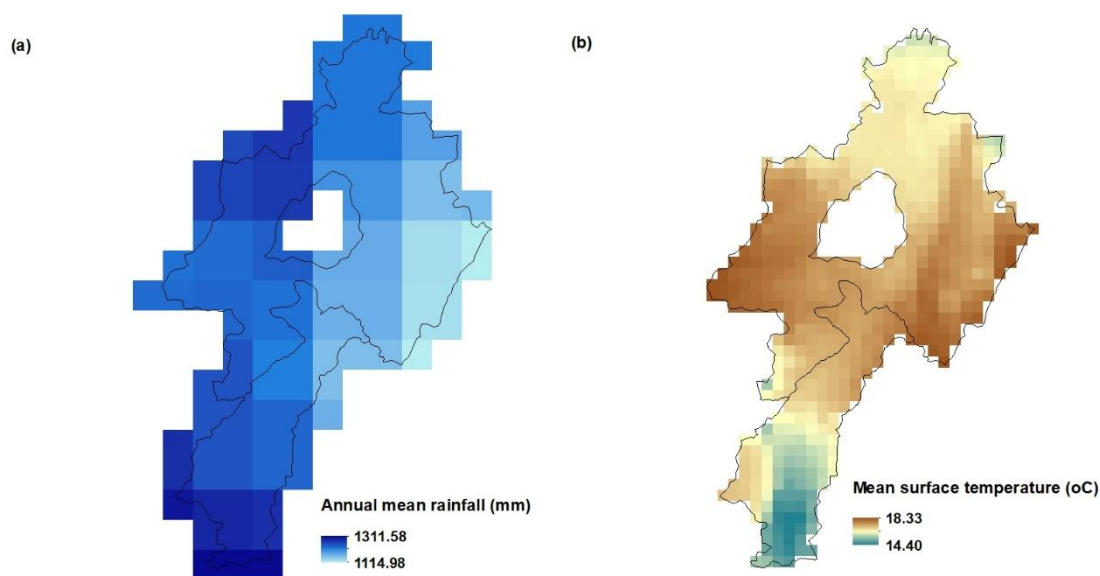


Figure 5. Annual mean rainfall (1981 to 2021) (a) and Mean Surface temperature (2000 to 2021) (b) maps of Doyogena(upper) and Lemo (lower) Woreda.

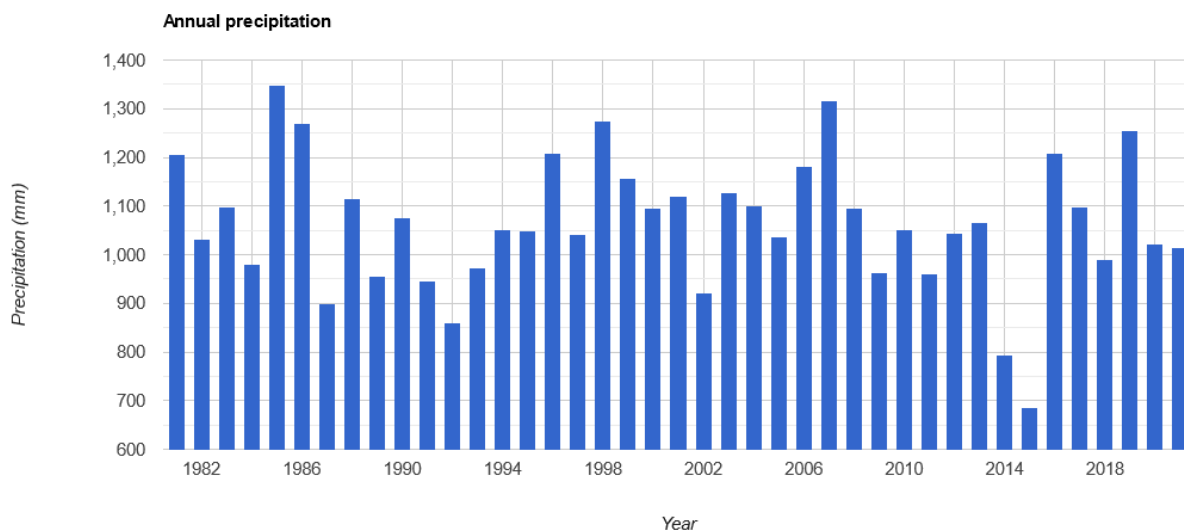


Figure 6. Temporal distributions of annual rainfall (1981 to 2021) over the Basona Worena Woreda of Amhara region.

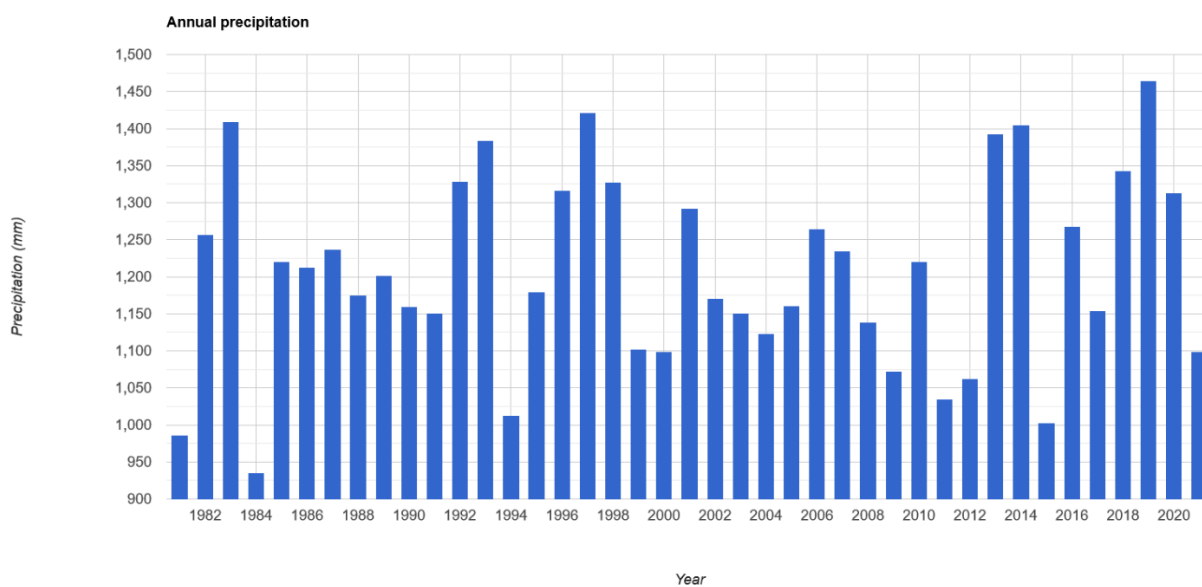


Figure 7. Temporal distributions of annual rainfall (1981 to 2021) over the Doyogena and Lemo Woreda in SNNP.

**Land use land cover:** PlanetScope satellite imagery for the period of 2022 (with a spatial resolution of 3.7 m) were used for the LULC analysis in the study area. Over 1100 sample points were used to train and validate nanoforest based classification model in the R working environment.

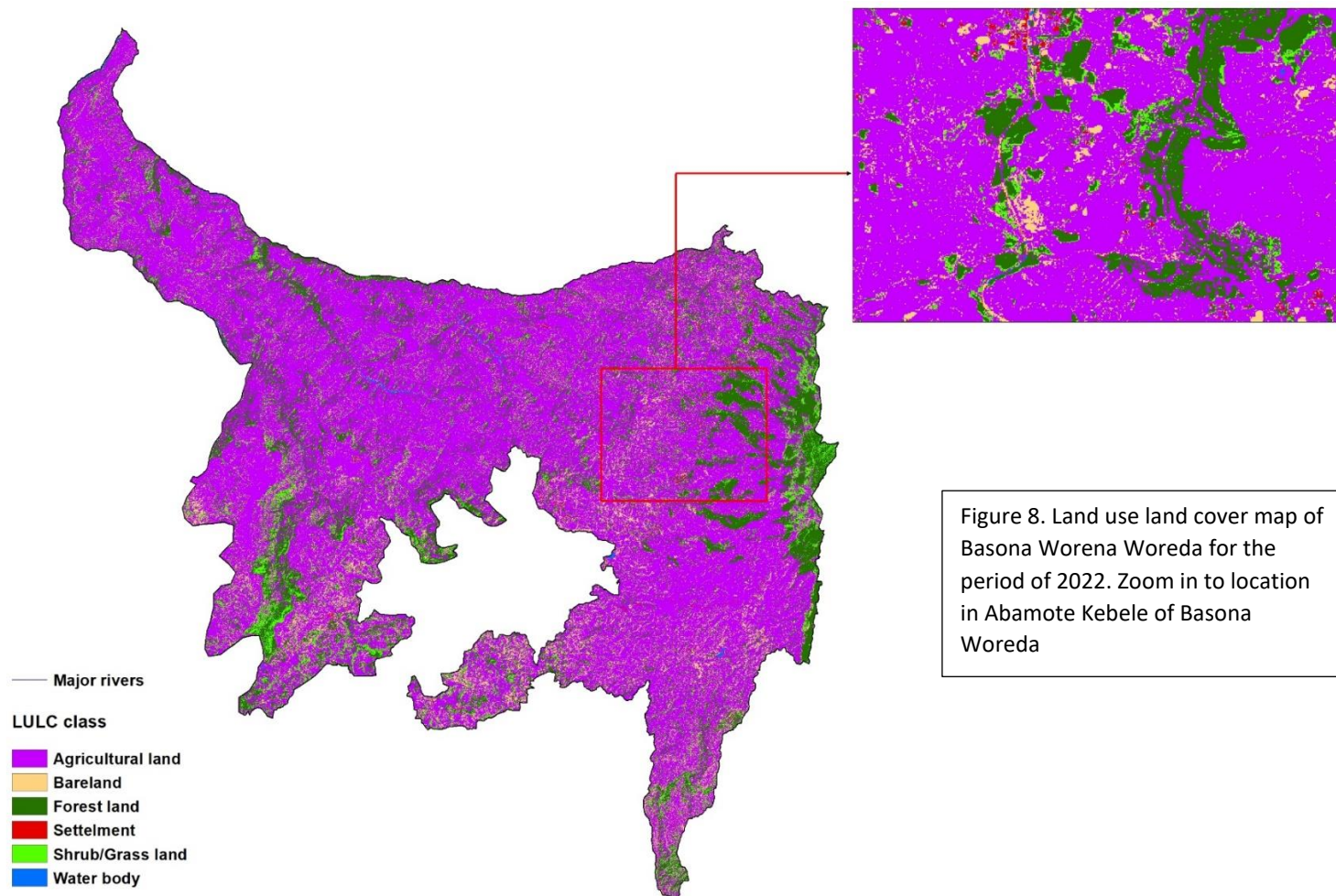


Figure 8. Land use land cover map of Basona Worena Woreda for the period of 2022. Zoom in to location in Abamote Kebele of Basona Woreda

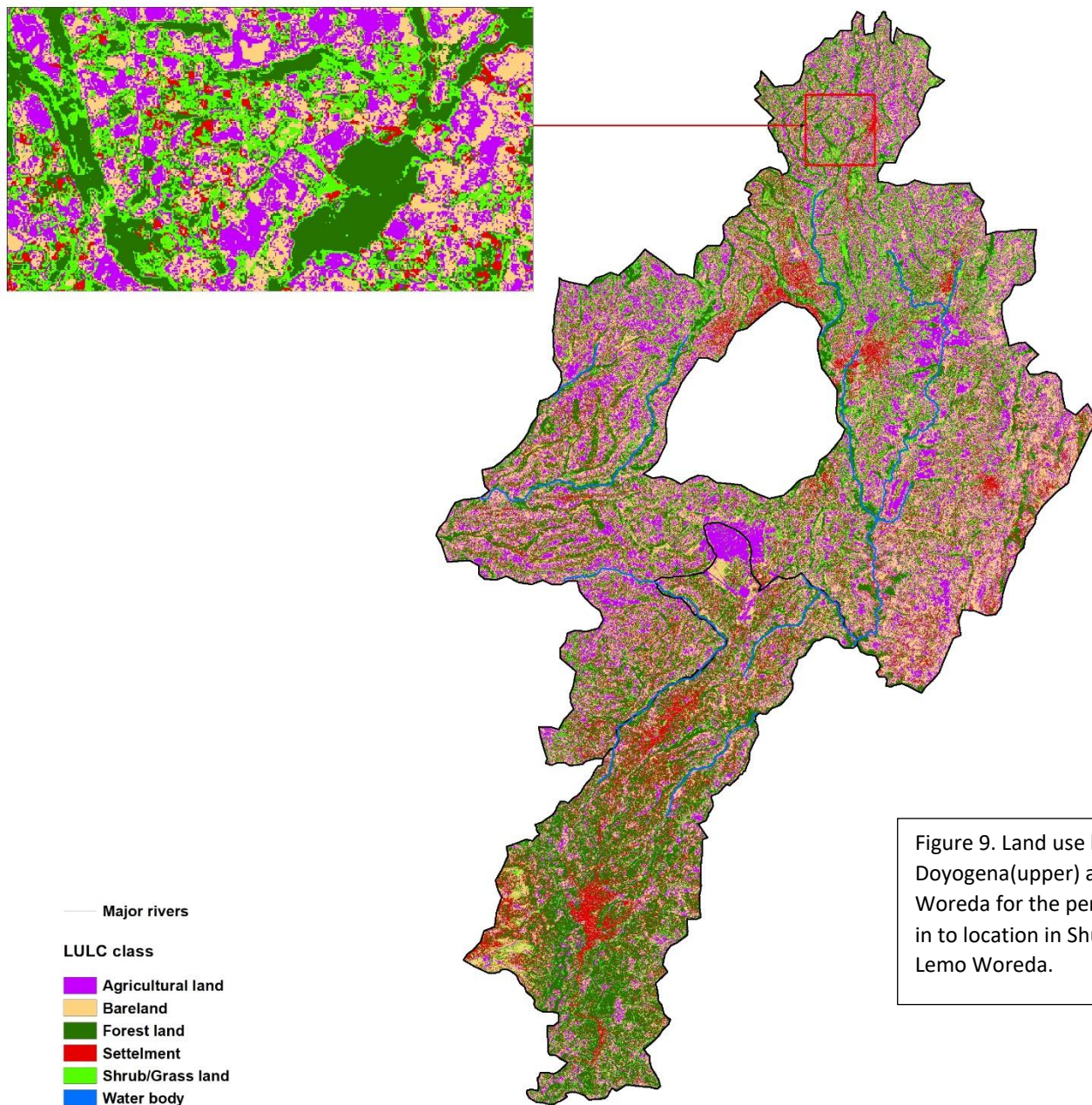


Figure 9. Land use land cover map of Doyogena(upper) and Lemo (lower) Woreda for the period of 2022. Zoom in to location in Shurmo Kebele of Lemo Woreda.

**Soil:** The soil of the study site was characterized based on the following soil physical and chemical properties- Soil pH, Soil depth, soil texture, soil type, Soil organic content, soil total nitrogen, and soil drainage class. The dataset was obtained from the iSDA soil database and from the digital soil map developed by CIAT-Ethiopia.

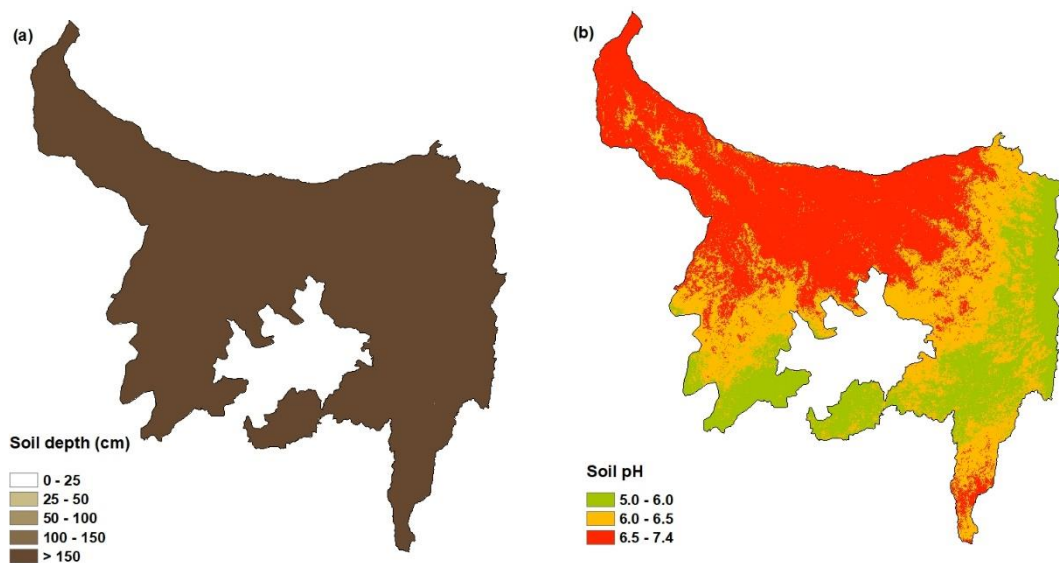


Figure 10. Soil depth (a) and Soil pH (b) maps of Basona Worena Woreda.

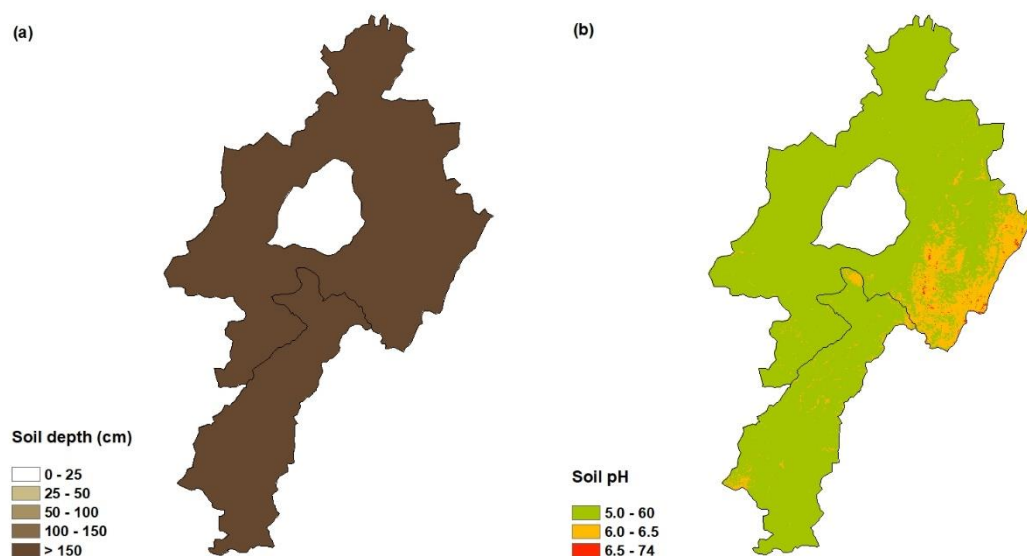


Figure 11. Soil depth (a) and Soil pH (b) maps of Doyogena (upper) and Lemo (lower) Woreda.

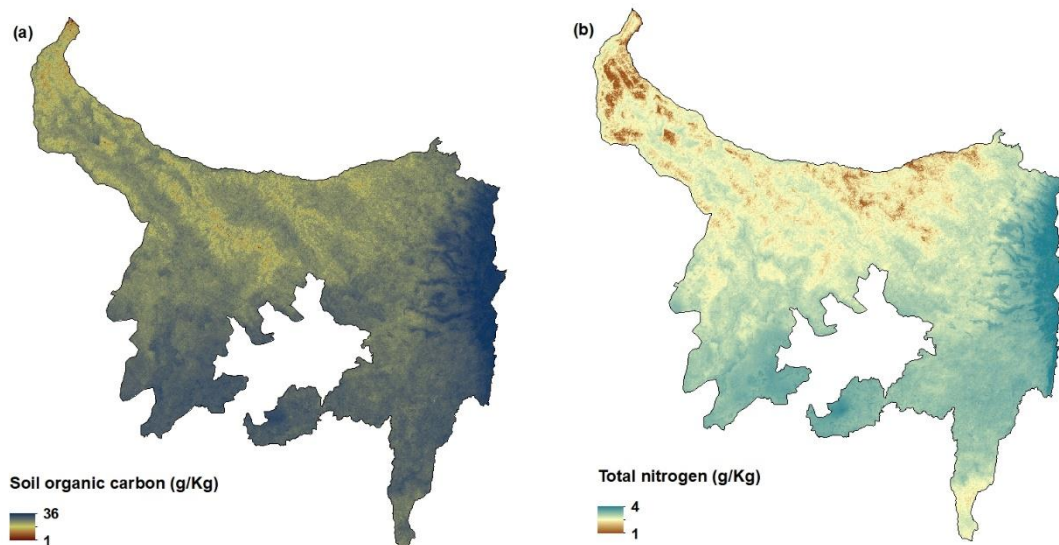


Figure 12. Soil organic carbon (a) and Soil total nitrogen (b) maps of Basona Worena Woreda.

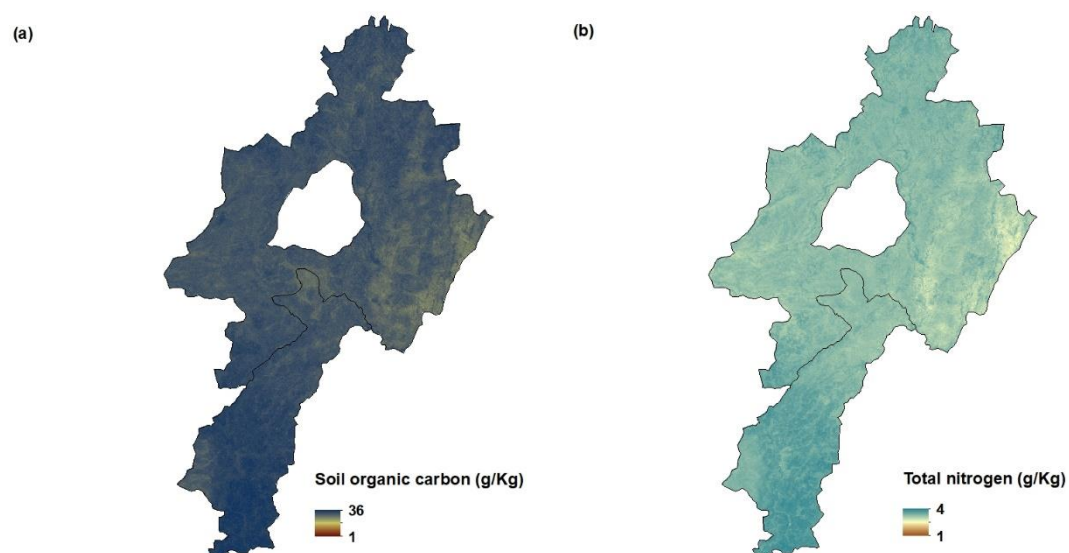


Figure 13. Soil organic carbon (a) and Soil total nitrogen (b) maps of Doyogena (upper) and Lemo (lower) Woreda.



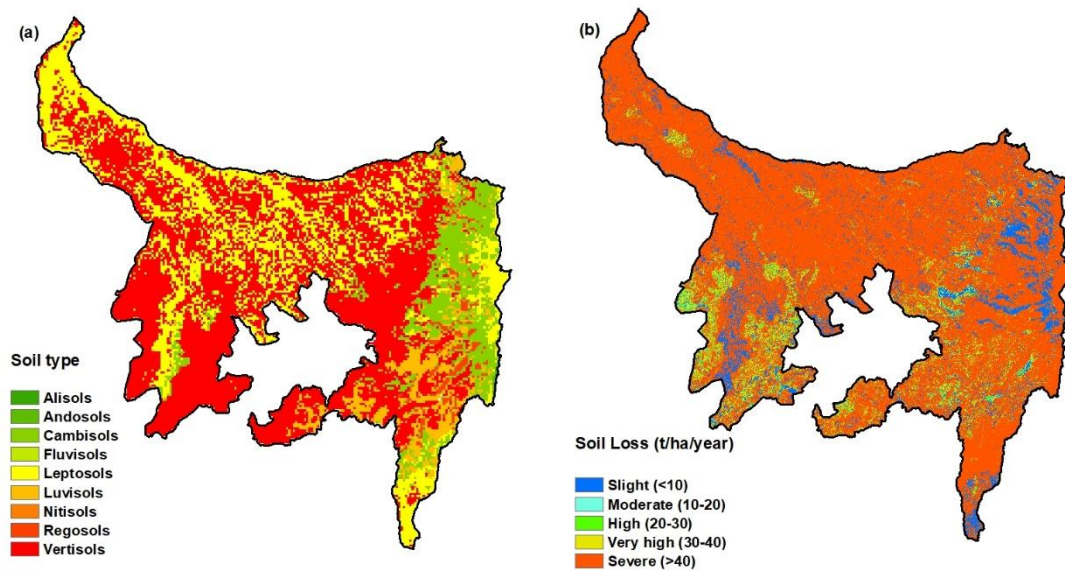


Figure 14. Soil type (a) and Soil loss (b) maps of Basona Worena Woreda.

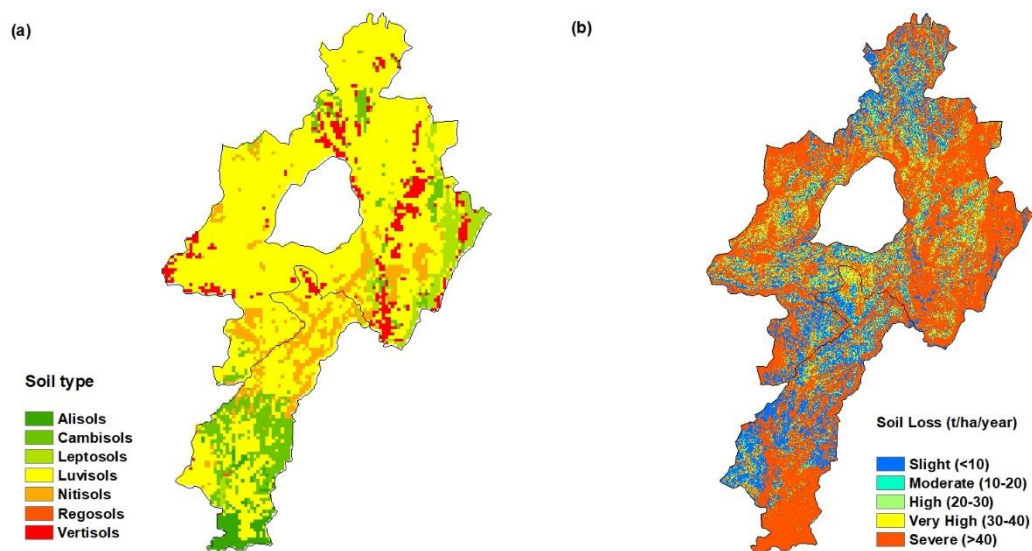


Figure 15. Soil type (a) and Soil loss (b) maps of Doyogena(upper) and Lemo (lower) Woreda.

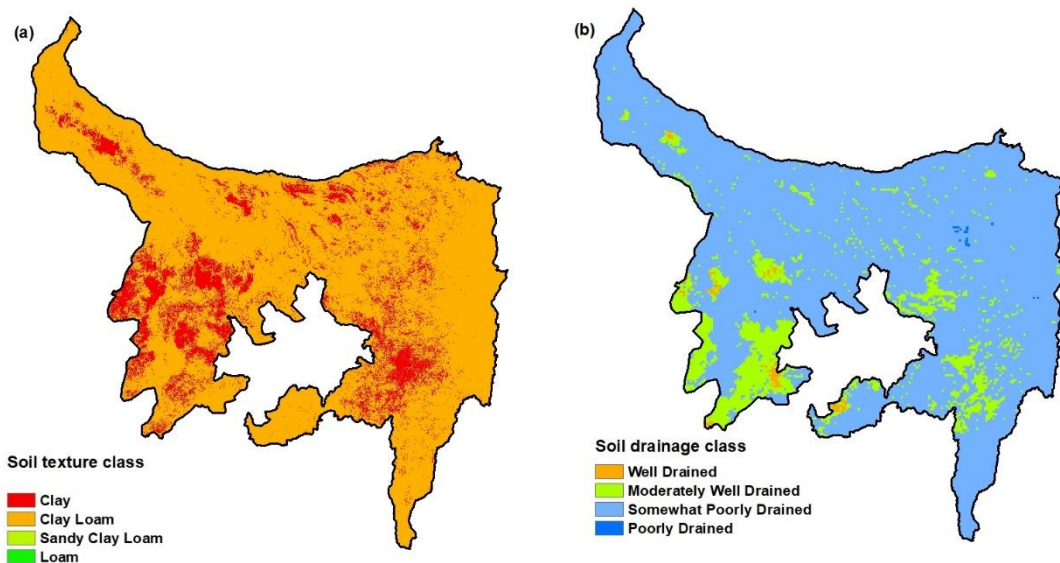


Figure 16. Soil texture class (a) and Soil drainage class (b) maps of Basona Worena Woreda.

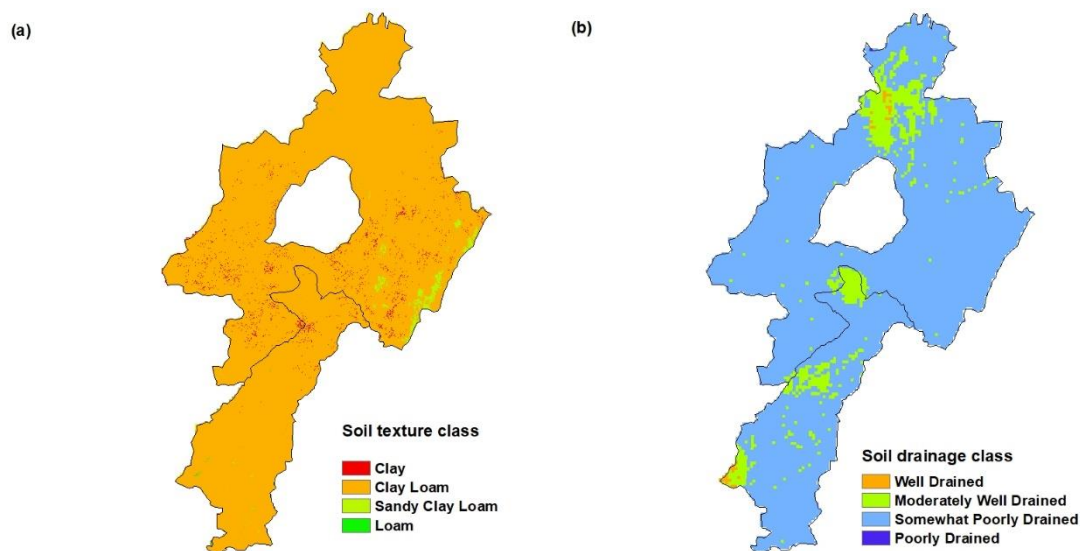


Figure 17. Soil texture class (a) and Soil drainage class (b) maps of Doyogena(upper) and Lemo (lower) Woreda.

**NPP and Carbon storage:** The Net Primary Production (NPP) and carbon storage were estimated using the MODIS Annual NPP product (for the period of 2021) and the WCMC Above and Below Ground Biomass Carbon Density. This dataset represents above- and below-ground terrestrial carbon storage (tonnes (t) of C per hectare (ha)) for 2010.

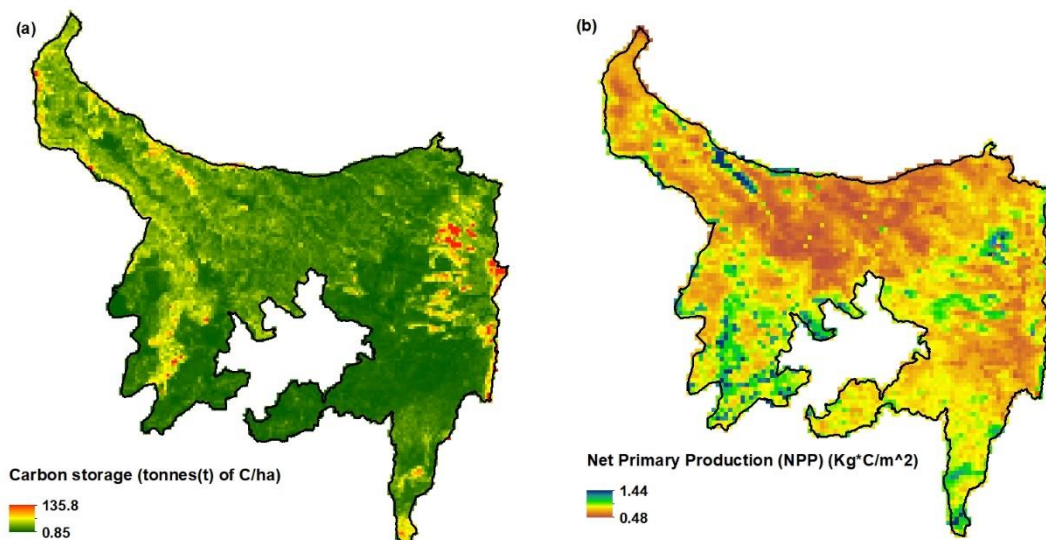


Figure 18. The above and below ground carbon storage (for 2010) (a) and annual Net Primary Production (for 2021) (b) maps of Basona Worena Woreda.

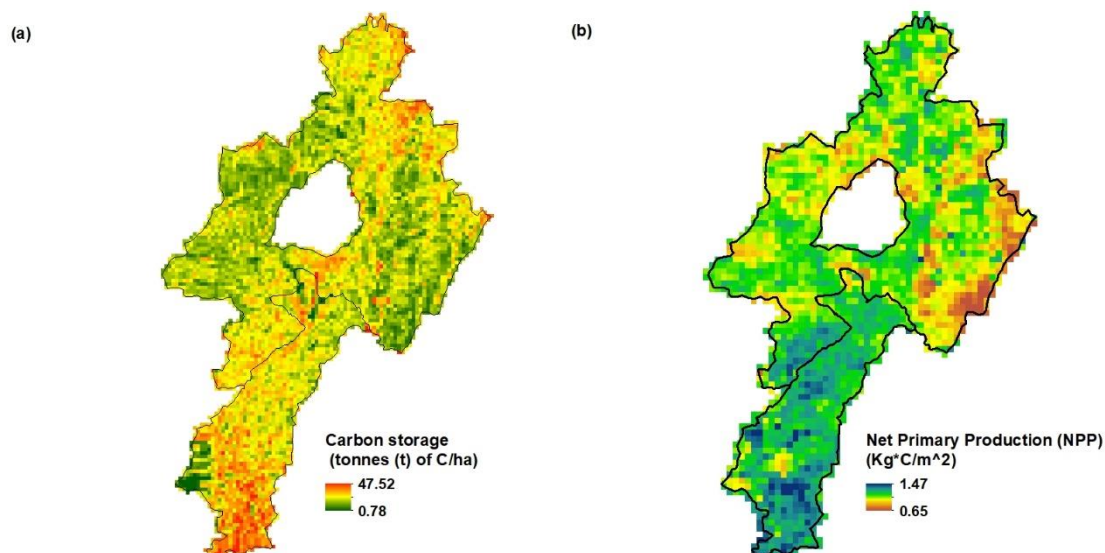


Figure 19. The above and below ground carbon storage (for 2010) (a) and annual Net Primary Production (for 2021) (b) maps of Doyogena(upper) and Lemo (lower) Woreda.