Chapter 2 Evaluation of Forest Cover Change between 2005 and 2009 in four Regional States of Ethiopia

Daniel Homeier

Research Highlights

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Environmental Policy Review 2011: Evaluation of Forest Cover Change between 2005 and 2009 in four Regional States of Ethiopia

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- This chapter examines relationships between governance institutions, access to forests, population pressures, and changes in forest cover in Ethiopia.
- Qualitative (literature review) and quantitative (spatial and statistical) data were analyzed for four Regional States: Tigray, Amhara, Oromia and the Southern Nations, Nationalities and Peoples region (SNNP).
- Additional data on household tree planting were obtained from the 2009 Ethiopian Rural Household Survey.
- Governance institutions at the regional level vary substantially. This is reflected in the observed differences in distribution of forest cover across regions.
- Areas farther from roads, which consequently may have less access to financial resources, experienced greater forest loss than areas closer to roads.
- Although deforested areas tend to be relatively densely populated, afforestation can occur in population dense areas.
- Despite observed declines in closed forest cover, tree planting has likely increased thin forest cover.
- International carbon markets may be able to also play a role in increasing forest cover, especially if regionally focused.

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Environmental Policy Review 2011: Evaluation of Forest Cover Change between 2005 and 2009 in four Regional States of Ethiopia

By Daniel Homeier

Executive Summary

"Evaluation of Forest Cover Change between 2005 and 2009 in four Regional States of Ethiopia" is the second chapter in *Environmental Policy Review 2011*, a report produced by the Environmental Policy Group in the Environmental Studies Program at Colby College in Waterville, Maine.

Forests are globally threatened, especially in Ethiopia where 12% or less of land area is forested. Loss of forest cover may be due to a number of factors, such as the cutting of timber for fuel wood and the expansion of agriculture. At the same time, changes in household tree planting practices, among other things, may be increasing forest cover in some degraded areas. By drawing upon a Geographic Information Systems (GIS) analysis of forest cover within four Regional States - Tigray, Amhara, Oromia and the Southern Nations, Nationalities, and Peoples region (SNNP) - this study aims to explore the relationships between governance institutions, access to forests, and population pressures, and changes in forest cover in Ethiopia.

A review of literature suggests regional governance institutions across Ethiopia are distinct from one another. GIS analyses of forest cover changes from 2005 to 2009 reveal that this distinction is reflected in the distribution of forests within and across regions. More specifically, forests vary in relation to regional boundaries, roads and railroads, cities, and population density from region to region. Generally speaking, densely populated areas are more deforested than less populated areas. Surprisingly, some areas closer to roads are less deforested than areas farther from roads.

Analyses of household-level survey data from 2004 to 2009 show that household tree planting increased substantially in all regions over the past decade, especially in the Tigray and Amhara regions. During the same time period the area of thin forest (forest in which trees and vegetation are sparse) increased most in Tigray and Amhara. The reflection of household tree planting practices in national forest cover data highlights the potential importance of household tree planting in a country facing threatened forest resources.

Differences in regional governance institutions suggest efforts to increase forest cover in Ethiopia must be regionally focused to fit regional conditions, including road access and population density. Efforts seeking to utilize global carbon markets such as REDD+ may more effectively increase forest cover if regionally focused. Finally, household tree-planting, a tool for increasing forest cover while addressing social concerns such as poverty, should be part of any regional development efforts.

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Introduction

Due to the combined stresses of population pressure and limited access to alternative resources, Ethiopian forests are under significant strain. According to the Food and Agriculture Organization of the United Nations (FAO), forest area accounted for approximately 12% of Ethiopia's total land area in 2005 (FAO, 2010). EarthTrends (2003) suggests forest cover in Ethiopia may be substantially less, as little as 5%. By any measure forest cover in Ethiopia is low compared to the 20.8% average for East Africa; and Ethiopia's forest cover is expected to continue decreasing in coming years (Mekonnen, 2009; European Commission et al., 2003).

Deforestation, along with other forms of land use change, is a substantial contributor to economic and environmental problems, ranging from global climate change to local food and energy scarcity. Forests provide numerous ecosystem services, or benefits provided by proper ecosystem functioning. Some ecosystem services provided by forests include erosion control, nutrient cycling, maintenance of biodiversity, water purification, control of desertification, carbon sequestration, and climate stabilization (Nair & Tieguhong, 2004). Deforestation alone was responsible for nearly 25% of worldwide anthropogenic CO_2 emissions during the 1990s (Houghton, 2003). Improvement of forest management practices are estimated to be capable of reducing worldwide CO_2 emissions substantially (Sohngen, 2009). Inextricably linked to ecosystem services, deforestation plays a role in a variety of social concerns, such as poverty and energy availability (Alem et al., 2010; Burgess et al., 2010). Rural and poor communities internationally, including those in Ethiopia, depend on forests for sources of energy, food, timber and income (Burgess et al., 2010; Scherr et al., 2005). Even urban areas depend heavily on forest resources: Alem et al. (2010) found that nearly one million trees must be cut annually to account solely for the amount of charcoal that is brought to Addis Ababa, the capital city of Ethiopia.[1]

By drawing upon Geographic Information Systems (GIS) analyses of forest cover within four Regional States: Tigray, Amhara, Oromia and the Southern Nations, Nationalities, and Peoples region (SNNP), this study aims to investigate the influence of governance institutions, access to forests, and population pressures on changes in forest cover in Ethiopia. These three variables were chosen because of their theoretical importance to forests as suggested by the literature (Mena et al., 2006; Berry, 2003; European Commission et al., 2003; Rudel et al., 1998). For example, in their 2003 report, the European Commission et al. identified institutions and

[1] For more on fuel wood, charcoal and energy sources in Ethiopia see chapter six in *Environmental Policy Review 2011*.

population pressure as "driving forces" impacting Africa's forests. They also identified increased access to forest via roads as a serious concern. Berry (2003) similarly identified institutional issues and population growth as root causes of land degradation in Ethiopia, while other researchers beyond Africa, such as Mena et al. (2006) and Rudel et al. (1998), have found that road access is significantly related to deforestation.

This chapter proceeds as follows. The methods section outlines the methodology followed for data collection and analysis, while a brief history of land use and institutions pertaining to forests in Ethiopia is provided in the historical context and institutions section. The results section contains the quantitative section of this chapter, providing land cover findings produced by spatial analysis. The discussion section then explores the relationship between the land cover findings and the history of land use and institutions to further develop our understanding of declining forest cover in Ethiopia, and the conclusions section summarizes the primary findings of this chapter and provides policy recommendations.

Methods

I collected three primary types of data; preexisting literature and interview data, spatial data, and survey data (containing household tree planting information) to evaluate how governance institutions, access to forests, and population pressures influence patterns of forest cover change in four Regional States: Tigray, Amhara, Oromia, and SNNP (Figure 2.1).

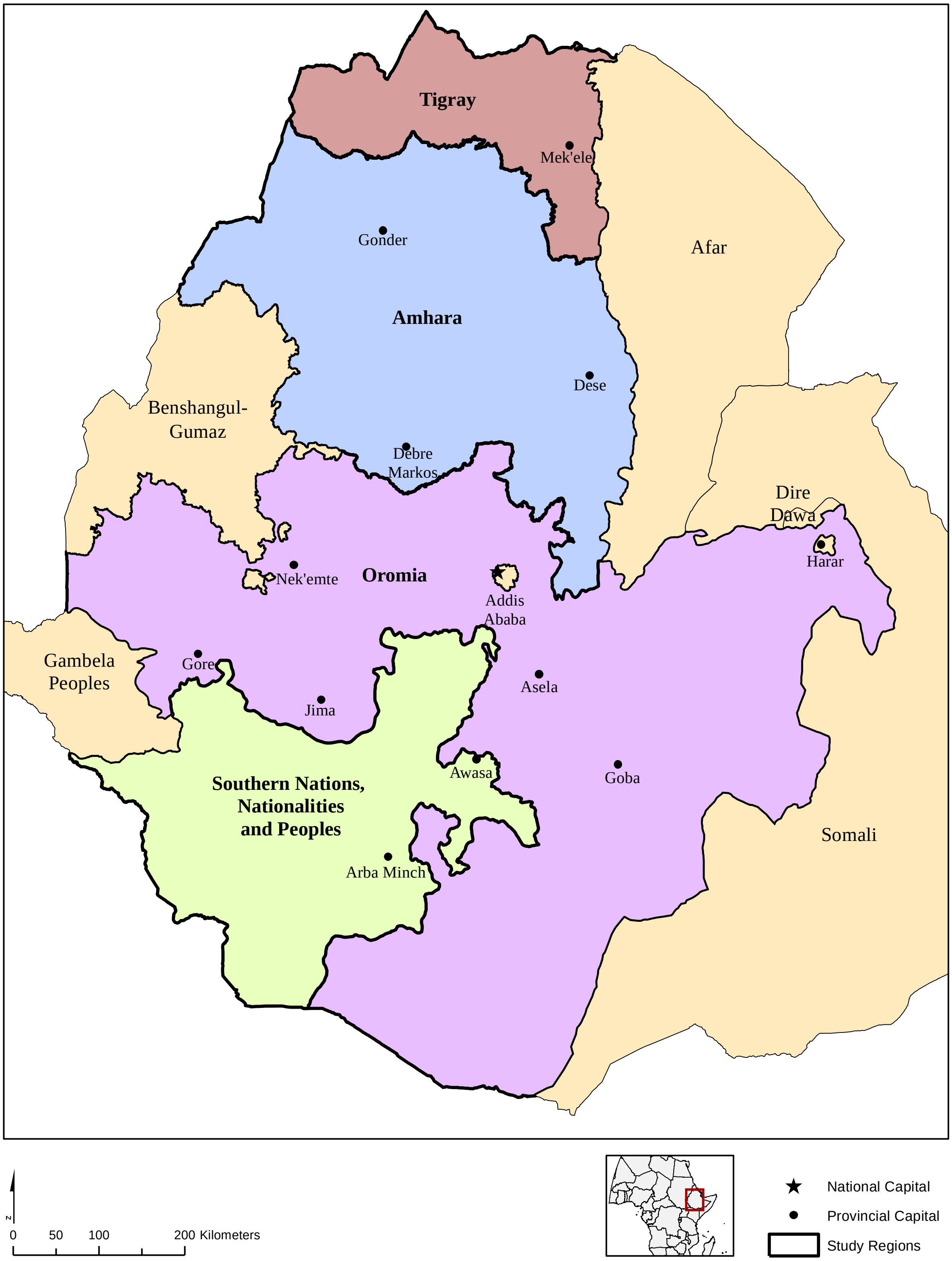

Figure 2.1 Study regions and national and provincial capitals of Ethiopia, GADM, 2011.

Literature Review and Interview Data

I used Web of Knowledge, Environment Complete, and Google Scholar to find peer reviewed journal articles pertaining to forest related institutions globally and in Ethiopia. In addition to an online literature search, I collected anecdotal information pertaining to forest cover and regional governance institutions through phone and email conservations with individuals involved in forests in a few of the study regions (for a complete list of interviews and attempted interviews see the Works Cited section). While I was not able to create a complete data set of regional institutions due to a lack of readily available institutional information at a regional level, I was able to make preliminary conclusions based on available sources.

Spatial Analysis

Spatial analyses sought to evaluate how (1) governance institutions, (2) access to forests, and (3) population pressures might influence forest cover. These three sets of variables are used to explain patterns of forest cover change in Ethiopia, and specifically whether a given parcel experienced reforestation, no change in forest, or deforestation between 2005 and 2009. Governance institutions are represented by region and proximity to regional borders. Access to forests is represented by spatial and quantitative analysis of forest cover as a function of distance from roads and railroads. Population pressures are represented by spatial and quantitative analysis of forest cover as a function of distance from cities and of the surrounding population density.

I collected GIS data primarily from ESRI, a popular source of GIS software (ArcGIS) and other online resources, including Ionia, the European Space Agency's global land cover organization, and DIVA-GIS, a web portal for online GIS resources supported by the Consultative Group on International Agricultural Research (CGIAR). For a complete list of GIS data sources (many of which are freely and publicly available through DIVA-GIS) see Table 2.1. For a depiction of variables used to represent governance institutions, access to forests, and population pressures in relation to forest cover change from 2005 to 2009, see Appendix 2F Figure 2.12.

Based on the availability of land cover data, I broke down spatial and statistical analysis into two main time periods, 2005 and 2009, for temporal comparison. It is important to note that 2005 spatial data is an amalgamation of data from 2005 to 2006, while 2009 data is strictly from 2009. I performed analyses of change in forest cover and visual representation of spatial data using ArcGIS 10 (for a more detailed explanation of my GIS analyses see Appendix 2E).

Table 2.1 GIS data sources, description and URL.

Variables	Description	Type	Source
Trees Planted	Ethiopian Rural Household Survey tree planting practices (2009 question q2p2s1e2, 2004 question q21d_2)	Non-spatial	International Food Policy Research Institute (http://www.ifpri.org/dataset/ethiopian-rural-household-surveys-erhs)
Administrative Boundaries	Country boundary and administrative subdivisions	Spatial	GADM (http://www.gadm.org/)
Gazetteer	Cities and national/provincial capitals	Spatial	National Geospatial-Intelligence Agency (http://earth-info.nga.mil/gns/html/index.html)
Population Density	2000 population density (per km^2) based on administrative boundaries	Spatial	SEDAC Gridded Population of the World (GPW) (http://sedac.ciesin.columbia.edu/gpw/)
Roads	Roads (year unknown)	Spatial	Digital Chart of the World
Land Cover	Global land cover raster data for 2004-2006 and 2009	Spatial	Ionia GlobCover (http://ionia1.esrin.esa.int/)
Elevation	SRTM 30	Spatial	USGS (http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/SRTM)
Mean Precipitation	1950-2000 2.5 arc-minutes	Spatial	WorldClim (http://www.worldclim.org/)
Mean Temperature	1950-2000 2.5 arc-minutes	Spatial	WorldClim (http://www.worldclim.org/)
Inland Water	Significant water bodies (rivers, canals, lakes)	Spatial	Digital Chart of the World

In regards to forest cover classifications, I considered the closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m in height) land use classification the least thin forest cover (henceforth "closed forest cover"). I considered the open (15-40%) broadleaved deciduous forest (>5m) land use classification to be a thinner forest cover (henceforth "open forest cover"). Lastly, I considered the mosaic forest/shrubland (50-70%)/grassland (20-50%) land use category to be the thinnest forest cover (henceforth "mosaic forest cover").[2]

Survey Data Analysis

Finally, in order to investigate household tree planting practices, I used tree planting data from the 2004 and 2009 versions of the International Food Policy Research Institute's Ethiopian Rural Household Survey (ERHS). The ERHS is an extensive questionnaire that began in 1989

[2] The FAO broadly defines forest as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 %, or trees able to reach these thresholds *in situ*. "It does not include land that is predominantly under agricultural or urban land use" (FAO, 2010, p. 5). Unfortunately, no such broad classification exists in LCCS, or consequently in the GlobCover classification of Ethiopian land cover (FAO, 2010). Therefore, the categories closest to representing forest cover in the four study regions are closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m), open (15-40%) broadleaved deciduous forest (>5m), and mosaic forest/shrubland (50-70%)/grassland (20-50%) (GlobCover, 2009).

and is administered approximately every five years to households within 15 villages in Tigray, Amhara, Oromia, and SNNP. The ERHS villages were chosen so that one to three villages per agro-ecological zones and sub-zones were represented. Within each village, households were selected randomly. While not representative of the entire country, the ERHS can be "considered broadly representative of households in non-pastoralist farming systems as of 1994" (Dercon & Hoddinott, 2011). I performed statistical analysis of the ERHS data to evaluate tree planting practices data using STATA SE 12.0. More specifically, I used bivariate analyses to explore the relationship between region and forest cover change, and a probit regression to explore the relationship between the number of trees planted and the regional location of tree planting. I also used Ordinary Least Squares (OLS) regression to explore the relationship between tree planting and education attained by household heads.

Historical Context and Institutions

In order to fully understand why forest cover in Ethiopia is sparse and threatened, a brief overview of the laws and institutions that shape forest use and protection is necessary. The Ethiopian historical context most relevant to forest cover is marked by three periods defined by the evolution in land rights systems: pre-1975 land reform, land reform under the Derg regime, and the post-Derg era up to today.

Pre-1975 Land Reform

Before 1975, Haile Selassie maintained a monarchy, controlling Ethiopia as an emperor. As Gebreegziabher (2009) notes, three land rights systems existed prior to and during Selassie's regime: the *risti* system; the *gulti* system; and church holdings. The *gulti* system of land rights is analogous to feudalism; *gulti* holdings were those held by royal individuals. Because of a lack of information regarding church land holdings and the relative rarity of the *gulti*, the most well-known and common historical Ethiopian land rights system is the *risti* system.

The *risti* system, like many traditional African land rights systems, was one in which land was communally held (Besley, 1995). Although individuals could claim the legal right to use land through proof of relation to the original landholder, they could not transfer rights to family members or to others by way of sale. To meet the needs of new individuals, land was redistributed; further weakening individual rights to a particular area and solidifying the reality that no one had rights to any one parcel of land. The system was considered relatively egalitarian in that equal distribution of land was ensured through a lottery system based on land quality (Gebreegziabher, 2009). But by weakening individual user rights, the *risti* system essentially deincentivized investment by land users (i.e., farmers) in the land they were using, often resulting in land degradation (Gebreegziabher, 2009).

Land Reform and the Derg Regime

Ethiopian land rights changed drastically during the mid-1970s. The historical system of decentralized land rights ended in 1974 when the Derg, a Marxist military junta, pushed Emperor Haile Selaisse from power. The Derg installed a government backed by the Soviets, led by Mengistu Haile Mariam, and promptly initiated nationwide land reform (Keeley & Scoones, 2000). The military regime seized all land, eliminating any existing rights, and redistributed land on a household basis. Through redistributions of land, nationalization of farms, abolishment of tenant farming and hired labor and control of prices, supplies, and markets, the government maintained centralized control over land distribution (Jagger et al., 2005; Holden, 2002; Keeley & Scoones, 2000). Because there was not enough land to redistribute evenly among all individuals within Ethiopia, and because hired labor was outlawed, a group of landless households was created. In recognition of widespread unemployment coupled with growing national environmental threats, the Derg initiated extensive conservation measures countrywide. The rural landless were thus put to work implementing vast state-run conservation projects, including tree planting.

In the long-run, however, the Derg forestry initiatives had little positive effect on forest cover (Jagger et al., 2005; Hoben, 1995). The conservation measures practiced by the Derg were recognized as byproducts of centralized, top-down rule. This often resulted in the destruction of tree planting efforts once the Derg regime fell, satisfying the desire of the people to revolt against the centralized regime, but environmentally only serving to further degrade the land (Keeley & Scoones, 2000). The Director of Concern for Environment, an Ethiopian NGO, asserted that even today some reforestation programs are criticized by local communities for being too top down in nature (CFE_2A, 2011).

Although the Derg's state-run land reform and centralized conservation projects were, for the most part, ineffective, elements of the Derg regime have shaped the contemporary resource management landscape in Ethiopia (Bewket, 2002). The Derg regime directly influenced Ethiopian forests by the fact that seedling or sapling trees planted during the Derg regime would have developed into a mature forest by the 21st century (Bewket, 2002). In other words, any evaluation of forests today must consider the actions that may have influenced forests decades prior.

Post Derg – Today

The decline of the Derg paralleled that of the Soviet Union. By 1991 the Derg was ousted and replaced by a transitional government. The Ethiopian People's Revolutionary Democratic Front (EPRDF) was elected to power. With the new government came a new democratic constitution. Governance was shaped around ethnic divisions within the country in an effort to move away from centralized government (Keeley & Scoones, 2000). For a variety of reasons, including the ethnic complexity of Ethiopia and its historical ethnic tensions, ethnic division of the country has proved to be challenging (Abraham, 2005). For example, the Abyssinian part of the country (located in the northern part of Ethiopia, now the Tigray and Amhara regions) has historically dominated the southern regions, resulting in fewer resources and less governing power in the south (Keeley & Scoones, 2000).

In addition to a new ethnically based governance scheme, woodlot management was decentralized and community management was reinstated (Jagger et al., 2005). Some lots of land were even privatized in forest re-planting efforts. However, land in Ethiopia is still state-owned, as Article 40 of the Constitution states: "the right to ownership of rural and urban land is exclusively vested in the state... and shall not be subject to sale or exchange" (FDRE, 1995).

Although EPRDF policies were a step away from the centralized control put in place by the Derg, land tenure has remained a heated political issue due to uncertainty created by the lack of a well-designed and enforced policy (Holden & Yohannes, 2002). Continuing land redistributions, such as those in 1992, 1993, and 1997, have not helped to reduce uncertainty amongst land-users. It is entirely feasible that such uncertainty can act as the lack of transferable land rights did during the pre-1975 period of Ethiopian history by weakening incentives to improve land, resulting in degradation. Ironically, protected National Forest Priority Areas were some of the areas hardest hit by failure of centralized control (Melaku, 2003). In light of this, localized (or decentralized) management of forests based on community based forest management is touted as one potential solution to deforestation (Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007).[3]

Current Institutional Context

Today, there are at least two levels of institutional context pertinent for the study of forest management in Ethiopia: federal and regional.[4]

Federal Institutions

The government bodies that oversee forestry issues (to varying degrees) are: the Federal Ministry of Agriculture and Rural Development (MoARD), the Federal Environmental Protection Authority (EPA), the Federal Ministry of Water Resources (MoWR), and the Federal Ministry of Mines and Energy (MoME). While all of these government bodies have specific roles regarding forestry, MoARD has the most significant role, which includes the listing of endangered native tree species and the coordinating of relevant federal and regional bodies (Environmental

[3] For a more nuanced explanation of community forest management, see Agrawal and Ostrom, 2001.
[4] Although not entirely relevant for a regional level analysis of forest cover, the international institutions outlined in Appendix A Table 2.11 are those most likely to influence forest cover in Ethiopia.

Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007).[5] For a detailed list of federal institutions relevant to forests in Ethiopia see Table 2.3.

These combined institutions, along with other lesser federal institutions concerned with forest policy, have had little success in conserving forests or increasing forest cover in Ethiopia, in large part due to poor funding and low priority within the government (Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007; Million, 2004 & 2001). Because of such relatively weak federal institutions, authors such as Keeley and Scoones (2000, p. 110) have observed that "the federal level has become less important, and it is in the regions that policy agendas are set, decisions taken and projects implemented."

Regional Institutions

As mentioned above, regional-level institutional power is effectively greater than national power in Ethiopia today (Keeley & Scoones, 2000). Regions, however, differ from one another in terms of both institutional strength and local participation in government. In their comparison of the Tigray and SNNP regions Keeley and Scoones (2000) found that in SNNP, there is little evidence of local participation, while in Tigray, there is a rich history of local participation in government. This seemed to affect citizens' confidence in the policy process. The distinction between Tigray and SNNP is not surprising considering the historical influence of the north: Tigray regional council members, for example, were closely involved with the EPRDF (Keeley & Scoones, 2000). Further emphasizing the disparity in power between administrative levels within Ethiopia, institutions at the *woreda* level (an administrative level a step smaller than regions) have been identified as too weak even to provide simple evaluation of tea plantation impacts on forests (Environmental Economics Policy Forum on Policies to Increase Forest Cover, 2007). For a brief outline of each study region and its respective forest policy landscape, see Table 2.3.

[5] During the pre-1975 and Derg period, various institutions influenced forests and forest policy in Ethiopia, such as Public Ownership of Rural Land Proclamation No. 31/1975 (Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007). For the sake of simplifying analysis, this review focuses on the post-Derg institutions.

Table 2.2 Federal institutions relevant to Ethiopian forests, see notes for sources.

Institution	Year	Description	Institution Evaluation
The Forest Conservation, Development and Utilization: Proclamation No. 94	1994	Classified three forest types: state, regional, and private forests. Expanded the role of private entities; required permits for forest use; established that violation of the proclamation would result in imprisonment and/or fine	No information
Ethiopian Forestry Action Program	1994	Created eight forestry development programs: Tree and Forest Reduction Program, Forest Resource and Ecosystem Management Program, Forest Industries Development Program, Wood fuel Energy Efficiency Development Program, Technology Development, Dissemination Program, Sectoral Integration Program, Planning, Monitoring and Evaluation Program, and Human Resources Development Program	Due to funding issues the effectiveness of these programs is questionable
Ethiopian Constitution: Proclamation No. 1	1995	Created Ethiopian government, FDRE; constructed the building blocks for environmental protection; maintained state ownership of land	No information
Conservation Strategy of Ethiopia and Environmental Policy of Ethiopia	1997	Highlighted the importance of sustainably conserving, developing, and utilizing forests and their resources	No information
Policy and Strategy on Forest Development, Conservation and Utilization	1997	Highlights state, private and community roles in forest management, forestry in regard to other resources (i.e. water), suitable afforestation/reforestation species, environmental impact assessments, and sustainable management of forests	Evidence suggests that the areas of concern were poorly addressed or enforced
Woody Biomass Inventory and Strategic Planning Project	2001-2004	Produced reports and strategic plans at both a federal and regional scale	No information
Forest Development, Conservation and Utilization: Proclamation No. 542	2007	Replaces the Policy and Strategy on Forest Development, Conservation and Utilization (1997); defined the types of forest ownership recognized at federal, private and state levels; grants MoARD forest management powers	Contains unclear provisions and does not account for community forests adequately
Ethiopian Wildlife Development and Conservation Authority Establishment: Proclamation No. 575	2008	The proclamation created the Ethiopian Wildlife Development and Conservation Authority and endowed it with various powers regarding wildlife; the Authority was not given the ability to regulate forests	Requires cooperation between the Authority and MoARD due to ecological links between forests and wildlife

Table 2.2 Notes: The Forest Conservation, Development and Utilization: Proclamation No. 94, Ethiopian Forestry Action Program, Ethiopian Constitution: Proclamation No. 1, Conservation Strategy of Ethiopia and Environmental Policy of Ethiopia, Policy and Strategy on Forest Development, Conservation and Utilization, and Woody Biomass Inventory and Strategic Planning Project, source: Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007; Forest Development, Conservation and Utilization: Proclamation No 542 and Ethiopian Wildlife Development and Conservation Authority Establishment: Proclamation No 575, source: Forum for Environment, 2011.

Table 2.3 Regional comparisons of factors relevant to forests, see notes for source.

Region	Policies	Identified Problems	NGO Activity	Protected Areas	Reforestation Projects	Localized Forest Management
Tigray	Yes	No information	Yes	Enclosures	No information	No information
Amhara	Yes, weak institutional capacity (budget, skills)	Unsustainable resource development/utilization, illegal logging, budget constraints, and poor infrastructure	No information	No information	No information	Yes (community management)
Oromia	Yes, poorly implemented due to budget constraints	Agricultural expansion, grazing, and timber/fuel wood/charcoal extraction	No information	Yes but either failed or narrowly implemented (forest priority areas)	Tree development program in development	Yes (3 Participatory Forest Management (PFM) projects in development)
SNNP	Yes, poorly implemented	Agricultural and settlement expansion, energy demands, and construction	No information	Demarcation and protection of forest	Demarcation and protection of forest, tree planting, enrichment plantation and water diversion (soil recovery)	Yes (PFM), not well supported

Table 2.3 Notes: Source for all four regions: Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007, p. 73-103. Information from region to region was inconsistent, as a result "no information" does not necessarily preclude that feature from a region, it simply means that Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute either did not find the information or include it.

Results

Land Cover

Figure 2.2 depicts the change in forest types between 2005 and 2009. For visual purposes, the legend was simplified so that forest (dark green) represents closed forest cover that did not change between 2005 and 2009, thin forest (beige) represents open and mosaic forest cover that did not change between 2005 and 2009, forest growth (bright green) represents open and mosaic forest cover that changed to closed forest cover between 2005 and 2009, and thin forest growth (red) represents closed forest that changed to open and mosaic forest cover between 2005 and 2009 (i.e., loss of closed forest).

Two things stand out in this figure of forest change. First, there is very little closed forest in Ethiopia and it is primarily located in the SNNP and Oromia regions. Second, much of the little closed forest that did exist in 2005 was converted to mosaic or open forest by 2009. For a more detailed analysis of land use change, see the explanation of Figures 2.4 and 2.5 below.

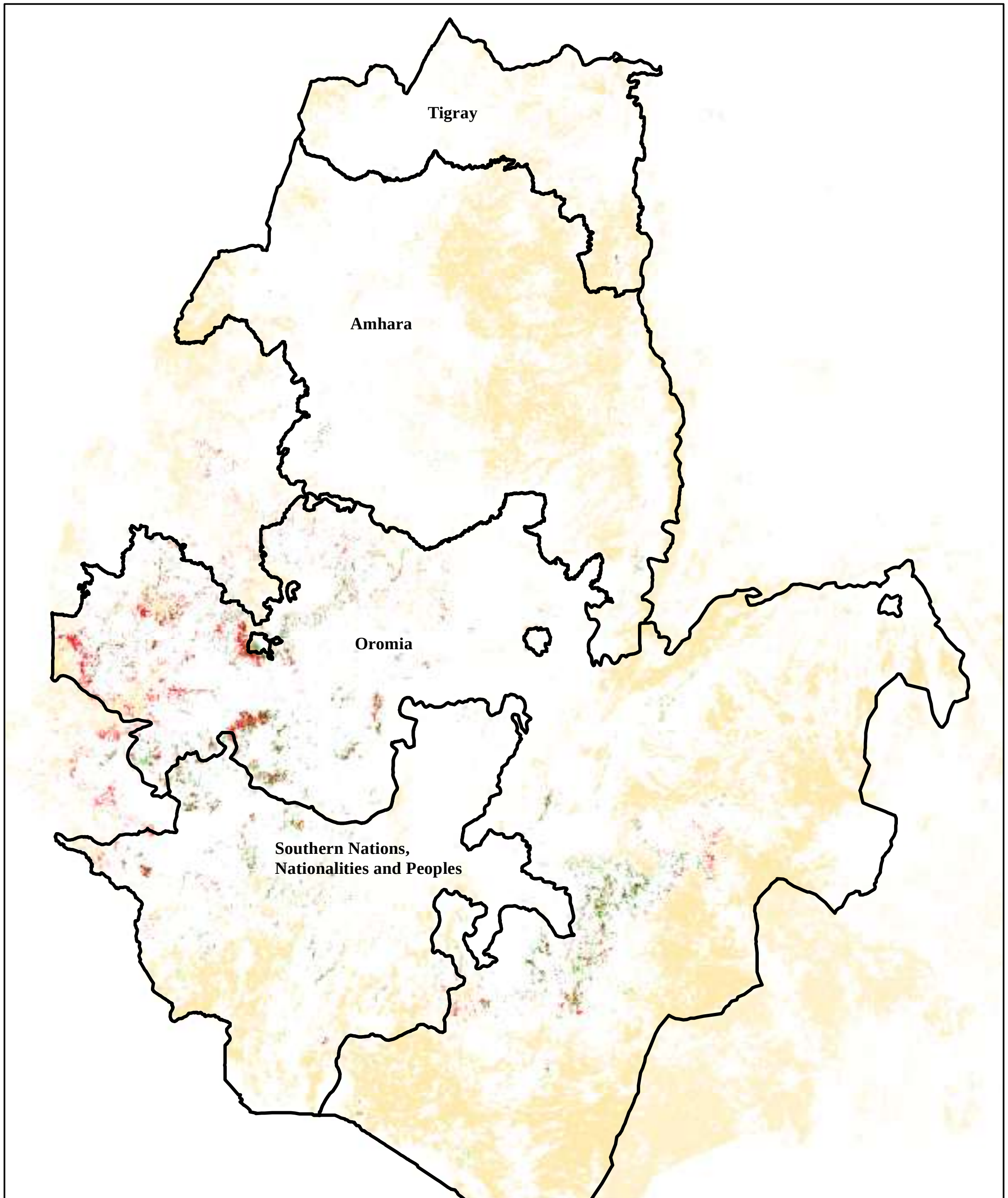
Tigray
Amhara
Oromia
Southern Nations,
Nationalities and Peoples

Figure 2.2 Growth and loss of closed forest and thin forest cover in study regions, GlobCover, 2011.

Figure 2.3 depicts change in all three forest cover types clumped into a closed/open/mosaic forest classification, between 2005 and 2009. Compared to Figure 2.2, Figure 2.3 uses a more inclusive definition of forest, including closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m), open (15-40%) broadleaved deciduous forest (>5m), and mosaic forest/shrubland (50-70%)/grassland (20-50%). The legend was again simplified for visual purposes so that forest (dark green) represents land falling in the general forest cover classification in both 2005 and 2009. Forest loss (red) represents change from the general forest cover classification to all other land cover types (such as agriculture). Forest growth (bright green) represents change from all other land cover types to the general forest cover classification. Other (beige) represents land classified as non-forest in both 2005 and 2009.

Unlike the previous figure, this figure depicts a larger coverage of general forest cover and a great deal of growth in the general forest cover classification. This figure also depicts the distribution of general forest cover along the eastern border of the Amhara and Oromia regions and more generally in the southeastern part of the country.

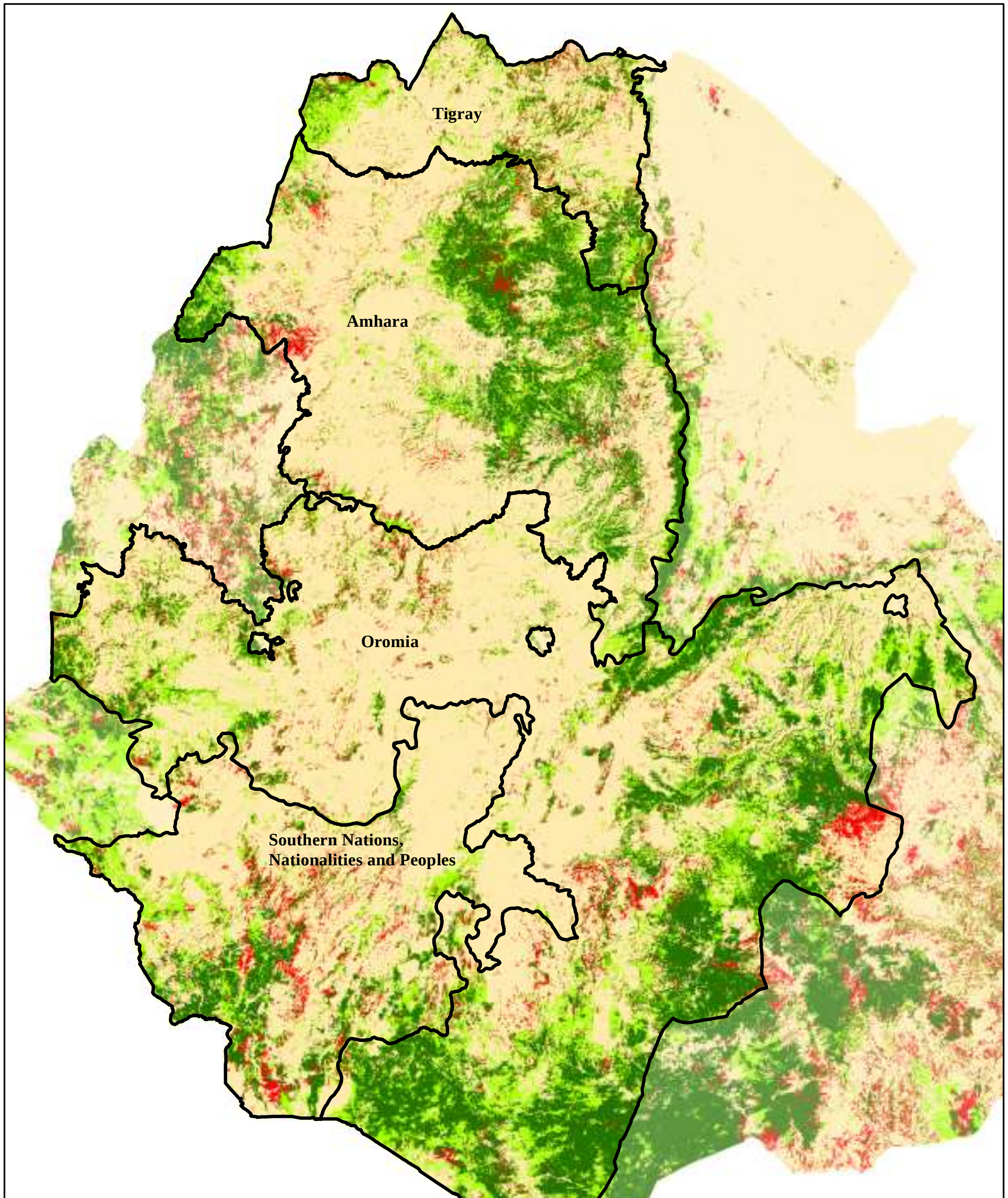
Tigray
Amhara
Oromia
Southern Nations,
Nationalities and Peoples

Figure 2.3 Growth and loss of closed/open/mosaic forest land cover and other land cover types (i.e., agriculture) in study regions, GlobCover, 2011.

Comparing mean Euclidean distances between features and areas of afforestation, unchanged forest, and deforestation within regions reveals a few things regarding the distribution of forests relative to features.[6] Predictably roads, compared to boundaries, cities, and railroads (when applicable), tend to be closer to afforestation, unchanged forest, and deforestation (Table 2.4). For the most part, deforestation areas tend to be closer to boundaries, cities, railroads, and roads than afforestation areas. Roads in the Amhara and Oromia regions are exceptions, as is the SNNP boundary.

Boundaries, cities, railroads, and roads tend to be nearly the same distance from afforestation (~.30km) and deforestation areas (~.28km) from region to region. The administrative boundary of SNNP, however, is an exception, the mean distance to afforested parcels in SNNP is triple (.91km) the distance to boundaries in the other three regions, and the mean distance to deforested parcels is five times as great (1.40km).

Unchanged forest – that is, forested area that remains forested over time – tends to be closer to roads than afforestation and deforestation areas, with the exception of in Oromia. Unchanged forest does not seem to be consistently near or far, compared to afforestation and deforestation areas, to boundaries or cities. Railroads, due to their presence in only two regions, are impossible to compare across all four regions. That said, they tend to be relatively far from all three forest change types compared to other features.

Table 2.4 Mean Euclidean distances between feature and areas of afforestation, deforestation, and unchanged forest normalized by maximum Euclidean distance from feature within region, GlobCover, 2011.

Region	Feature	Afforestation Mean Distance Standardized	Unchanged Forest Mean Distance Standardized	Deforestation Mean Distance Standardized
Tigray				
	Boundary	0.29	0.25	0.28
	Cities	0.51	0.37	0.37
	Railroads	N/A	N/A	N/A
	Roads	0.16	0.13	0.14
Amhara				
	Boundary	0.32	0.33	0.28
	Cities	0.45	0.43	0.40
	Railroads	0.56	0.53	0.60

6 Euclidean distance is the distance from a pixel representing a forest parcel to the closest feature of interest pixel.

	Roads	0.18	0.17	0.25
Oromia				
	Boundary	0.30	0.29	0.26
	Cities	0.45	0.48	0.35
	Railroads	0.52	0.53	0.45
	Roads	0.13	0.15	0.20
SNNP				
	Boundary	0.91	1.04	1.40
	Cities	0.44	0.41	0.39
	Railroads	N/A	N/A	N/A
	Roads	0.22	0.18	0.21

A comparison of the mean population density of afforestation, unchanged forest, and deforestation areas reveals distinct trends from region to region (Table 2.5). For example, in Tigray afforestation and unchanged forest occur in less densely populated areas than deforestation. The same is true for Oromia. The opposite, however, is true for SNNP, where deforestation occurs in less densely populated areas than afforestation. Compared to the other three regions, Amhara is an outlier in that deforestation occurs in areas less densely populated than both unchanged forest and afforested areas. Notably, overall density in Amhara is high relative compared to the other regions. Generally, unchanged forest tends to be in less densely populated areas than deforestation areas.

Table 2.5 Mean population density (people/km^2) for areas of afforestation, unchanged forest, and deforestation, GlobCover, 2011.

Region	Afforestation Mean Population Density (km^2)	Unchanged Forest Mean Population Density (km^2)	Deforestation Mean Population Density (km^2)
Tigray	45.7	58.9	76.1
Amhara	81.6	82.5	77.7
Oromia	41.4	27.2	51.8
SNNP	55.2	36.1	49.5

In the figures below the analysis of land cover from 2005 to 2009 is broken down into two comparisons for easy interpretation. The first is a percentage of the study regions' total land area, represented by four forest cover types in 2005 and 2009. This is designed to depict differences in distribution of land cover between regions. The second is a comparison of forest cover types within each region to illustrate changes in land cover distribution between 2005 and 2009. Figures 2.4 and 2.5 depict the first comparison while Appendix 2B shows the second comparison. All depictions contain three forest cover types: mosaic forest-shrubland/grassland, open broadleaved deciduous forest, and closed to open broadleaved evergreen or semi-deciduous forest.

In 2005, closed forest cover represented a relatively small percentage of all four study areas' total land area (see Figure 2.4). Tigray and Amhara contained the lowest percentages, with .01% and .10%, respectively. Oromia and SNNP had greater percentages of closed forest cover, with 3% and 2% respectively. Oromia and SNNP had greater percentages of open broadleaved forest, both being 6%, than Tigray and Amhara, 1% and 3% respectively. Conversely, Tigray and Amhara had greater percentages of mosaic forest, with 18% and 22% respectively, compared to 17% and 11% for Oromia and SNNP.

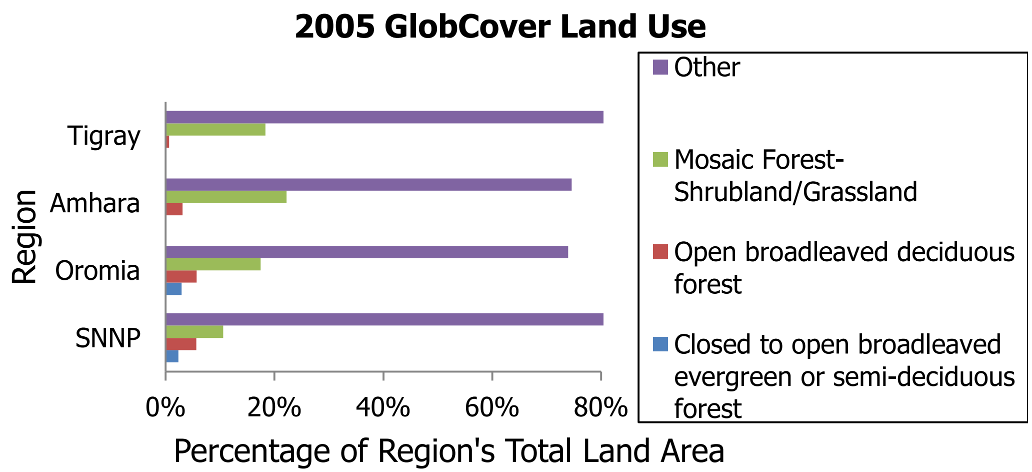

Figure 2.4 Percentage of study regions' land area represented by four land cover types in 2005, GlobCover, 2006.

The land cover distribution across regions in 2009 was similar to that of 2005 (see Figure 2.5). Oromia and SNNP regions again contained more closed forest cover. However, from 2005 to 2009, closed forest cover in both regions declined while mosaic and open forest increased across all four regions (for a more detailed depiction of temporal change within each region see Appendix 2B). Mosaic forest cover increased, especially in the Amhara and Tigray regions considering both had 32% mosaic forest cover in 2009. SNNP and Oromia still have relatively less mosaic forest cover with 14% and 25%, respectively. Within SNNP and Oromia, however, open forest cover increased to a greater degree and continued to maintain a larger percent coverage with 8% and 10%, respectively.

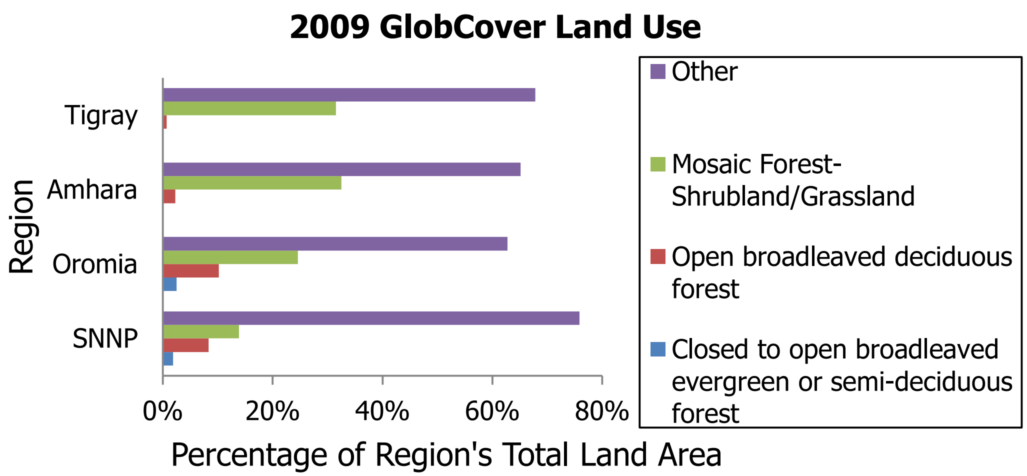

Figure 2.5 Percentage of study regions' land area represented by four land cover types in 2009, GlobCover, 2011.

Across all four study regions, closed forest decreased from 1,224,953 ha to 1,046,666 ha from 2005 to 2009, resulting in a 44,000 hectare per year decrease (or a 14.6% change).

Household Tree Planting

Although not representative of tree cover, the Ethiopian Rural Household Survey (ERHS) tree planting data can inform the forest cover data results. For example, regional increases or decreases in forest cover may be explained by corresponding changes in household tree planting practices within the same region. More specifically, the ERHS planting data suggest that in 2009, in comparison to 2005, across all four regions the average household planted a greater number of trees. Increases were proportionally greatest in the Tigray region, followed by Amhara, SNNP and Oromia (see Table 2.6).

Table 2.6 Mean number of trees planted per household in 2004 and 2009, ERHS 2011.

Region	Mean number of trees per household 2004	Mean number of trees per household 2009	Percent Change
Tigray	23	417	1713%
Amhara	172	512	198%
Oromia	558	712	28%

SNNP	721	1196	66%
Total	297	761	156%

Table 2.6 Notes: Mean number of trees is based on the total trees planted per household in 2004 and in 2009.

A probit regression evaluating the decision to plant any tree (yes/no) as a function of the region in which the planting household was located found that the Amhara, Oromia, and SNNP regions were all significantly different (at a greater than 95% confidence level) from Tigray in their decision to plant in 2009 (See Table 2.7). Due to the complexity in interpreting probit regression coefficients, it is only reasonable to conclude that being in Amhara or Oromia reduces the odds of planting trees, while being in SNNP positively influences the odds of planting (based on the coefficient sign).

Table 2.7 Probit regression for tree planting as a function of household location by region in 2009, ERHS, 2011.

Variable	Odds Ratio	Coefficient	Standard error	z	P>|z|
Education	1.378	0.186	0.031	5.82	<0.001***
Farmer	1.111	0.075	0.082	0.92	0.358
Region					
Amhara	0.148	-1.110	0.148	-7.50	<0.001***
Oromia	0.382	-0.550	0.143	-3.87	<0.001***
SNNP	2.980	0.530	0.166	3.23	0.001**
Constant	5.018	0.952	0.136	7.01	<0.001
N	1564				
LR $\chi^2(5)$	230.39				
Prob>χ^2	0.000				
Psuedo R^2	0.1352				
Log likelihood	-736.933				

Table 2.7 Notes: *, **, and *** indicates statistically significant at a 5%, 1% and .1% level (respectively). For the Region variable, the category *Tigray* was omitted to avoid collinearity.

Evaluating the number of trees to plant and the level of education held by the household head with an OLS regression found that relative to having no education, having one to six and six to twelve years of education has a significant (at a slightly greater than 95% confidence level for both) effect on the number of trees planted in 2009 (see Table 2.8). Based on the coefficient, this impact is substantial; households in which the household head had some education on average planted over 300 more trees than those with no education. University level education, however, was not found to have a significant influence on planting behavior.

Table 2.8 An Ordinary Least Squares regression evaluating the number of trees planted and level of education of head of household in 2009, ERHS, 2011.

Variable	Coefficient	Standard error	t	P>|t|
Level of Education				
1-6 years	334.62	115.68	2.89	0.004**
6-12 years	336.75	160.33	2.10	0.036*
University	82.66	108.95	0.76	0.488
Constant	643.09	64.33	9.98	<0.001
Number of observations	1564			
Prob>F	0.012			
R-squared	0.006			
Adj R-squared	0.005			
Root MSE	1725.2			

Table 2.8 Notes: *, **, and ** indicate statistically significant at a 5%, 1% and .1% level (respectively).

Discussion

The evolution of Ethiopian governance institutions provides a valuable context for understanding forest cover in Ethiopia. For example, changes in property regime types, which occurred as governments changed during the 20th century, has had little positive influence on forests in Ethiopia (Melaku, 2003). In response to the widespread failure of highly centralized governments such as the Derg, communal management is an option considered today for improved resource management (WRI, 2003). This is, unfortunately, based on the assumption that because of the widespread use of the *risti* system, communal land ownership defined pre-1975 Ethiopian land regimes. Such an assumption is based on a generalized notion of pre-1975 Ethiopia and results in the loss of details regarding diverse situations and potentially inaccurate perceptions of power structures and their effects (Rahmato, 1990). Therefore, when communal management is implemented as a solution, it does not always solve the environmental and social issues that many hope it will (Crook, 2003). Changes in the structure of governance institutions, such as implementing communal resource management, must consider all aspects of the institutional landscape.

In the case of Ethiopia, the relationship between national and regional administrative power is an aspect of governance institutions that must be considered. Kefauver, in the first chapter of *Environmental Policy Review 2011*, found that regions generally adopt national level policy. Therefore, while national institutions may be poorly enforced, it is still important that policy is created at a national level. For example, the recent creation of The Reducing Emissions from Deforestation and Forest Degradation Readiness Preparedness Proposal at a national level means that the policy may be implemented at a regional level to improve foreign investment in Ethiopian forests (EPA, 2011). However, a lack of strong national level policy means that regional policies may be an unorganized patchwork of forest policies that do not address the cross boundary nature of environmental problems, such as forest degradation and loss. The analysis of forest cover presented here, especially when measured in relation to regional boundaries, population density of forest areas, and in terms of changes in forest cover across boundaries, supports the conclusion that differences in regional governance institutions are reflected in forest cover. Differences in tree planting practices, as measured by the ERHS, also provide support for this conclusion.

The variation in distance of regional boundaries from forest parcels suggests that regional boundaries, and the regions they enclose, are distinct from one another. For example, forest change tends to be relatively far from SNNP's boundaries compared to other regions, suggesting that SNNP's regulation of forest use along its boundaries may be weaker than other regions'. That said, it is important to note that administrative boundaries tend to follow natural features, such as mountain ranges, and therefore cannot be used with great confidence to describe forest cover characteristics. But comparing the changes in forest cover across regions may be a more reliable way of showing that regions are distinct from one another. For example, the sizeable increase observed in mosaic forest within the Tigray and Amhara regions compared to the Oromia and SNNP regions suggests that the two northern regions may differ in regards to tree planting or deforestation institutions.[7]

The differences in regional scale policy are exacerbated by a lack of regional scale information, such as whether or not NGOs are involved in preventing deforestation or the extent of protected forest areas. Robert Sturtevant, a Peace Corps volunteer working at the Wondo Genet College of Forestry (and a Natural Resources and Extension Forestry Specialist at the Colorado State Forest Service), expressed also having a difficult time finding forestry information (2011). Regardless, federal creation of institutions, strengthening of

[7] The increase in mosaic forest cover in the Amhara and Tigray regions in conjunction with the relatively small decrease in open and closed forest and a decrease in other land uses suggests that other land uses are possibly transitioning from very thin forest to less thin forest. This makes sense considering mosaic and open forest cover are likely the result of either one of two things, the degradation of closed forest or the forestation of non-forested land. A similar difference exists between open and mosaic forest. Forested mosaic cover may result in open forest while degraded open forest may result in mosaic forest.

property rights throughout Ethiopia, and encouraging local management may be vital to growth of forest cover (Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute, 2007).

Considering the disparity in national and regional power and inconsistencies in governance institutions across regions, international institutions are unlikely to have a major role in shaping forest cover in Ethiopia. That said, REDD+, a mechanism with which wealthy nations pay developing nations to reduce deforestation and degradation utilizing a carbon market, is an example of an international funding institution that could be implemented in Ethiopia (Parker et al., 2008; Peskett et al., 2008). In addition to REDD+, two financing mechanisms and programs, the Global Environmental Fund and the World Bank BioCarbon Fund, have already managed to support beneficial programs for forests in Ethiopia despite the challenging institutional landscape. Both the Humbo Regeneration Project and the Sodo Reforestation Project are supported through World Vision, suggesting such an organization has potential for providing future benefits to Ethiopian people and forests. For a brief outline of international institutions supporting a carbon market that may benefit forests in Ethiopia, see Table 2.9.

Table 2.9 International institutions relevant to carbon markets and Ethiopian forests, see notes for sources.

Institution	Date	Description	Institution Evaluation
World Bank BioCarbon Fund	2004-2007	World bank administered fund to support carbon sequestration and conservation, including afforestation and reforestation, and REDD	Supports Humbo Community-based Natural Regeneration Project
World Vision	2006	Christian relief organization working to stem the causes of poverty and injustice, supports global carbon sequestration schemes	Supports Sodo Reforestation Project and Humbo Community-based Natural Regeneration Project
REDD +	2005-2009	Reducing Emissions from Deforestation and Forest Degradation may promote sequestration of atmospheric CO2 while creating benefits for communities with potential annual payments greater than $30 billion	The continuing issue of insecure land tenure that has historically caused land degradation in Ethiopia may make the successful application of REDD+ difficult; in order for distribution of payments to work effectively, tenure must be well defined and secure; the lack of support and funding that has prevented many of the federal level institutions from helping Ethiopian forests may also negatively affect the application of REDD+

Table 2.9 Notes: World Bank BioCarbon Fund, source: The World Bank Carbon Finance Unit (http://wbcarbonfinance.org/Router.cfm?Page=BioCF); World Vision, source: World Vision (http://www.worldvision.org/content.nsf/about/who-we-are?open&lpos=top_drp_AboutUs_WhoWeAre); REDD +, source: Slunge, 2011 and Peskett et al., 2008.

How access to forests by way of roads influences forest cover may inform the way in which international efforts, using institutions such as REDD+, may best focus their efforts. Based on the distribution of forest change relative to roads, forests tend to be deforested in areas farther from roads and remain unchanged (or in some instances become afforested) in areas closer to roads. This somewhat counterintuitive finding – that access to forests via roads decreases the likelihood of deforestation – may suggest that the wealth, development, and increased ease of enforcement that come as a result of roads may be beneficial for maintaining and increasing forest cover. In other words, the additional economic opportunities provided by roads may effectively remove the resource strain on forests while increasing their intact value. While this supports the general theory of the environmental Kuznets curve, in which "there is an inverted U-shape relation between environmental degradation and income per capita," it suggests that the tipping point after which environmental degradation decreases, at least in Ethiopia, may be relatively low in terms of GDP, perhaps requiring rural households have access to only a few vital, but relatively inexpensive, resources (Stern et al., 1999).

The role of population pressure, in terms of distance from cities and population density of forest areas, in influencing forest cover further supports the conclusion that economic development may decrease deforestation and increase afforestation. Generally, forested parcels that remain forests appear in less population-dense areas than deforested areas. Similarly, standing forests tend to be farther from cities, and thus the populations they contain. Both of these findings are consistent with the notion that population pressures result in resource pressure (European Commission, 2003). But at the same time, based on the findings from Amhara and SNNP, it seems *afforestation* often also occurs in relatively densely populated areas. This implies that while population pressure often threatens forest, it does not necessarily have to.

How governance institutions, access to forests, and population pressures work together to influence forest cover across all four study regions within Ethiopia reveals inconsistencies with the literature. As FAO (2010) and estimates cited by Mekonnen (2009) suggest, forest cover in Ethiopia is low, ranging from 5% to 12%. Across all four study regions, the loss of approximately 44,000 hectares of closed forest per year between 2005 and 2009 seems high based on the EarthTrends 2003 estimate of 40,000 hectares of forest loss per year between 1990 and 2000. Conversely, compared to estimates by FAO in 2010, based on a WBISPP 2000 report, of approximately 60,000 hectares of forest loss per year between 2000 and 2005, the findings seem low.

Although any measure of forest cover in Ethiopia is low, the country seems to fare slightly better than surrounding countries. Ethiopia lost slightly less forest from 1990 to 2000 than Sub-Saharan Africa overall (EarthTrends, 2003). Furthermore, East Africa generally fares better in terms of forest loss than other regions within Africa: Africa as a continent accounted for more than half of the world's forest loss between 1990 and 2000 and most of that forest loss was concentrated in Southern and West Africa (European Commission et al., 2003). This may be in part explained by tree planting efforts, as measured by the ERHS, in Ethiopia.

Not only do the ERHS tree planting figures suggest that the Tigray and Amhara regions increased tree planting substantially, but also the Environmental Economics Policy Forum for Ethiopia and Ethiopian Development Research Institute noted substantial tree planting practices in the same regions (2007).[8] Furthermore, the observed increase in tree planting coincides with a sizeable increase in mosaic forest cover and decrease in other land uses in the same regions. Tree planting is, therefore, a likely cause of the increase in mosaic forest cover. Based on the positive impact tree planting has had in Tigray and Amhara, Bishaw's suggestion that initiatives to incentivize tree planting should be incorporated into afforestation and reforestation projects seems like a worthy one (2001). Considering one to twelve years of education positively increases the number of trees planted per household, marrying tree planting efforts with educational efforts will likely improve tree planting outcomes. Such a union further emphasizes that regardless of their effect on forests, tree planting programs are valuable in that they support local communities with food, fuel wood, income and ecosystem services (Bishaw, 2001; Hagos et al., 1999).

Conclusion

In evaluating governance institutions, access to forests, and population pressures within the Regional States of Tigray, Amhara, Oromia, and SNNP, it is clear that regions within Ethiopia are distinct from one another in regard to all three variables. Any future efforts to increase forest cover in Ethiopia therefore must consider regional context. International carbon finance institutions, such as REDD+, will likely be more successful if they are implemented at a regional scale and are not exclusively reliant on strong national institutions (as such institutions may not be present or, if present, may not be locally enforced or contextually appropriate). National-level efforts to improve forest policy, such as implementing carbon finance, are still vitally important but must be recognized as a foundation upon which regional administrations can build their own policy, allowing them to adapt policy to meet regional needs. With this in mind, a well-organized and comprehensive dataset of forest information on a regional scale is needed. Such a dataset is especially

[8] The probit regression of ERHS tree planting as a function of household location further supports the conclusion that regions are different from one another in terms of forest cover, in this case by number of trees planted per household.

valuable considering the variety of roles regional boundaries, roads, cities and population density play in shaping forest cover within regions. These factors ought to be considered when locating projects that aim to improve forest cover. Such projects would be wise to incorporate tree planting, as it seems to have significant potential to increase forest cover.

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Appendices

Appendix 2A

Table 2.A International institutions relevant to Ethiopian forests, see notes for sources.

Institution	Date	Description	Institution Evaluation
Convention on Biological Diversity	1994	Binding treaty on sustainable development focusing on conservation of biodiversity, sustainable use of biodiversity, and fair/equitable distribution of diversity benefits	Recognizes the importance of forest resources in Ethiopia and outlines threats; fails to outline robust action plans for protecting forests
UN Convention to Combat Desertification	1997	Convention to fight desertification and its effects	No information
UN Framework Convention on Climate Change and Kyoto Protocol	1994, 2005	Convention encouraged reduction of GHG emissions, protocol obligated reduction	Created CDM, under which projects such as the 2006 Humbo Community-based Natural Regeneration Project have been internationally supported
Global Environment Fund	1990	Investment and management of private equity in clean technology, emerging markets, and sustainable forestry	Grant supporting projects pertaining to environment such as Country Partnership Program on Sustainable Land Management

Table 2.11 Notes: Convention on Biological Diversity, source: Institute of Biodiversity Conservation 2005 and Convention on Biological Diversity (http://www.cbd.int/convention/about.shtml); Kyoto Protocol, source: Brown et al., 2011; UN Framework Convention on Climate Change and Kyoto Protocol, source: United Nations Framework Convention on Climate Change (http://unfccc.int/kyoto_protocol/items/2830.php); Global Environment Fund, source: Environmental Economics Policy Forum, 2007 and Global Environment Fund (http://www.globalenvironmentfund.com/).

Appendix 2B

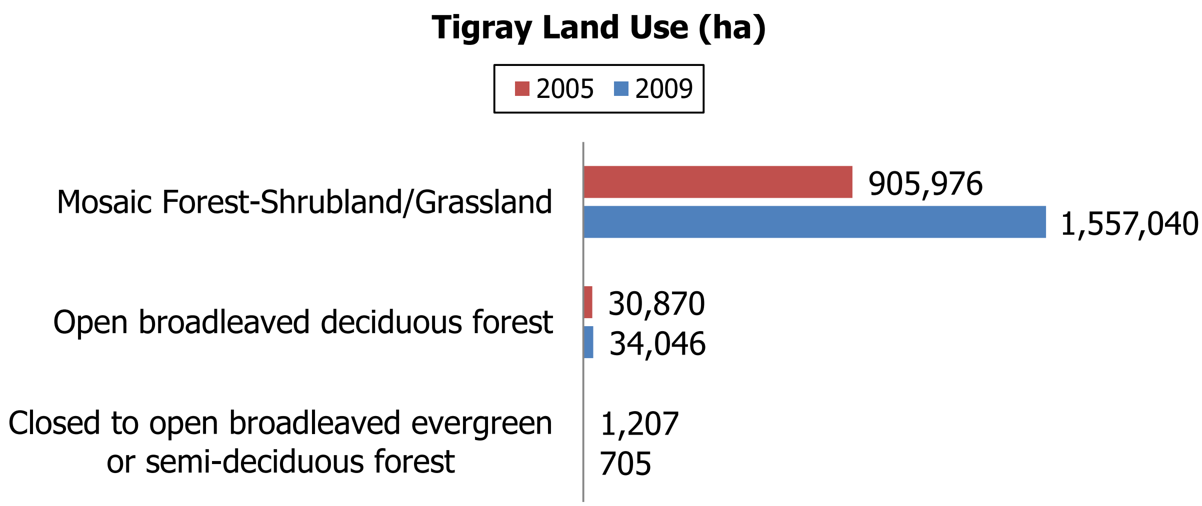

Figure 2.B1 Land use in Tigray region, Ethiopia, in 2005 and 2009. The three land uses noted are not representative of all land uses in Tigray (i.e., those identified as *other* in figures 2.4 and 2.5), GlobCover, 2011.

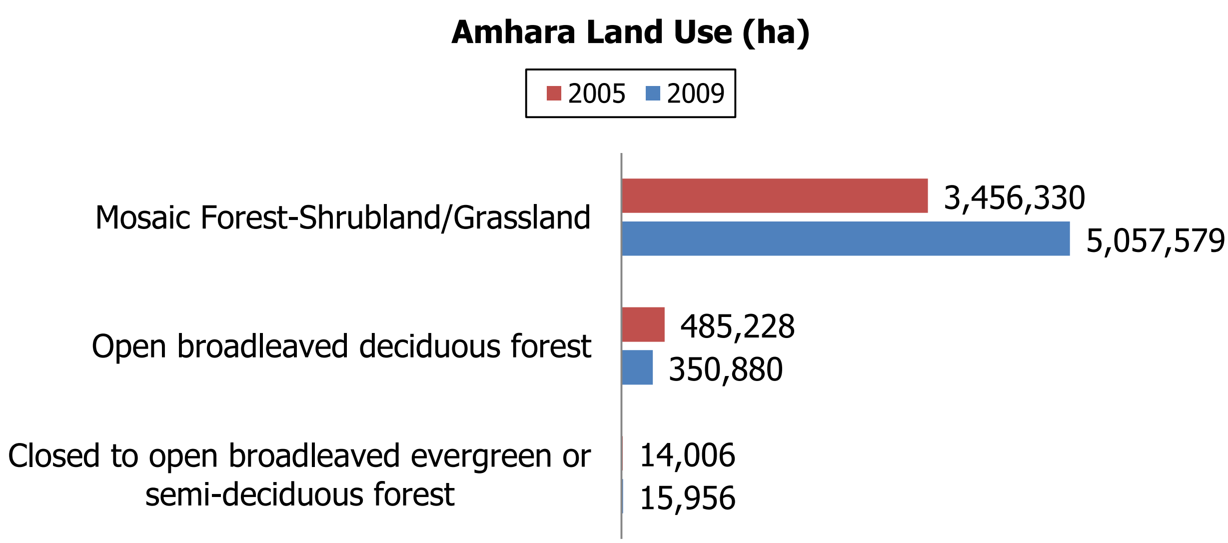

Figure 2.B2 Land use in Amhara region, Ethiopia, in 2005 and 2009. The three land uses noted are not representative of all land uses in Amhara (i.e., those identified as *other* in figures 2.4 and 2.5), GlobCover, 2011.

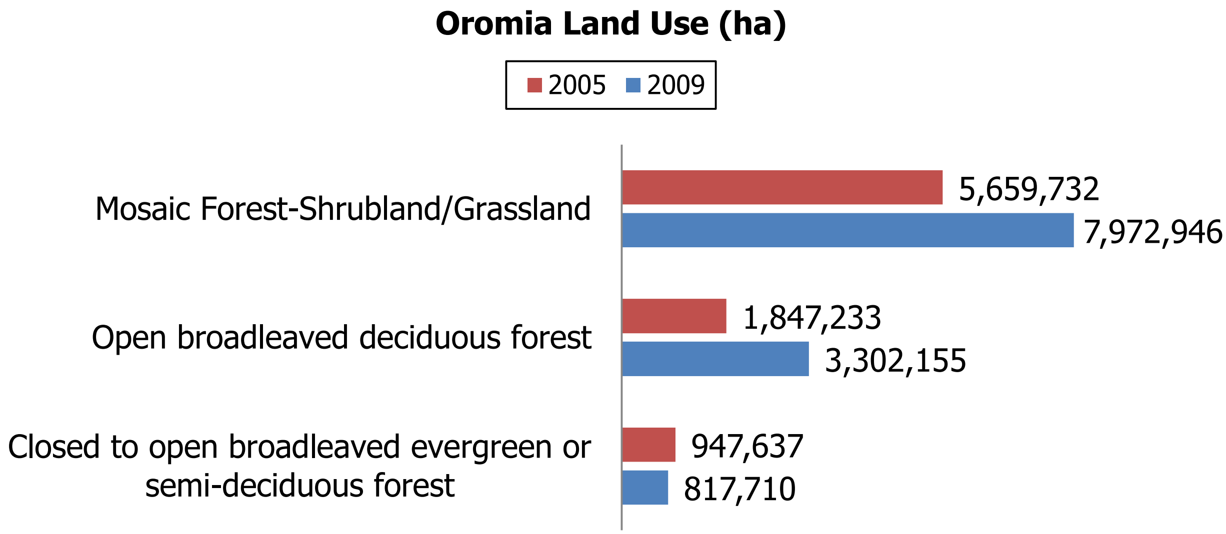

Figure 2.B3 Land use in Oromia region, Ethiopia, in 2005 and 2009. The three land uses noted are not representative of all land uses in Oromia (i.e., those identified as *other* in figures 2.4 and 2.5), GlobCover, 2011.

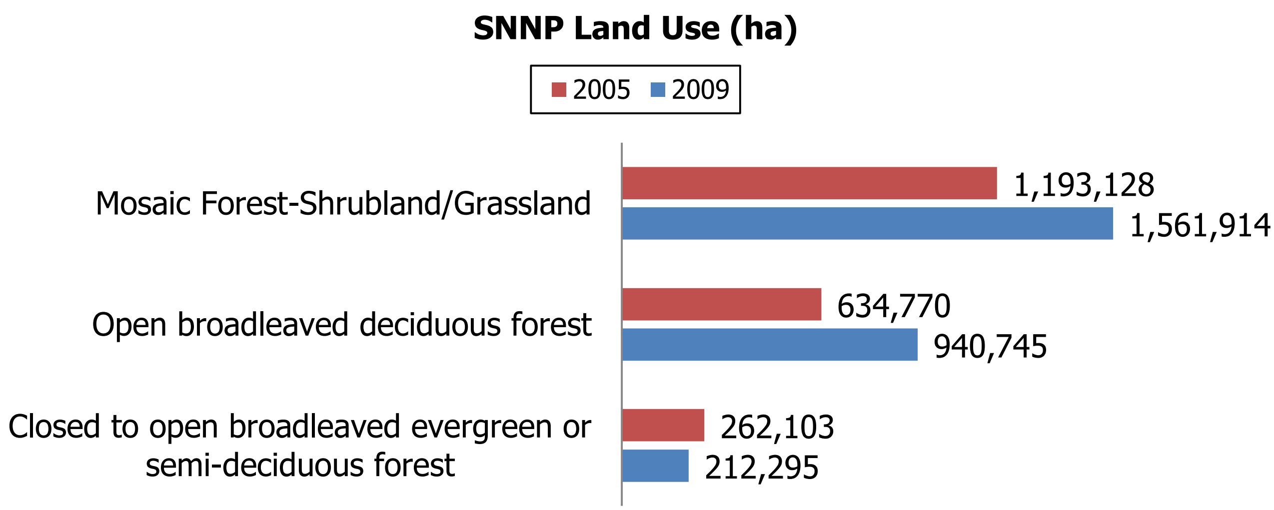

Figure 2.B4 Land use in SNNP region, Ethiopia, in 2005 and 2009. The three land uses noted are not representative of all land uses in SNNP (i.e., those identified as *other* in figures 2.4 and 2.5), GlobCover, 2011.

Appendix 2C

Table 2.C1 2005 Land cover type and coverage (ha) in study regions, GlobCover, 2011.

2005 GlobCover Land Use	Tigray (ha)	Amhara (ha)	Oromia (ha)	SNNP (ha)
Irrigated croplands	0	0	0	0
Rainfed croplands	427,533	330,812	1,048,152	184,398
Mosaic Croplands/Vegetation	1,108,820	4,938,039	7,206,009	2,263,540
Mosaic Vegetation/Croplands	1,180,772	833,657	7,015,453	3,577,801
Closed to open broadleaved evergreen or semi-deciduous forest	1,207	14,006	947,637	262,103
Closed broadleaved deciduous forest	0	0	0	0
Open broadleaved deciduous forest	30,870	485,228	1,847,233	634,770
Closed needleleaved evergreen forest	0	0	0	0
Open needleleaved deciduous or evergreen forest	0	0	0	0
Closed to open mixed broadleaved and needleleaved forest	0	0	0	0
Mosaic Forest-Shrubland/Grassland	905,976	3,456,330	5,659,732	1,193,128
Mosaic Grassland/Forest-Shrubland	5,367	59,181	250,066	32,627
Closed to open shrubland	718,749	4,541,993	7,201,810	2,510,343
Closed to open grassland	45,571	93,517	163,558	50,282
Sparse vegetation	400,515	43,081	443,113	142,389
Closed to open broadleaved forest regularly flooded (fresh-brackish water)	0	0	0	936
Closed broadleaved forest permanently flooded (saline-brackish water)	0	0	0	0
Closed to open vegetation regularly flooded	0	0	27,762	52,724
Artificial areas	19	0	946	0
Bare areas	112,031	453,220	395,505	239,236
Water bodies	1,738	315,281	232,064	104,946

Table 2.C2 2009 Land cover type and coverage (ha) in study regior 2011.

2009 GlobCover Land Use	Tigray (ha)	Amhara (ha)	Oromia (ha)	SNNP (ha)
Irrigated croplands	0	0	0	0
Rainfed croplands	394,386	321,304	1,024,754	180,711
Mosaic Croplands/Vegetation	1,116,417	5,652,377	7,797,863	2,430,968
Mosaic Vegetation/Croplands	1,140,385	525,703	5,745,276	3,669,040
Closed to open broadleaved evergreen or semi-deciduous forest	705	15,956	817,710	212,295
Closed broadleaved deciduous forest	0	0	0	0
Open broadleaved deciduous forest	34,046	350,880	3,302,155	940,745
Closed needleleaved evergreen forest	0	0	0	0
Open needleleaved deciduous or evergreen forest	0	0	0	0
Closed to open mixed broadleaved and needleleaved forest	0	0	0	0
Mosaic Forest-Shrubland/Grassland	1,557,040	5,057,579	7,972,946	1,561,914
Mosaic Grassland/Forest-Shrubland	4,933	47,366	237,517	18,514
Closed to open shrubland	248,396	3,028,391	4,813,450	1,787,424
Closed to open grassland	30,850	78,893	48,544	33,264
Sparse vegetation	303,871	25,213	240,056	100,486
Closed to open broadleaved forest regularly flooded (fresh-brackish water)	0	0	0	936
Closed broadleaved forest permanently flooded (saline-brackish water)	0	0	0	0
Closed to open vegetation regularly flooded	0	0	26,082	50,513
Artificial areas	0	0	956	0
Bare areas	106,471	147,283	185,334	158,982
Water bodies	1,670	313,398	226,397	103,430

Appendix 2D

Table 2.D Contacts during the Fall of 2011.

Name	Organization	Position/Title	Email	Telephone	# of Times Contacted	Did they Respond?
	Wondo Genet College of Forestry	Professor			3	yes
	World Bank				1	yes
	Ministry of Water Resources				1	no
	Concern for Environment	President			1	
	World Bank				1	yes
	World Vision				1	yes
	Canada Clean Development Mechanism & Joint Implementation				1	no
	Addis Ababa University	Professor			1	yes
	Peace Corps	Volunteer			2	yes
	World Vision				1	no
	World Bank				1	no

Appendix 2E

The GIS model outlined in Figure 2.E1 is a basic reclassification procedure consisting of two steps. First, I utilized the reclass tool to identify areas of forest and no forest in the 2005 and 2009 data. Second, by adding the two reclassified rasters using the raster calculator I was able to identify forest change (forest loss, unchanged forest and forest growth).

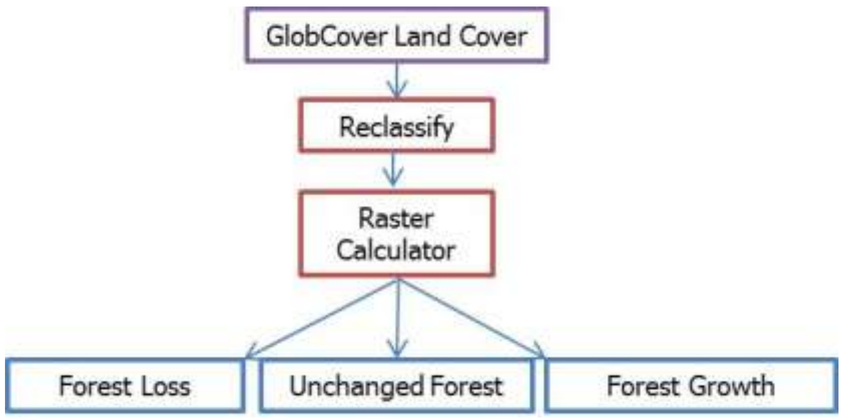

Figure 2.E1 Reclassification of GlobCover Land Cover model.

Figure 2.E2 depicts the method I utilized to calculate mean distance of roads, cities, regional boundaries and railroads from areas of forest (those created in Figure 2.E1). This model consists of three steps. First, for each variable I used the Euclidean Distance tool to create Euclidean distance rasters. Second, I used the raster calculator to multiply the Euclidean distance raster by the forest change raster so that the output would be the forest raster with Euclidean distance values for each pixel. Third, I divided the mean distance of each Euclidean distance raster by the maximum Euclidean distance possible in that raster no normalize the values. I also incorporated population density into this model by skipping the Euclidean distance step so that forest pixels would assume the population density value.

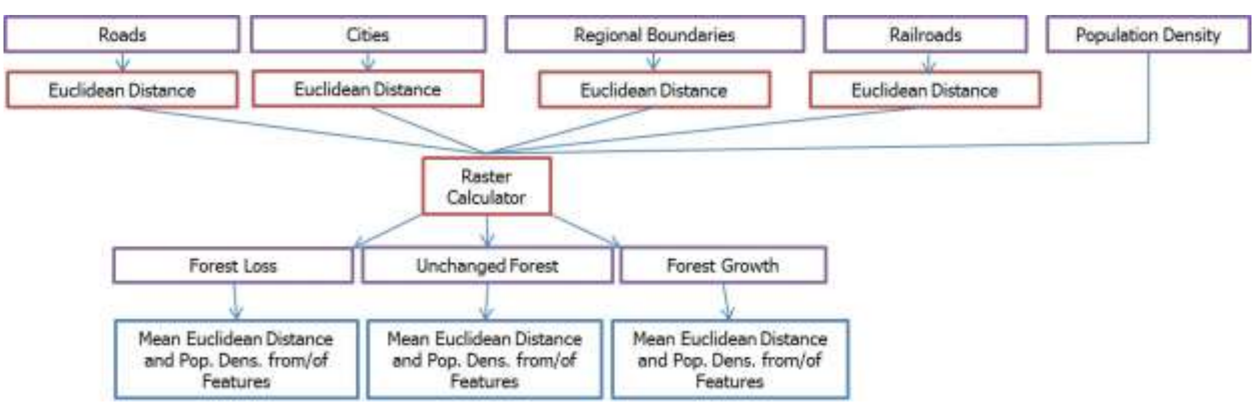

Figure 2.E2 Mean Euclidean distance analysis model.

Appendix 2F

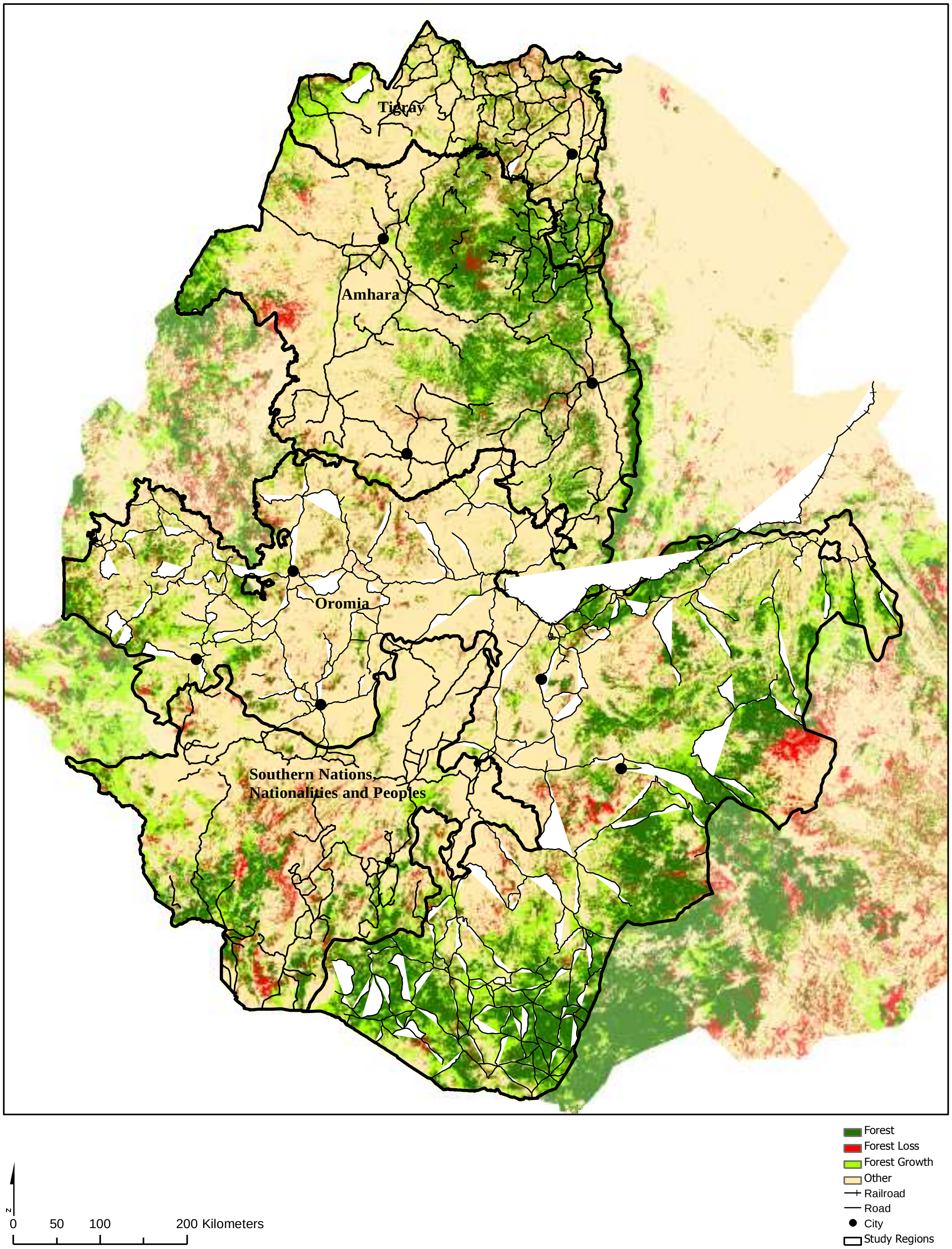

Figure 2.F Variables representing governance institutions, access to forests, and population pressures in relation to forest cover change 2005-2009, GlobCover, 2011 and GADM, 2011.