FOLUR Project "Preventing Forest Loss, Promoting Restoration, and Integrating Sustainability into Ethiopia's Coffee Value Chains and Food Systems"

TITLE: Forest Cover Change Analysis in Ethiopia's Coffee Forest Systems: A Case Study of the 22 project Woredas

February, 2026

Addis Ababa

1. Introduction

Forests are essential components of Ethiopia's environmental and economic landscape, providing critical ecosystem services and supporting the livelihoods of millions (Solomon, et al., 2018[1]). Known for its unique biodiversity, Ethiopia's coffee forests hold immense ecological and cultural significance. These forests not only contribute to local economies through coffee production but also play a key role in carbon sequestration and climate regulation (Tigabu & Gessesse, 2025[2]). However, rapid changes in land use, driven by agricultural expansion and urbanization, threaten the integrity of these vital ecosystems.

The importance of understanding forest cover dynamics cannot be overstated, particularly in the context of Ethiopia's Coffee Forest Systems. Climate change and unsustainable land practices challenge the sustainability of these forests, necessitating detailed assessments of forest cover change (Debebe et al., 20233). The need for accurate data has led to the implementation of various initiatives, including the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program, which aims to mitigate emissions by protecting forest resources(Dessie & Kleman, 20074). Despite these efforts, there remains a significant gap in comprehensive analyses of forest cover changes affecting Ethiopia's coffee regions.

In addition, our study examines the socio-economic pressures that influence forest cover in these weredas. Issues such as land tenure insecurity, agricultural intensification, and population growth are critical in shaping land-use patterns. It is integrating environmental data with socio-economic factors seeks to offer insights into the complexities surrounding forest management strategies (Tola et al., 2023). These findings will be crucial for

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[1] Solomon, N., Hishe, H., Annang, T., Pabi, O., Asante, I. K., & Birhane, E. (2018). Forest cover change, key drivers and community perception in Wujig Mahgo Waren forest of Northern Ethiopia. *Land*, *7*(1), 32. https://doi.org/10.3390/land7010032.

[2] Tigabu, A., & Gessesse, A. A. (2025). Mapping forest cover change and estimating carbon stock using satellite-derived vegetation indices in Alemsaga forest, Ethiopia. *PLOS ONE*, *20*(2), e0310780. https://doi.org/10.1371/journal.pone.0310780.

[3] Debebe, B., Senbeta, F., Teferi, E., Diriba, D., & Teketay, D. (2023). Analysis of forest cover change and its drivers in biodiversity hotspot areas of the Semien Mountains National Park, Northwest Ethiopia. *Sustainability*, *15*(4), 3001. https://doi.org/10.3390/su15043001.

[4] **Dessie, G., & Kleman, J. (2007).** Pattern and magnitude of deforestation in the South Central Rift Valley region of Ethiopia. *Mountain Research and Development*, *27*(2), 162–168. https://doi.org/10.1659/mrd.0730.

policymakers and stakeholders aiming to develop sustainable land-use practices that balance environmental conservation with economic development.

This study focuses on a geospatial analysis of forest cover change in 22 selected weredas that are part of Ethiopia's coffee forest systems. Using advanced satellite imagery and Geographic Information System (GIS) tools, it aims to quantify and visualize the extent of deforestation and forest degradation trends over recent decades. It provides empirical data on forest cover changes this research contributes to a better understanding of the factors driving these transformations and their implications for local communities and biodiversity.

Ultimately, this research aims to inform future strategies for forest management in Ethiopia’s coffee forest systems. It identifies areas of significant change and understanding causes to contribute to more effective conservation initiatives that protect both the ecological integrity of Ethiopia's forests and the livelihoods that depend on them. The insights gained from this study will be invaluable in guiding future conservation efforts and achieving sustainable development goals in the regions and program area.

2. Objectives

2.1. General Objective

To conduct a high-resolution forest geospatial analysis for the FOLUR Impact Program covering 22 Woredas’ to determine the forest cover changes between 2016 and 2025.

2.2. Specific Objectives

- Generate an accurate, high-resolution spatial map of forest cover change for the project Woredas and draw recommendations points for conservation.

3. Methodology

This study employs a robust, satellite-based approach to map forest cover of FOLUR project woredas, for the year 2024, utilizing high-resolution Planet NICFI imagery and advanced geospatial processing techniques. The methodology consists of data acquisition, preprocessing, and classification.

3.1. Satellite Data Acquisition

3.1.1. Planet NICFI Imagery

To achieve high-precision forest cover mapping, Planet NICFI (Norway's International Climate & Forests Initiative) Level-1 satellite imagery was selected due to its:

- High spatial resolution (4.77 m), enabling detection of small forest patches and fragmented landscapes.
- Monthly temporal coverage, ensuring up-to-date observations.
- Free availability for tropical regions, making it cost-effective for large-scale forest monitoring.
- Consistent acquisition schedule, reducing gaps in data availability.

3.1.2. Image Selection & Mosaicking:

- Timeframe: December 2024 – January 2025 (minimizing cloud interference and optimizing vegetation visibility).
- Processing Platform: The System for Earth Observation Data Access, Processing, and Analysis for Land Monitoring (SEPAL), developed by the Food and Agriculture Organization (FAO), was used to download, mosaic, preprocess and classify the imagery.

3.1.3. Data Processing Using SEPAL

- SEPAL, a cloud-based geospatial platform, was chosen for its ability to streamline large-scale forest monitoring with:
  - Automated cloud and shadow masking (reducing manual errors).
  - Multi-temporal compositing (enhancing image clarity).
  - Integration with machine learning classifiers (facilitating accurate land cover classification).

3.2. Forest Cover Classification Approach

A supervised classification workflow was implemented, combining spectral analysis, and vegetation indices to distinguish forest from non-forest areas.

3.2.1. Preprocessing

1. Cloud & Shadow Removal:
   - SEPAL's built-in Quality Assessment (QA) masks were applied to filter clouds, haze, and shadows.

    - Visual inspection ensured radiometric consistency across mosaics.
2. Image Enhancement:
    - Normalized Difference Vegetation Index (NDVI) was computed to improve vegetation detection.

3.2.2. Training Data Collection

- Reference Samples:
    - Forest & non-Forest training points were manually collected using:
        - Planet NICFI imagery (primary source).
        - Google Earth high-resolution basemaps (secondary validation).

3.2.3. Classification Algorithm

The Random Forest (RF) classifier was selected due to its:

- Robustness against overfitting and noise.
- Ability to handle non-linear spectral relationships.
- High performance in heterogeneous landscapes.

Input Features:

- Spectral bands (Red, Green, Blue, Near-Infrared).
- Derived indices (NDVI).

4. Result and Discussion

4.1. Forest Cover Changes in Woredas with Over 50% Coverage

Result in Fig-1 shows analysis of forest cover within several weredas, a notable classification has emerged indicating high forest cover levels, defined as areas with more than 50% tree cover. This category, encompassing a range from 51% to 100%, includes six weredas: Yayu, Sheko, Guraferda, Chora, Goma, and Kercha. Each of these areas demonstrates significant forest retention, which is crucial for biodiversity, climate regulation, and the livelihood of local communities. Among the high forest cover weredas, Yayu leads with impressive forest coverage of 82%, positioning it as a critical ecological zone that likely supports diverse species and rich habitats. Sheko follows closely at 77%, evidencing a strong environmental stewardship that might be attributed to community engagement or effective forestry policies. In contrast, while Guraferda (70%), Chora (58%), and Goma (57%) maintain substantial forest areas, their slightly lower percentages suggest opportunities for conservation and sustainable management practices to enhance forest resilience.

The high forest cover documented in these weredas implies several environmental benefits, including the preservation of ecosystems and habitats essential for wildlife. The substantial tree cover acts as a carbon sink, contributing significantly to global carbon sequestration efforts (Tebkew et al., 2025[5]). Furthermore, these forests are likely to play a critical role in maintaining watershed health, reducing soil erosion, and enhancing local climate conditions, which is vital for agricultural practices in surrounding areas (Adisu et al., 2026[6]).

The high level of forest cover is not just an environmental asset but also a socioeconomic benefit for the communities residing in these weredas. Forests provide resources such as timber, non-timber forest products, and raw materials for livelihoods (Shiferaw et al., 2023[7]). The maintenance of such forest systems may facilitate ecotourism opportunities, promoting economic diversification while preserving natural habitats. However, it is essential to balance resource extraction with sustainable practices to prevent overexploitation and ensure that these communities continue to benefit from their natural resources (Girma et al., 2023[8]).

[5] **Tebkew, M., Mengie, T., & Szemethy, L. (2025).** "Outcomes of Community-Based Forest Management for Biodiversity Conservation in Northwest Ethiopia." *Forests (MDPI)*, 16(9), 1488–1505.
[6] **Adisu, S., Aga, A. M., Moisa, M. B., Tadesse, A. W., & Jing, L. (2026).** "Spatiotemporal Analysis of Forest Cover Change in Southwestern Ethiopia: Revealing Degradation Pathways and Management Implications." *Trees, Forests and People*, 24, 101181.
[7] **Shiferaw, M., Kebebew, Z., & Gemeda, D. O. (2023).** "Effect of Forest Cover Change on Ecosystem Services in Central Highlands of Ethiopia: A Case of Wof-Washa Forest." *Heliyon*, 9(7), e18173.
[8] **Girma, G., Tilahun, S. A., Moges, M. M., Wondie, A., & McClain, M. E. (2023).** "Participatory Forest Management for Improving Livelihood Assets and Mitigating Forest Degradation: Lessons Drawn from the Central Rift." *Current Research in Environmental Sustainability*, 5(1), 100205.

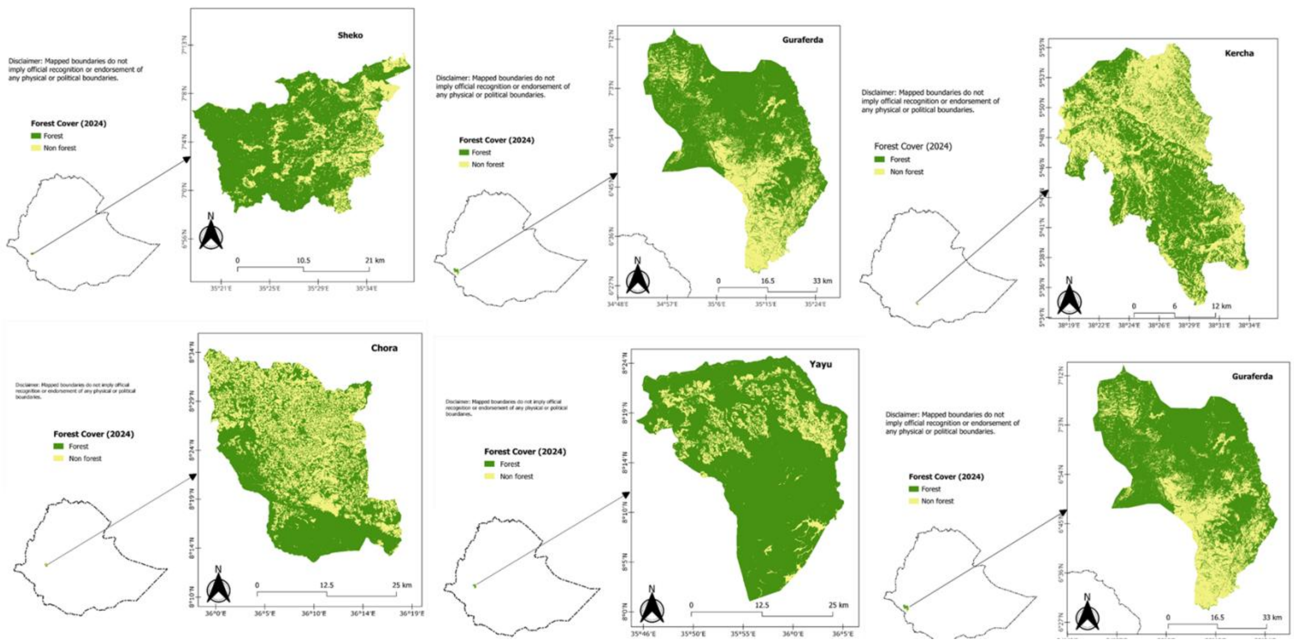

Figure 1- depicting High Forest Cover wereda which is above 50% forest cover

4.2. Medium category Forest covers Change for Woredas (26% to 50%)

Result in Fig-2 shows forest cover in various weredas has revealed significant findings regarding areas characterized by medium forest cover, defined as those with tree cover ranging from 26% to 50%. This category includes five weredas: Gimbo, Nensebo, Decha, Bulehora, and Shisho Ande, each demonstrating varying degrees of forest retention that are critical for local ecosystems and communities.

Gimbo and Nensebo are at the forefront of this category, both exhibiting a forest cover percentage of 42%. This level of coverage suggests that these areas are crucial for local biodiversity and can play a role in carbon sequestration efforts. Their relatively healthy forest ecosystems may provide important resources for local communities, along with opportunities for sustainable practices in forestry. Decha, with a forest cover of 41%, similarly indicates that it could benefit from conservation strategies aimed at enhancing its ecological integrity.

In contrast, Bulehora and Shisho Ande show forest cover percentages of 39% and 33%, respectively. These numbers reflect a concerning trend, as lower forest cover could lead to increased vulnerabilities in the local environment (Mengistu et al., 2025[9]). Reduced tree cover may mean fewer habitats for wildlife, increased soil erosion, and diminished capacity for carbon storage, which is vital in combating climate change (Ahmed & Lemessa, 2025[10]). The communities in these areas face greater risks related to environmental degradation, necessitating prompt attention to forest management practices.

The medium forest cover observed in these weredas has both environmental and socioeconomic implications. Forest ecosystems serve as vital resources for local populations, providing timber, fuelwood, and non-timber products necessary for livelihoods (Demisse et al., 2024[11]). However, the balance between resource utilization and conservation is delicate. Sustainable practices, including community forestry initiatives and reforestation efforts, are imperative to enhance forest health and productivity.

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[9] **Mengistu, T., Tilahun, M., Wei, W., Tsegaye, L., & Girma, T. (2025).** "Restoration Success Stories: Evidence from Gurage and Wolaita Zones under the GLI Framework." *Alliance of Bioversity International Publication*, 3(1), 12–19.

[10] **Ahmed, S. & Lemessa, D. (2025).** "Patterns and Drivers of Above- and Below-ground Carbon Stock in Afromontane Forest of Southern Ethiopia." *Tropical Ecology*, **66(1)**, 88–104.

[11] **Demisse, B. A., Dittoh, S., Salifu, E., Moges, M. M., & Belete, M. D. (2024).** "The Impact of Ethiopian Green Legacy Initiative (GLI) on Landscape Functionality and Plant Species Diversity in Lake Hawassa Watershed." *Ecohydrology*, 17(3), e2676.

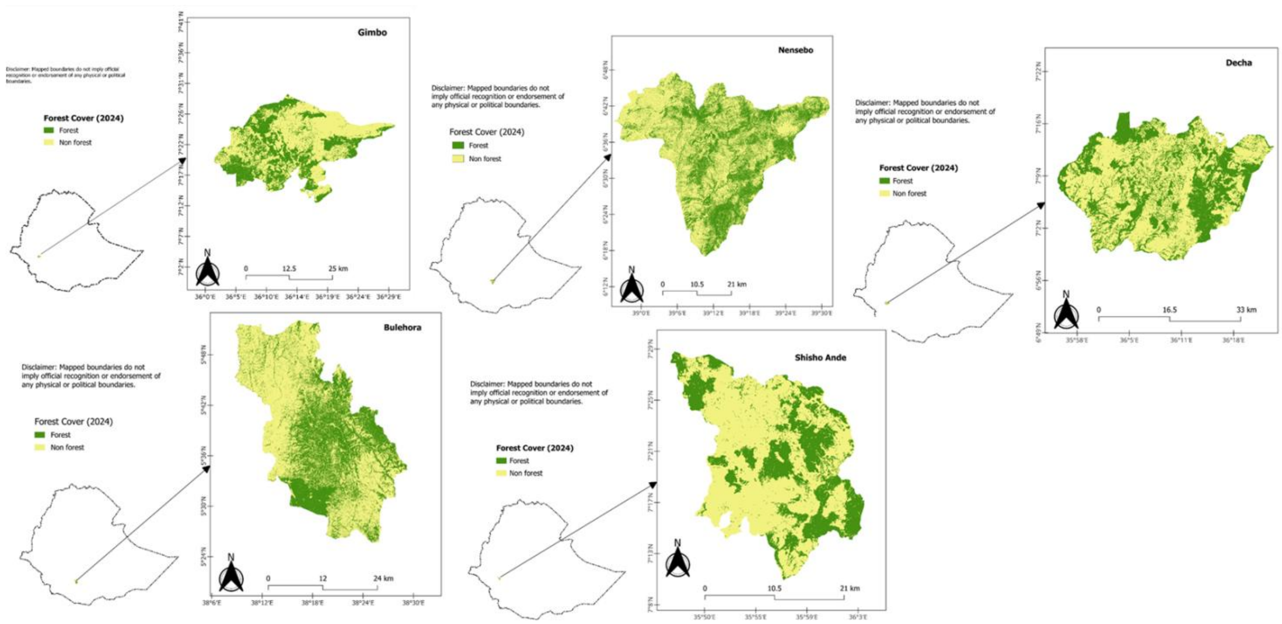

Figure 2_ Depicting Medium Forest Cover (26% to 50%)

4.3. Lower category Woredas in Forest covers Change (0% to 25%)

Result in Fig-3 analysis of forest cover has unveiled critical insights regarding areas with low forest cover, defined as those having tree cover between 0% and 25%. This category encompasses a number of weredas, including Yirgachefe, Dodola, Shay Bench, Chire, Adaba, Kochere, Bensa, Kersa, Wenago, Abaya, and Dale. The range of forest cover in these regions highlights significant ecological challenges that are vital for local environmental stability and community resilience.

Yirgachefe stands at the highest end of this category with a forest cover of 24%. This level, while the highest among the low cover weredas, indicates considerable ecological pressures that could jeopardize biodiversity and exacerbate issues such as soil erosion and climate vulnerability. Dodola and Shay Bench follow closely with forest cover percentages of 22% and 21%, respectively. The limited tree cover in these areas suggests a critical need for immediate interventions to enhance forest restoration and conservation efforts, as they may face significant degradation and loss of ecosystem services (Ahmed & Temessa, 2025[12]).

The other weredas, including Chire, Adaba, and Kochere, exhibit even lower forest covers, ranging from 19% to 21%. This declining trend poses serious risks not only to local wildlife but also to the communities that depend on forests for their livelihoods. Limited forest resources can lead to increased reliance on alternative, often unsustainable, practices, exacerbating environmental degradation and reducing the capacity of the land to support agriculture and other economic activities. The stark low forest cover percentages observed in Bensa (13%), Kersa (10%), and Wenago (7%) indicate areas that may be on the brink of ecological collapse, necessitating urgent conservation measures.

Abaya and Dale, with even lower forest covers of 6% and 4%, represent the most critical situations within this category. These weredas are likely experiencing severe habitat loss and the negative effects of climate change, leading to diminished natural resources essential for human survival. The implications of low forest cover are dire, highlighting the pressing need for sustainable land management practices that prioritize reforestation, soil conservation, and community engagement in environmental stewardship (Kassaye et al., 2025[13]).

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[12] **Ahmed, S. & Temessa, D. (2025).** "Patterns and Drivers of Above- and Below-ground Carbon Stock in Afromontane Forest of Southern Ethiopia." *Tropical Ecology*, **66(1)**, 88–104.

[13] **Kassaye, M., Emiru, E., & Tsega, A. (2025).** "Carbon Stock Dynamics in Ethiopian Forests: A Systematic Review for Sustainable Forest Management towards Climate Change Mitigation." *Trees, Forests and People*, **21**, 100841.

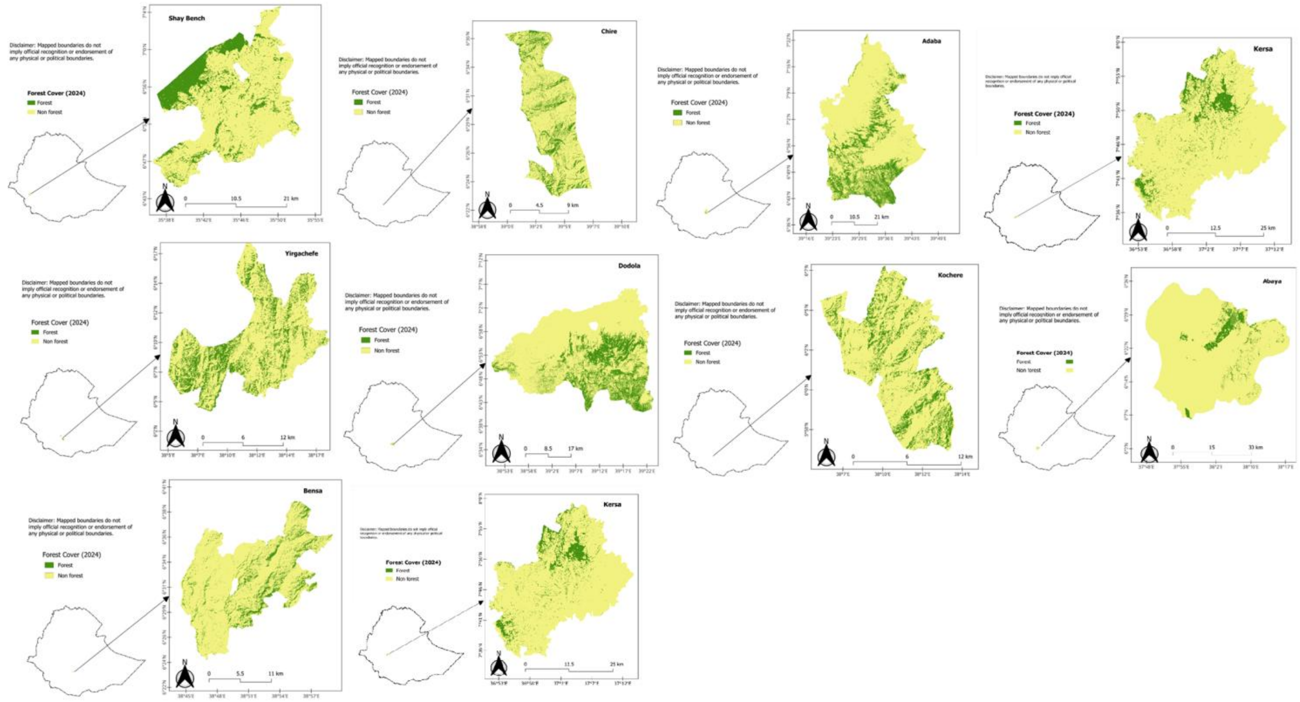

Figure 3- Depicting High Forest Cover wereda which have Low Forest Cover (0% to 25%)

5. Conclusion and Recommendation

Regarding the high forest as moving forward, strategic recommendations should focus on the sustainable management of these high forest cover areas. This includes the implementation of community-led conservation initiatives, the establishment of protected areas to safeguard critical habitats, and policies that encourage reforestation and afforestation. Additionally, integrating traditional ecological knowledge with scientific approaches could enhance resource management and fulfill conservation goals. Collaborative efforts among stakeholders, including local communities, government agencies, and environmental NGOs, will be essential to ensure the ongoing health and sustainability of these vital forest ecosystems.

The medium forest cover wereda in order to ensure the sustainability of these medium forest cover areas, several strategic recommendations can be implemented. These include promoting community involvement in forestry management, increasing awareness about the benefits of maintaining healthy forests, and implementing policies aimed at forest restoration. Collaboration among local governments, NGOs, and community members will be essential in fostering resilience within these ecosystems and balancing economic needs with environmental stewardship. This is done by strengthening the management of medium forest cover weredas, we can work towards a more sustainable future for both the environment and local communities.

With respect to low forest cover wereda in order to address the challenges in these weredas, strategic actions must be undertaken. These include implementing grassroots reforestation initiatives, promoting agroforestry practices, and raising awareness about the significance of forest conservation among local populations. Additionally, collaboration with stakeholders such as government agencies, NGOs, and local communities will be crucial in mobilizing resources and developing comprehensive strategies to restore forest ecosystems. This is done by focusing on these urgent measures, it is possible to reverse the trends of deforestation and foster a more sustainable environment for both the ecosystems and the communities that depend on them.

- Implement Community-Led Conservation Initiatives
- Strengthen Collaborative Efforts for Forest Restoration
- Establish Protected Areas and Raise Awareness

6. Annex

The resulting data, detailed in Table 1, indicates the forest area in hectares for each woreda. Additionally, Figures 1 - 22 illustrate the spatial locations of these forests. The forest cover ranges from 4 % (Dale woreda) to 82 % (Yayu woreda). This information helps to differentiate fragmented natural forests that should be reconnected through establishing corridors for connecting fragmented habitats. It also helps to identify which woredas have to focus on conservation of existing natural forests and restoration of degraded forests.

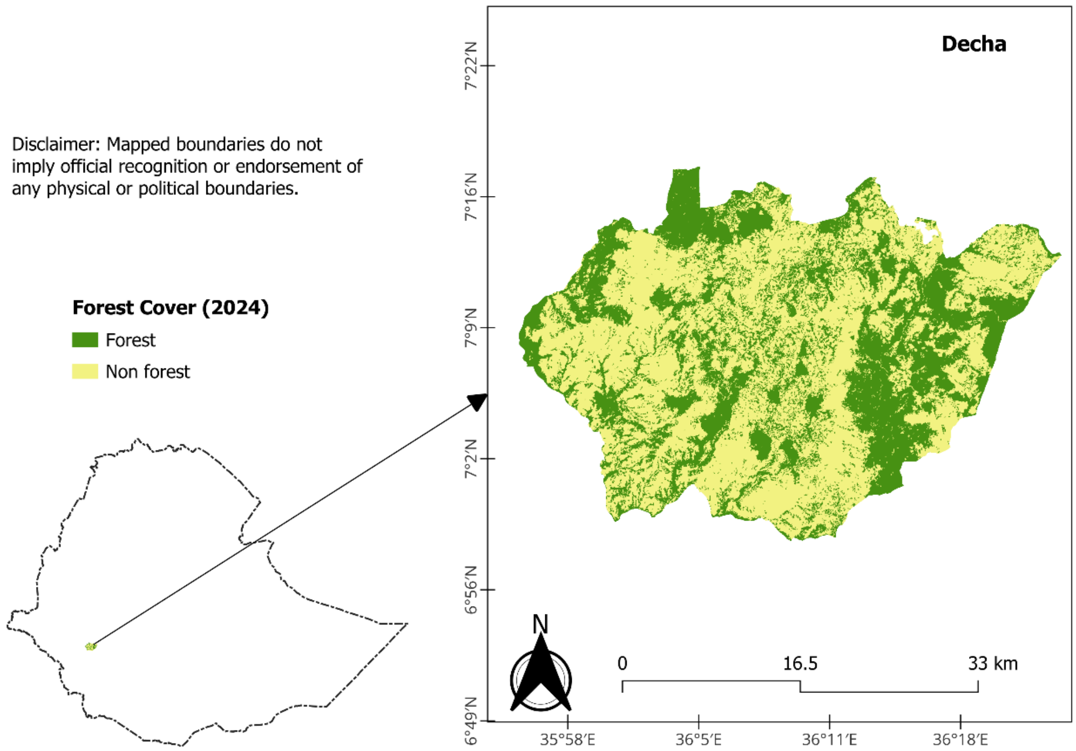

Figure 1: Land cover map of Decha woreda for the year 2024

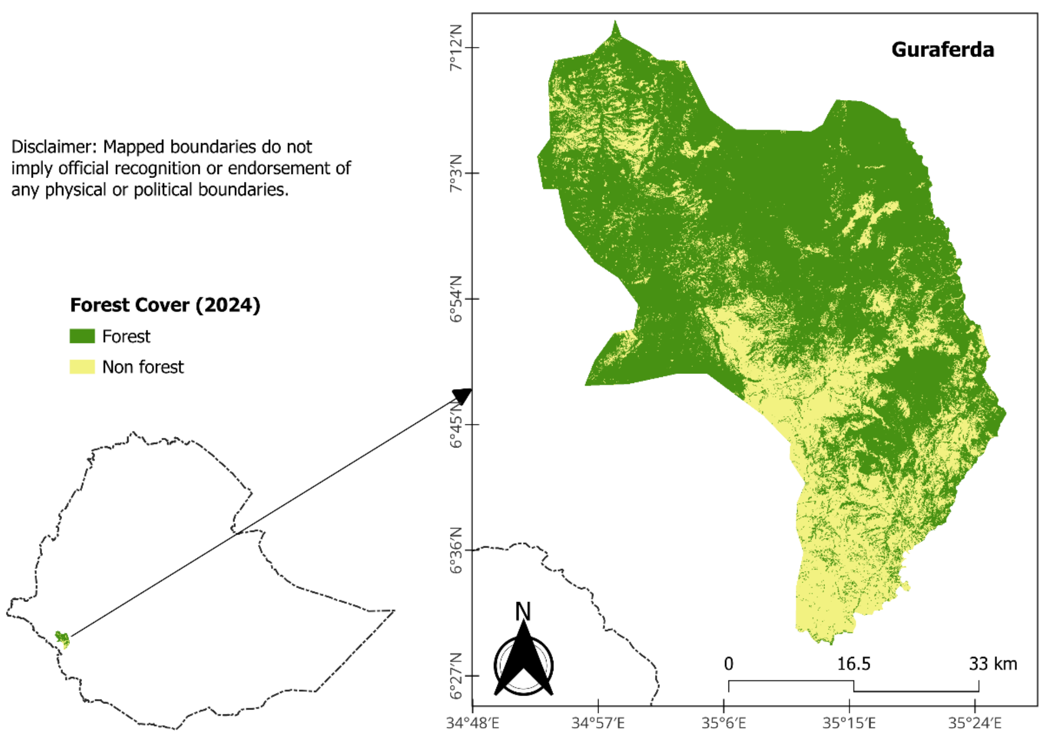

Figure 2: Forest cover map of Guraferda woreda for the year 2024

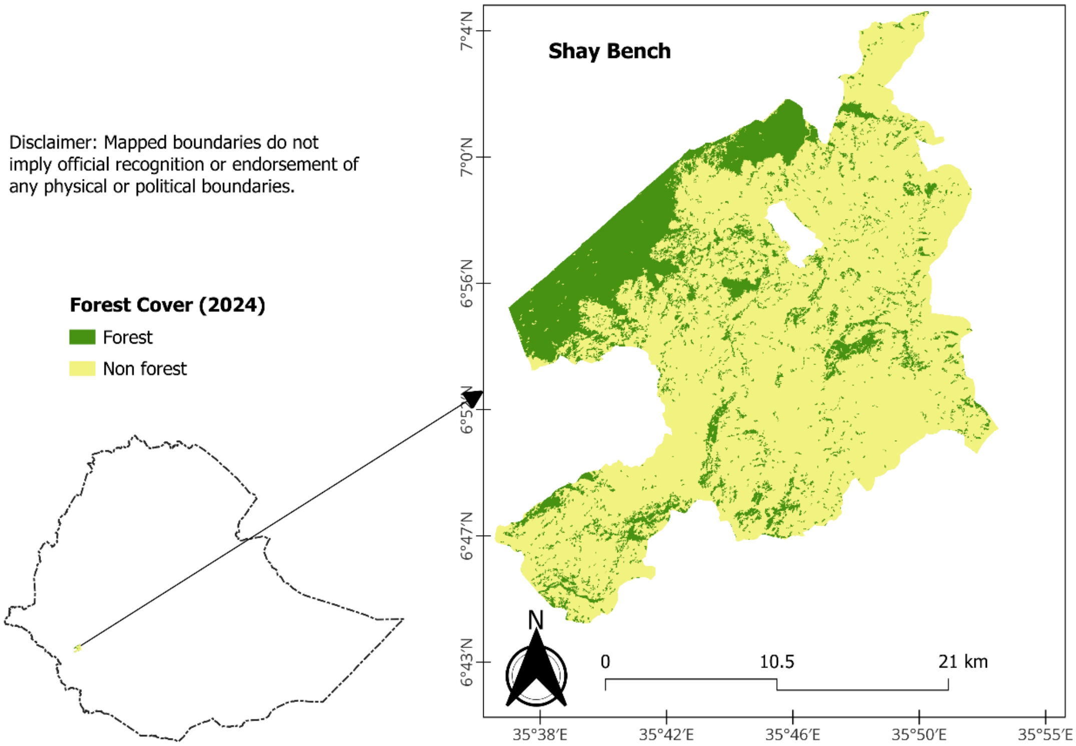

Figure 3: Land cover map of Shay Bench woreda for the year 2024

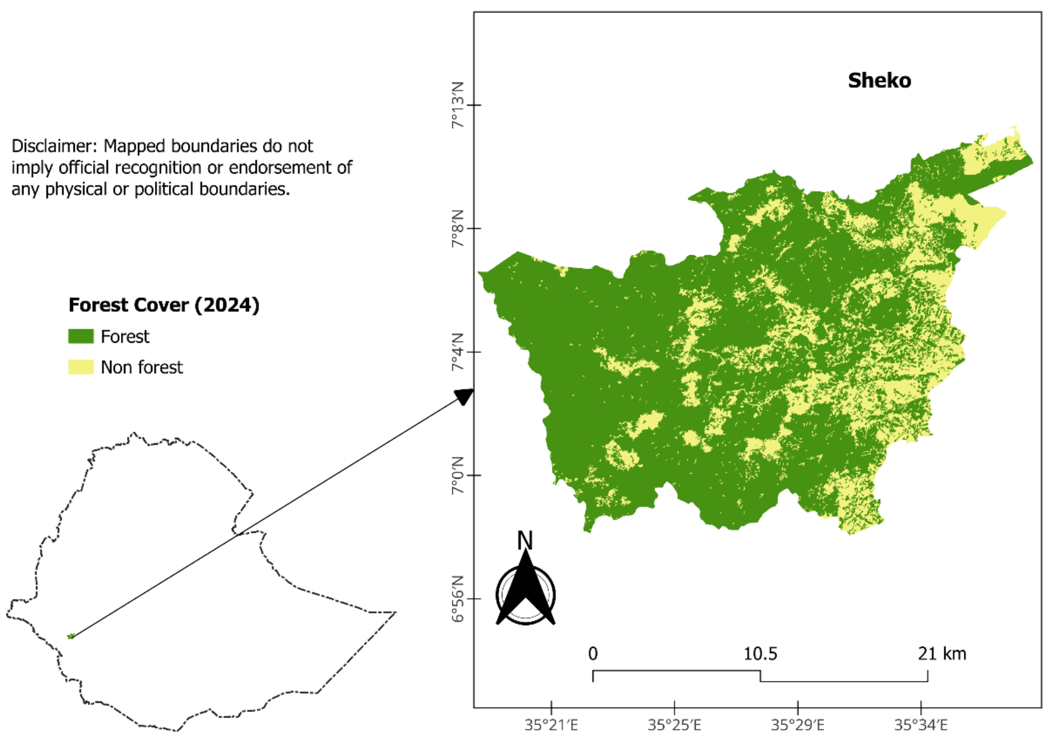

Figure 4: Forest cover map of Sheko woreda for the year 2024

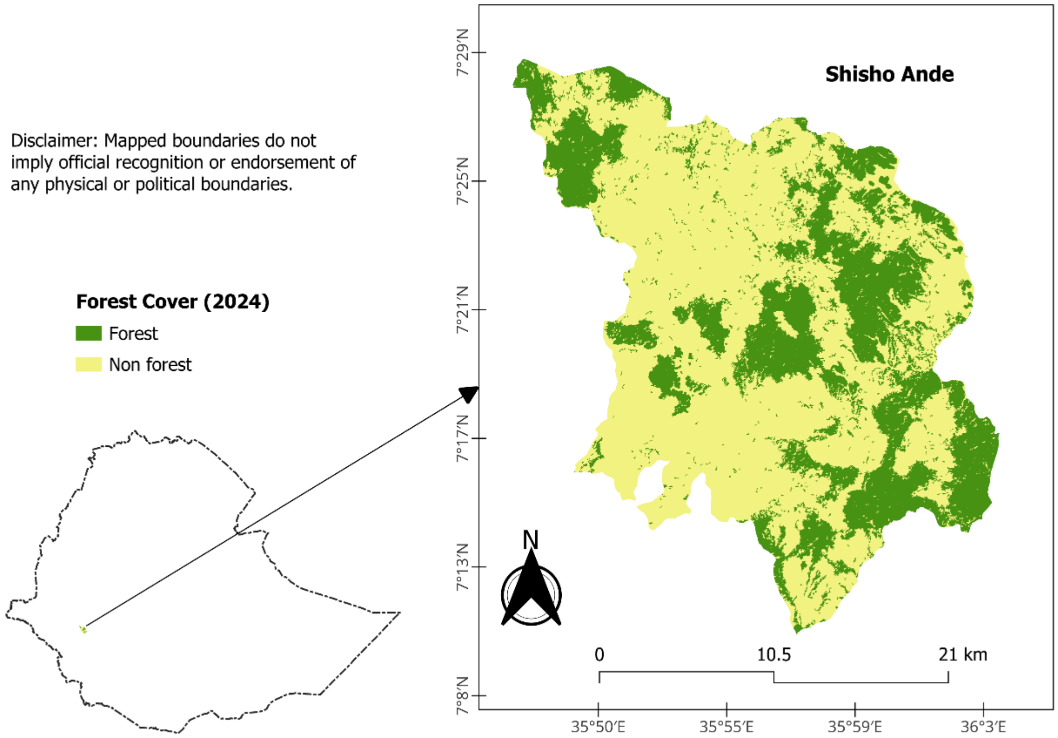

Figure 5: Land cover map of Shisho Ande woreda for the year 2024

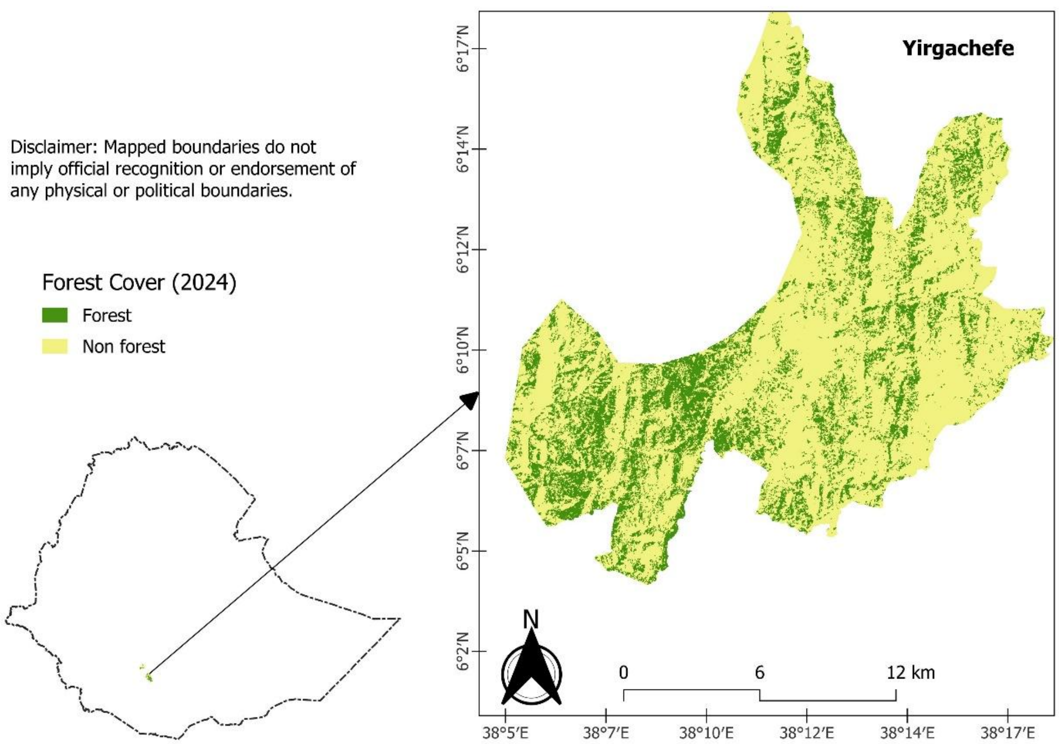

Figure 6: Forest cover map of Yirgachefe woreda for the year 2024

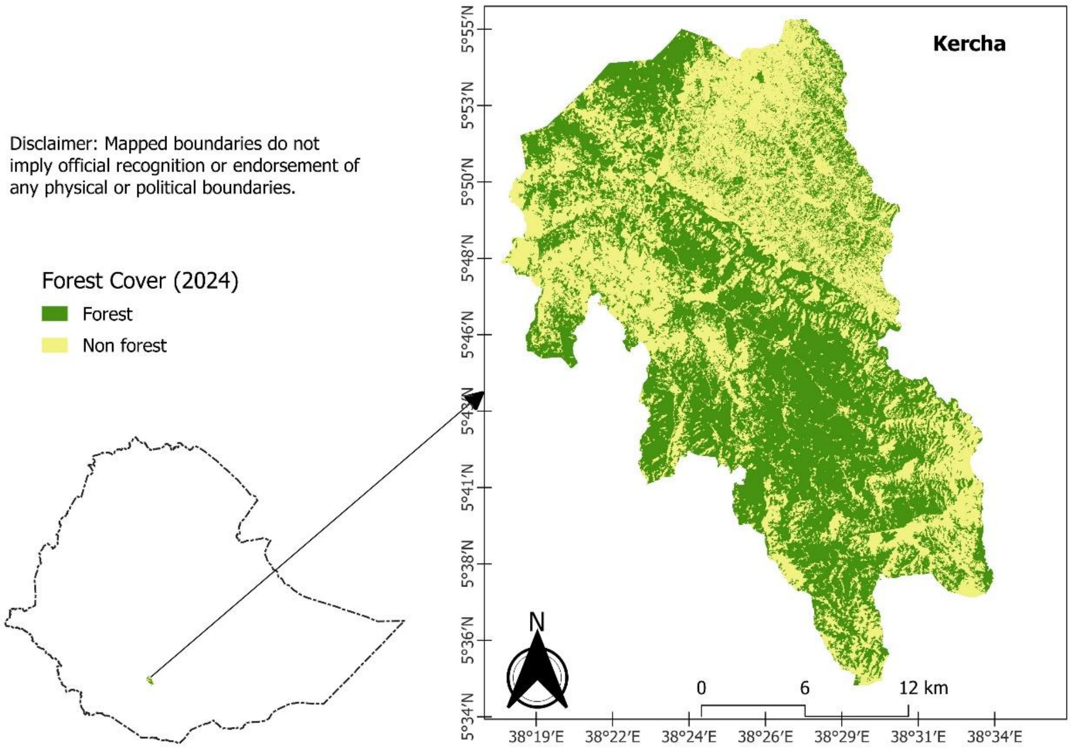

Figure 7: Land cover map of Kercha woreda for the year 2024

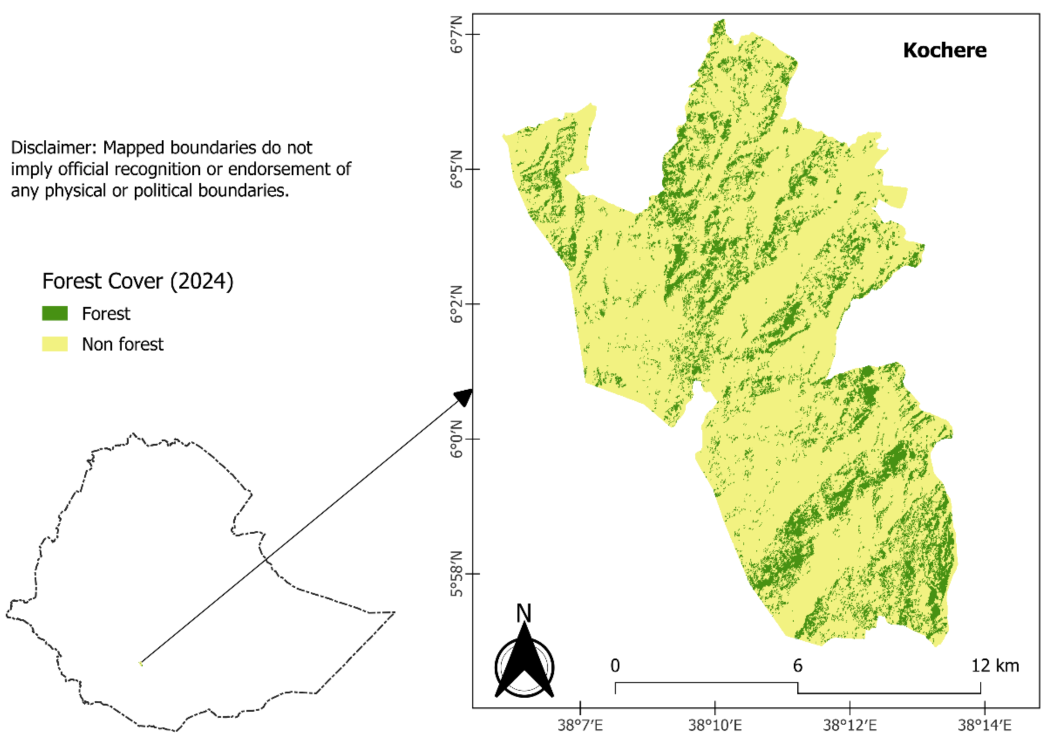

Figure 8: Forest cover map of Kochere woreda for the year 2024

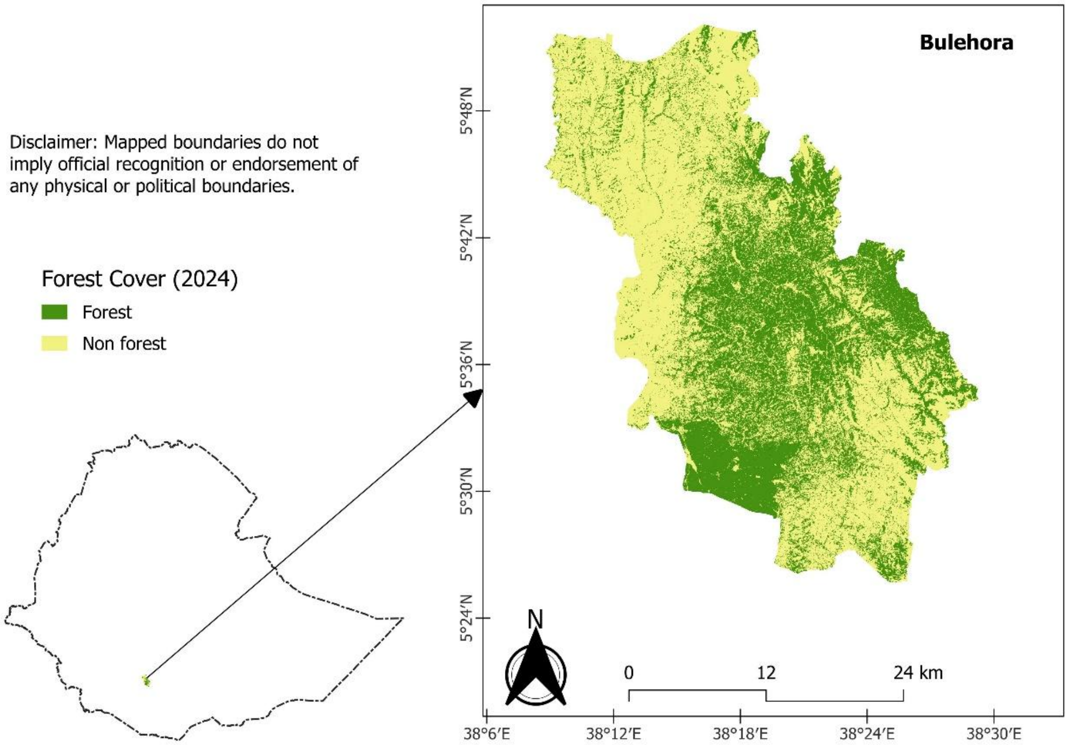

Figure 9: Land cover map of Bulehora woreda for the year 2024

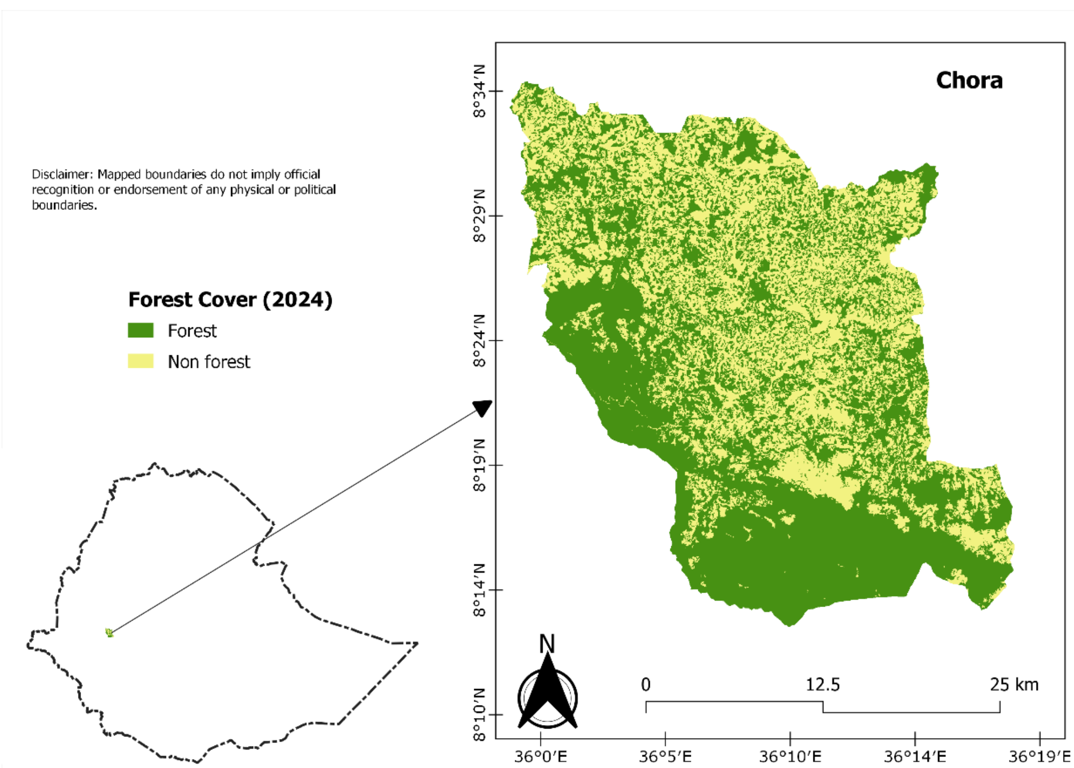

Figure 10: Forest cover map of Chora woreda for the year 2024

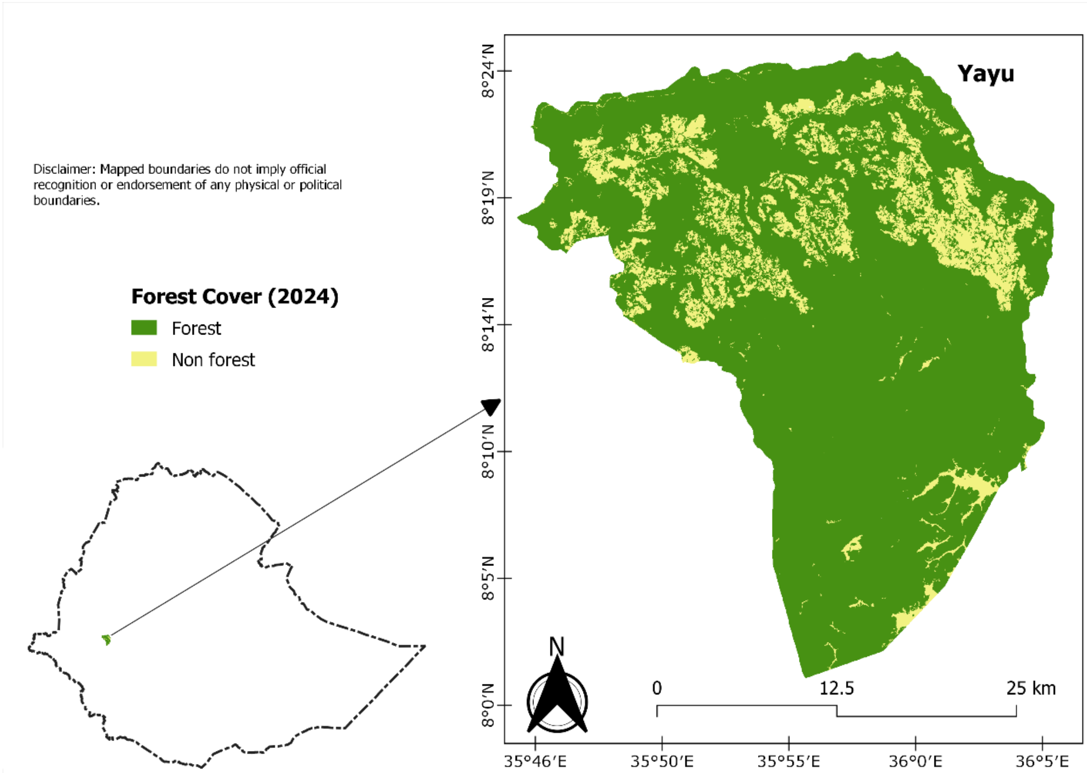

Figure 11: Land cover map of Yayu woreda for the year 2024

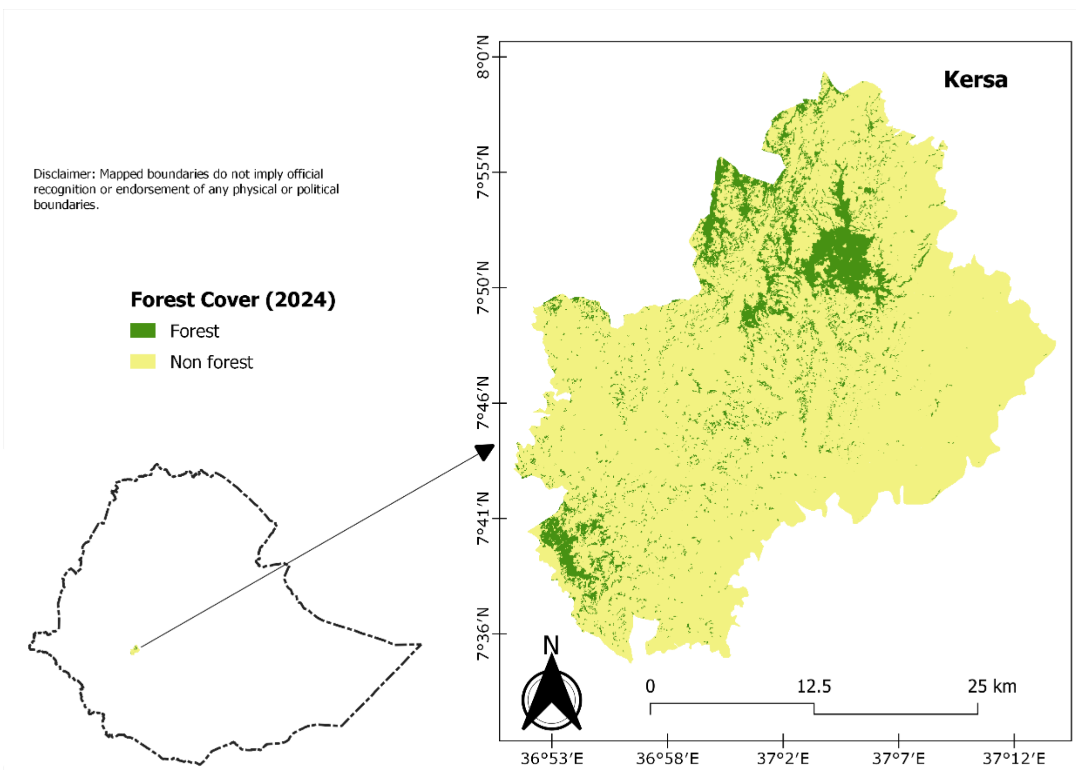

Figure 12: Forest cover map of Kersa woreda for the year 2024

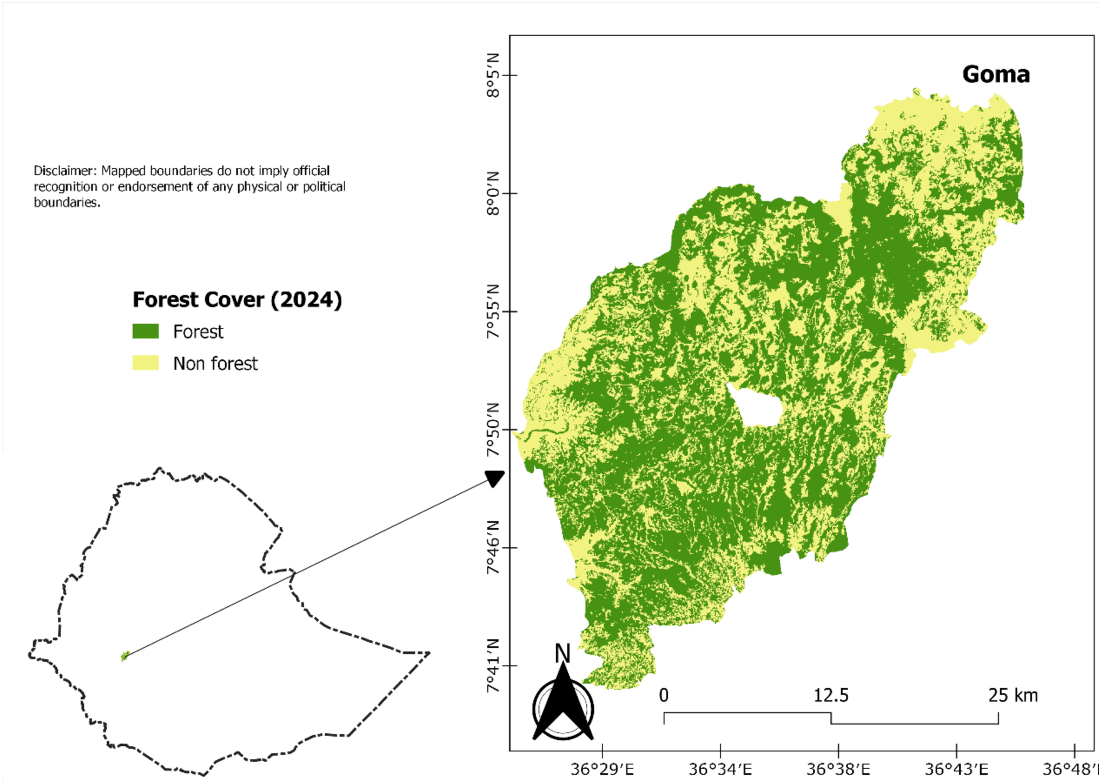

Figure 13: Land cover map of Goma woreda for the year 2024

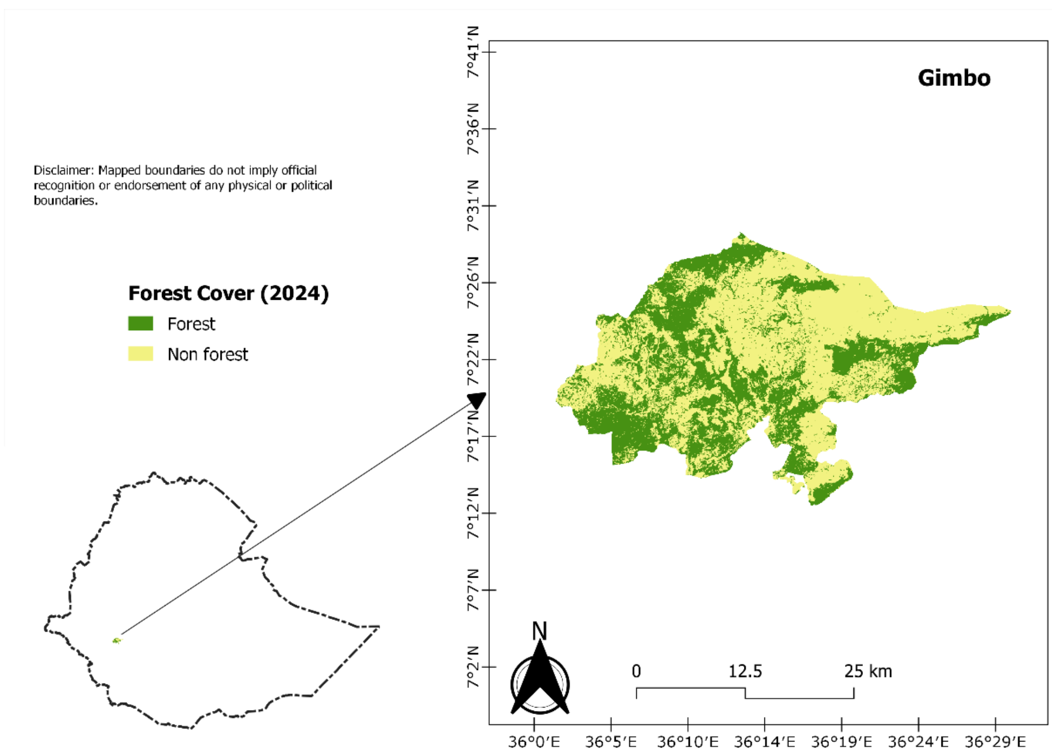

Figure 14: Forest cover map of Gimbo woreda for the year 2024

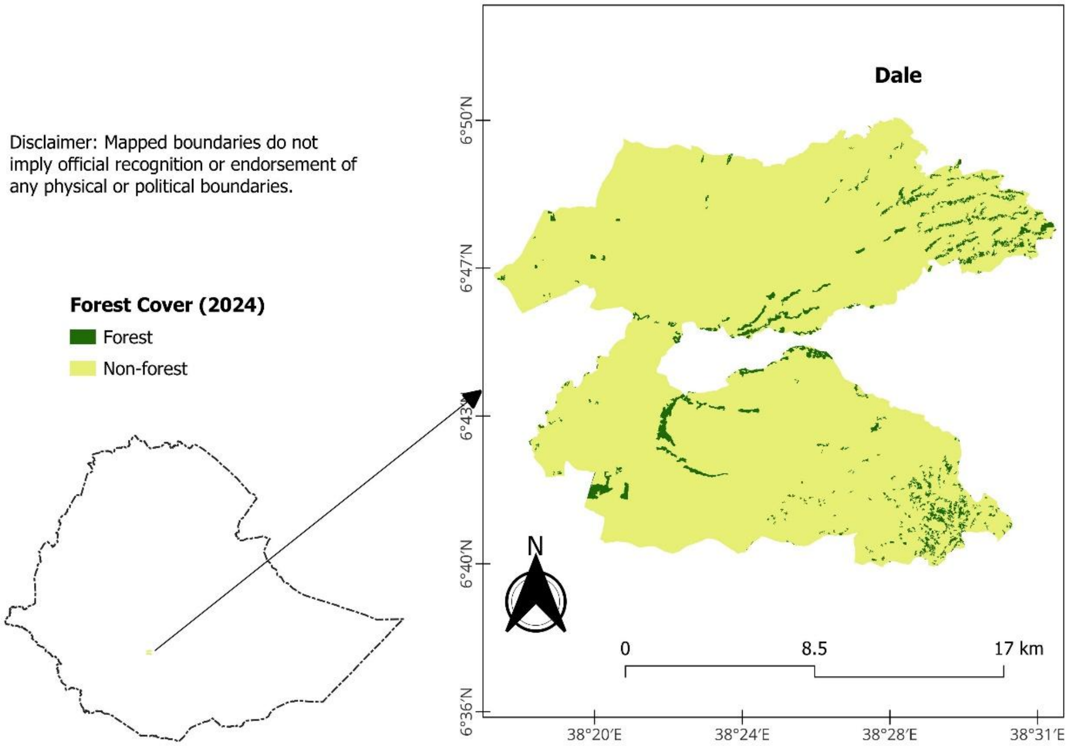

Figure 15: Land cover map of Dale woreda for the year 2024

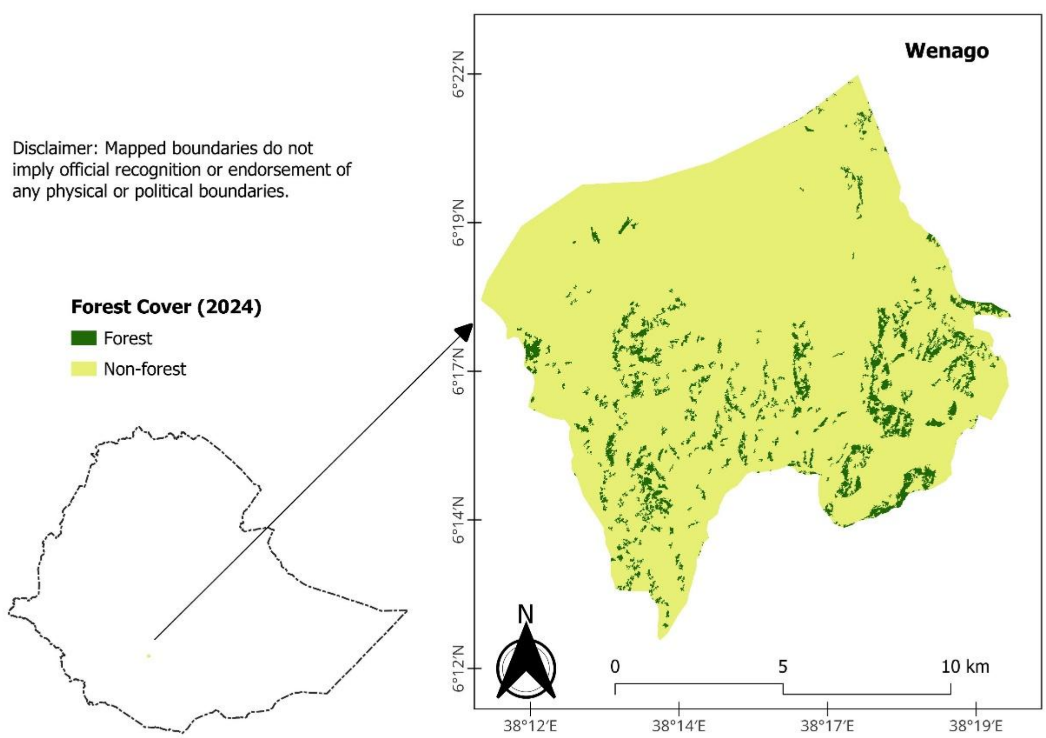

Figure 16: Forest cover map of Wenago woreda for the year 2024

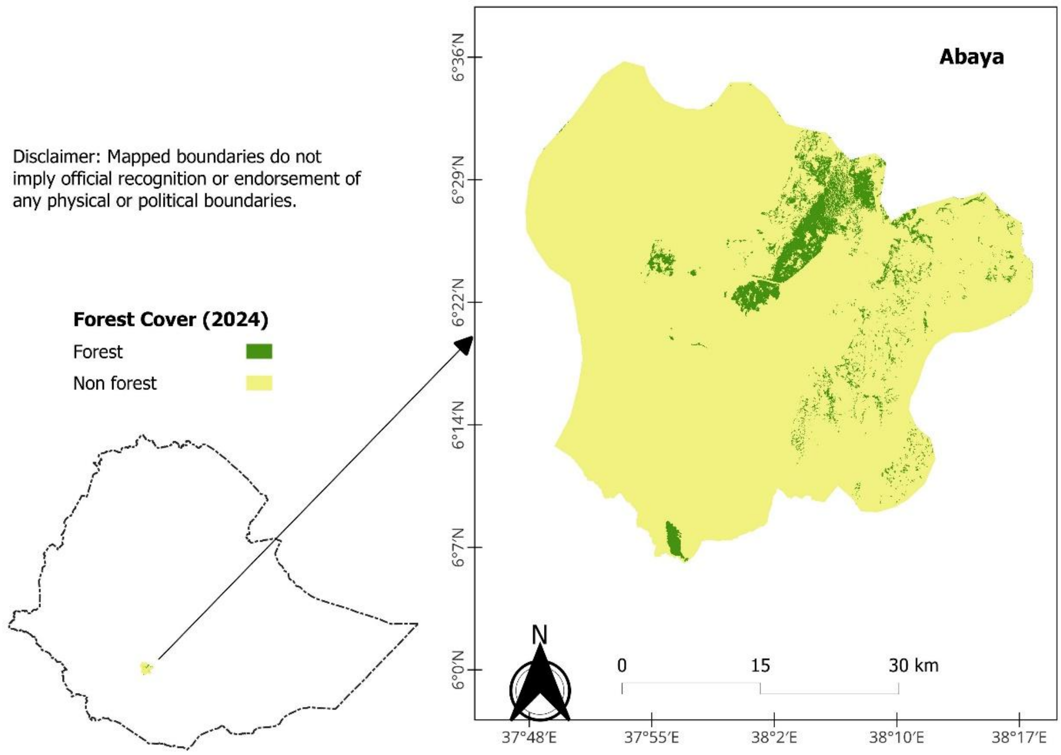

Figure 17: Land cover map of Abaya woreda for the year 2024

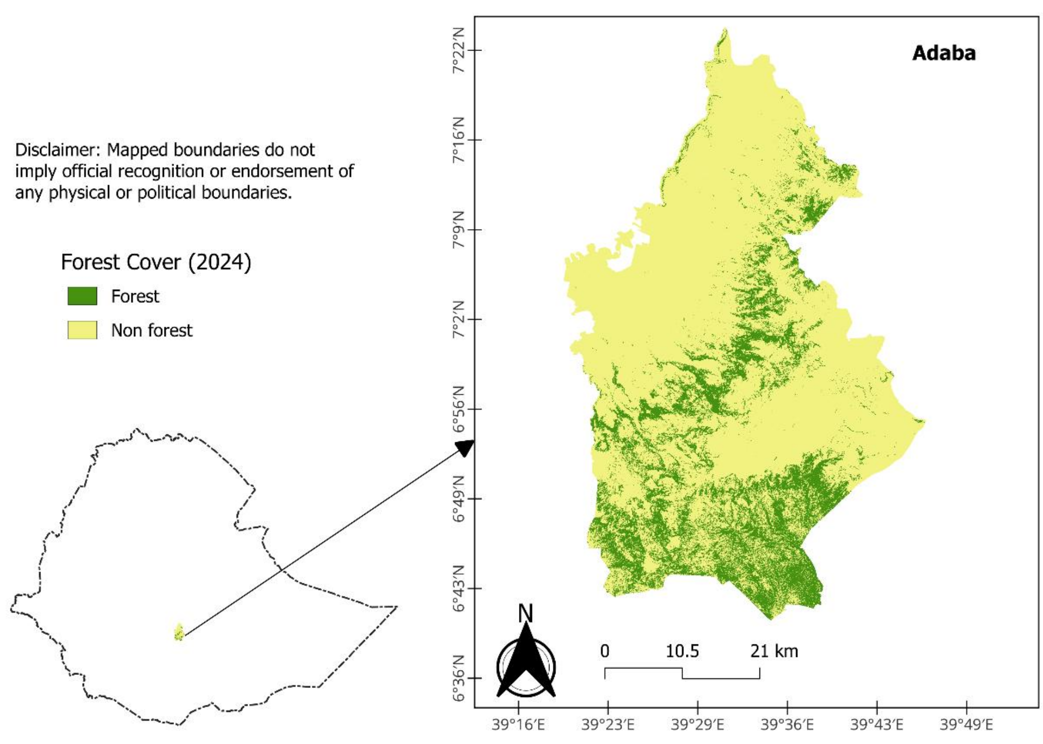

Figure 18: Forest cover map of Adaba woreda for the year 2024

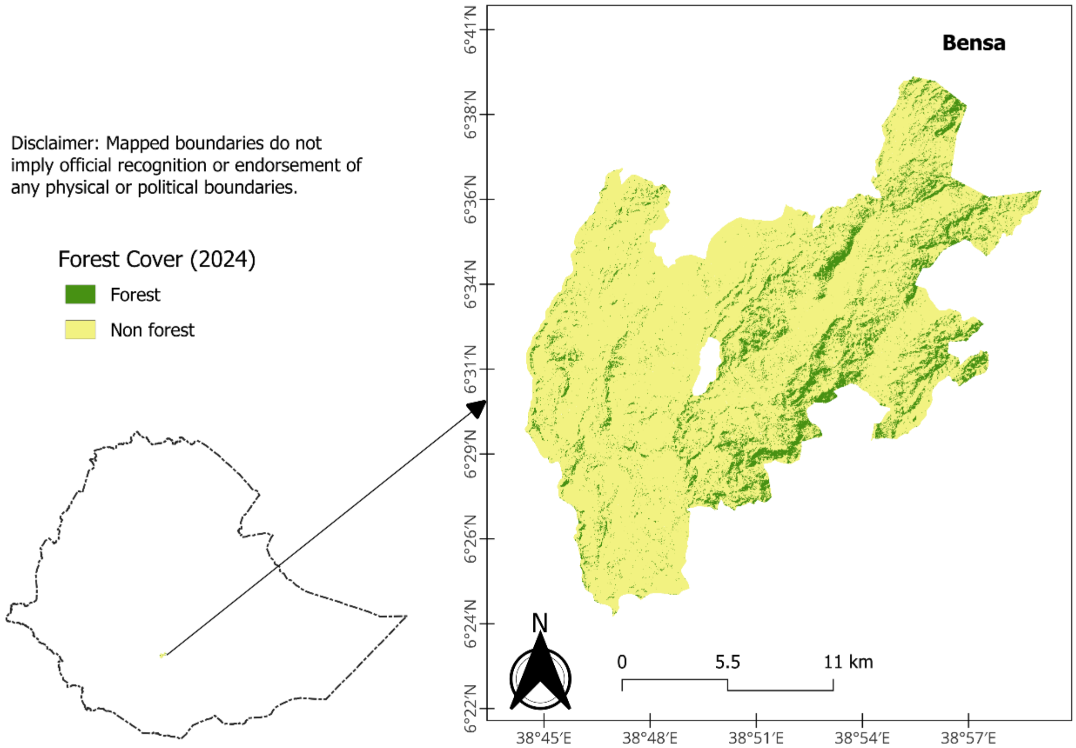

Figure 19: Land cover map of Bensa woreda for the year 2024

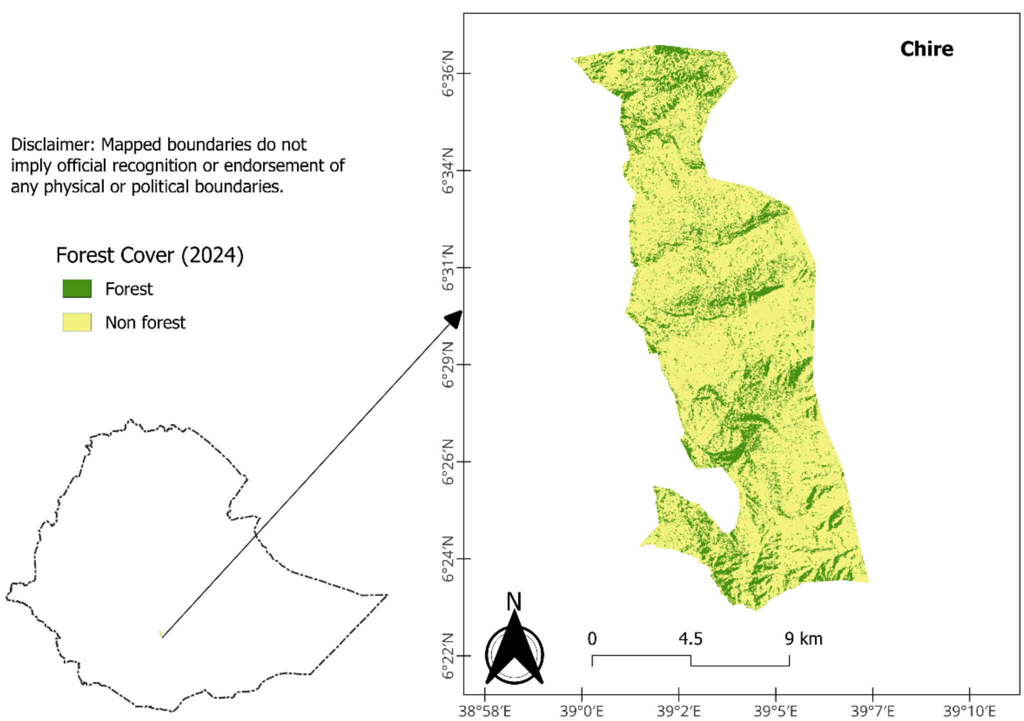

Figure 20: Forest cover map of Chire woreda for the year 2024

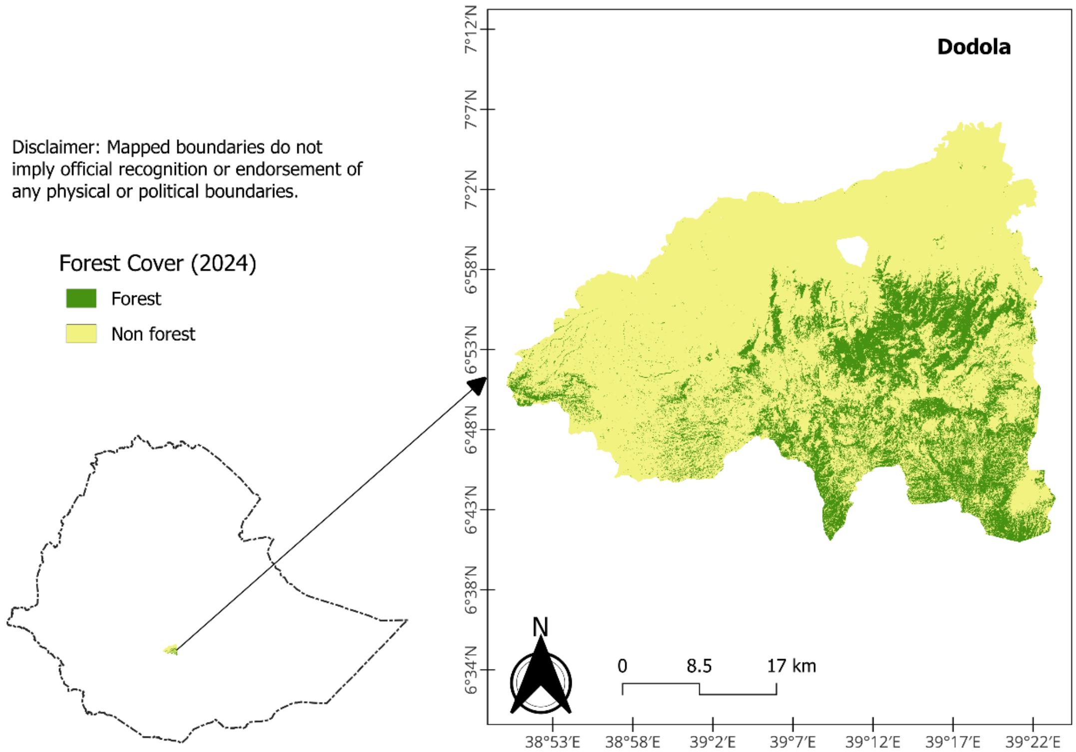

Figure 21: Land cover map of Dodola woreda for the year 2024

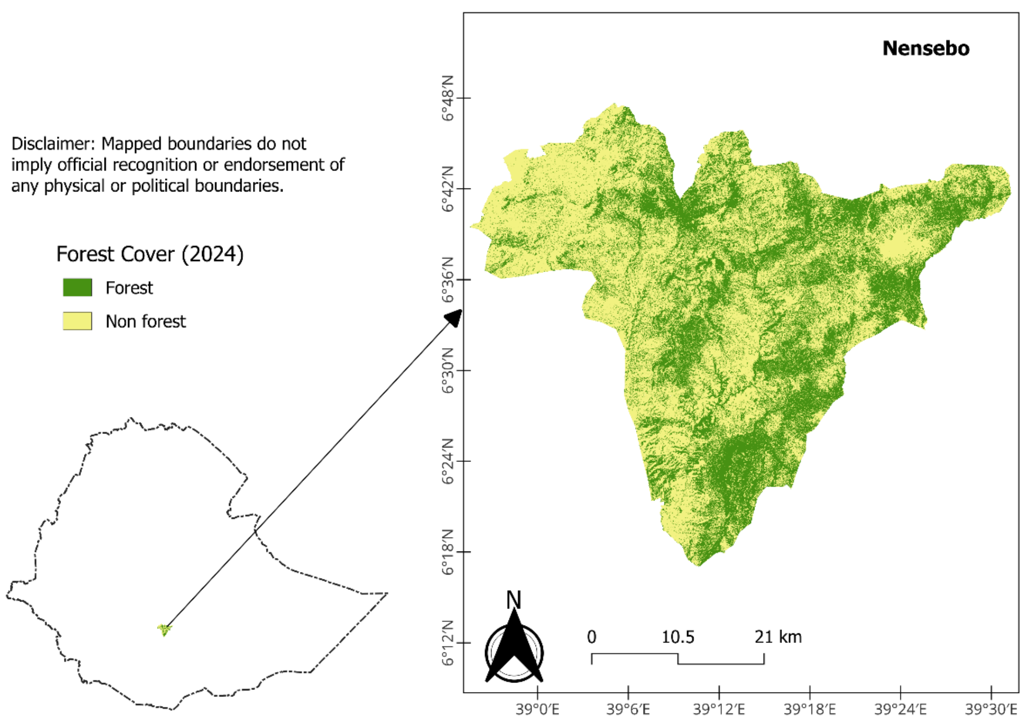

Figure 22: Forest cover map of Nensebo Woreda for the year 2024

Table 1: Forest cover per woreda

No	Wereda	Forest cover (2024) (ha)	Percentage from the total land (%)
1	Decha	43,675	41
2	Guraferda	178,358	70
3	Shay Bench	11,846	21
4	Sheko	37,501	77
5	Shisho Ande	18,666	33
6	Yirgachefe	6,051	24
7	Kercha	28,640	51
8	Kochere	2,891	19
9	Bulehora	38,304	39
10	Chora	48,163	58
11	Yayu	74,924	82
12	Kersa	9,351	10
13	Goma	49,383	57
14	Gimbo	32,897	42
15	Dale	1,149	4
16	Wenago	966	7
17	Abaya	10,144	6
18	Adaba	43,911	20
19	Bensa	4,209	13
20	Chire	3,501	21
21	Dodola	36,665	22
22	Nensebo	68,304	42