Aus dem Institut für Agrar- und Ernährungswissenschaften
(Geschäftsführender Direktor: Prof. Dr. Reihold Jahn)

der Naturwissenschaftlichen Fakultät III
(Dekan: Prof. Dr. Peter Wycisk)

der Martin-Luther-Universität Halle-Wittenberg

Identifying and understanding the patterns and processes of forest cover change in Albania and Kosovo

Dissertation

zur Erlangung des akademischen Grades
doctor agriculturarum (Dr. agr.)

vorgelegt von
Kuenda Laze (M. Sc. Environmental Sciences)
geb. am 1 Mai 1970 in Skrapar

Gutachter: Prof. Dr. Alfons Balmann
Dr. Daniel Müller

Verteidigung am: 18 November 2013

Halle/Saale 2013

Acknowledgements

This research was done during my time at the Leibniz Institute of Agriculture Development in Central and Eastern Europe (IAMO), Halle (Saale). Many people have contributed to this work, and without their support this research could hardly have been possible in the way it is presented now. Every step towards good progress has been very enjoyable. The next few paragraphs will acknowledge these people's contributions, starting with funding and theme orientation, their very helpful comments, discussions, data provision and intensive encouragement and support.

I am deeply grateful to my supervisors Dr. Daniel Müller and Prof. Dr. Alfons Balmann for funding the research and supporting it in the stage it is now.

Many thanks go to three people from the Helmholtz Center for Environmental Research (UFZ). I had very useful discussions with Dr. Sven Lautenbach on the R programming. The discussions with PD. Dr. Thorsten Wiegand and Dr. Raja Kanagaraj have been rewarding for the habitat suitability work. I am in debt to Stefan Suess for his voluminous work on the satellite imagines, to Valbona Simixhiu, Genc Xhillari and Gent Kromidha in Albania, and Ekrem Gjokaj, the staff of the Ministry of Agriculture, Forestry and Rural Development in Kosovo, as well as the Institute of Environmental Agency Kosovo, which made essential data available to this research.

After arriving in Halle (Saale), I received a lot of support from my IAMO colleagues, starting with BSE and the administration, who are always very helpful and kind - many thanks to all of them. I thank you very much Hauke Schnicke for always being helpful in German when mine was very poor, later to Dr. Amanda Sahrbacher and Florian Schierhorn for being good colleagues and sharing an office with them. I thanked you very much Dr. Karin Kataria for very useful discussions on calculations on local variations, always friendly times when we talked, and Dr. Zhanli Sun on the ArcGIS. I enjoyed very much having two Albanian colleagues and friends at IAMO - Klodjan Rama and Sherif Xhema - talking in our native language was always good. I enjoyed the organization in Poland we did with Graduate School groups, particularly with Swetlana Renner and Prof. Dr. Martin Petrick. Many thanks go to Jim Curtiss for editing the dissertation and making it more interesting to read.

The German course at the University has been worthwhile and enjoyable, with a very good teacher Elli Mack and best friends Dr. Timothy March and Dr. Melinda Noronha.

At the very end, this research could have never be written without the immense support and encouragement from my family and sister Ermira, who all prefer to let me work on it and finalize it peacefully while they had to pass many hard times by themselves. This monograph is dedicated first to my family. But it is also dedicated to good people that wish things to get better in Albania and Kosovo for themselves, their families, for their children and their future newcomers, and for those who do their best to make their lives better and help save the natural environment there.

Table of Contents

Tables

Figures

Abbreviations

AIC	Akaike information criterion
AIC_c	Corrected Akaike Information Criterion
AUC	Area under the curve of the ROC, Receiver operating characteristic curve
CoE	Council of Europe
CPOP	Commune population
CPPOP	Commune projected population in 2004
CV	Cross validation
D^2	explained deviance
DEM	Digital elevation model
ELPA	Environmental Legislation and Planning Albania
EMERAL	Network of Areas of Special Conservation Interest of Council of Europe
EURONATUR	European Nature Heritage Fund
FAO	United Nations Food and Agriculture Organization
FCCHA00	Forest cover change from 1988 to 2000 in hectare
FCCHA07	Forest cover change from 2000 to 2007 in hectare
FCHA	Forest cover in hectare
$FCKM^2$	Forest cover in square km
FCPER	Forest cover in percentage
FT	Forest transition
GLMs	Generalized linear models
GLS	Generalized least squares
GWR	Geographically weighted regression
ICBL	International Campaign to Ban Landmines
INSTAT	Institute of Statistics Albania
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Nature Conservation
KORA	Coordinated research projects for the conservation and management of carnivores in Switzerland

LUCC	Land use/ cover change
MAFRD	Ministry of Agriculture, Forestry and Rural Development of Kosovo
$NFCKM^2$	Non-forest cover in square km
OLS	Ordinary least squares
PCA	Principle components analysis
R	Statistical software
REML	Restricted maximum likelihood estimation
ROC	Receiver operating characteristic curve
SOK	Statistical Office of Kosovo
$TFCKM^2$	Total forest and non-forest cover in square km
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UTM	the Universal Transverse Mercator, geographical coordinate system
UXOM	Unexploited objects and mines
VEPOP	Village estimated population in 1991
VPOP	Village population
VPPOP	Village projected population in 2004
WB	The World Bank

Glossary

Deforestation	Deforestation is the process of forest cover change indicating the areas that were covered by forests in 1988 and 2000 and were not covered by forests in 2000 and 2007, respectively.
Forestation	Forestation is a process of forest cover change indicating the areas that were not covered by forests in 1988 and 2000, but were covered by forests in 2000 and 2007, respectively.
High forest	It is a term for a woodland or forest with a well-developed natural structure. It is used in both ecology and woodland management, particularly in contrast with even-aged woodland types such as coppice and planted woodland (Wikipedia).
Spatial heterogeneity	A spatial effect of spatial data. Differences of location across space is known as the spatial heterogeneity effect (Anselin, 1988).
Local coefficients/GWR coefficients	These coefficients were estimated by GWR.
Local influence	This meant the influence caused by local coefficients in a response-determinant relationship.
Local influence variation	This is the change of local influence across the space for a relationship between a determinant and the response variable in a certain period of time.
Pixel	This is a single point in a raster image (Wikipedia). Pixel is the smallest unit from the satellite imagines.
Vector	Vector data are points, lines, curves, polygons, which are based on mathematical expressions to represent images

	in computer graphics (Wikipedia).
Raster	Raster data is a data structure representing a generally rectangular grid of pixels, or points of color viewable via a monitor, paper, or other display medium (Wikipedia).
Shape file	Shape file are the format of geospatial vector data for a geographic information system (Wikipedia).
Species	Species is one of basic units of the biological classification and taxonomic rank (Wikipedia); they are brown bear, wolf and lynx in this study.
Umbrella species	They are species selected for making conservation related decision, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat (Wikipedia).
Flagship species	The flagship species concept holds that by raising the profile of a particular species, it can successfully leverage more support for biodiversity conservation at large in a particular context (Wikipedia).

1. Introduction

Forests are crucial for humanity and harbor a significant portion of the planet's biodiversity (Diaz et al., 2006; Hooper et al., 2005; Millenium Assessment, 2005a; Rudel, 2002). Changes in forest ecosystems threaten the provision of such services and are among the most important drivers of global environmental change (Asner et al., 2005; DeFries et al., 2006; Lepers et al., 2005), as they can erode the basis of local livelihoods, and compromise human well-being in many areas of the world (Chomitz, 2007; Kareiva et al., 2007; Turner II and Meyer, 1994; Vitousek et al., 1997). In addition, activities such as logging, forest overuse and mismanagement may lead to forest habitat fragmentation (Lindenmayer and Fischer, 2006), which is one of the key drivers of global species loss (Fischer and Lindenmayer, 2007). Forests that have been affected by forest fragmentation, selective logging or a first fire subsequently become even more vulnerable to fires (Cochrane, 2001; Csiszar et al., 2004; Siegert et al., 2001, cited in Lambin and Geist, 2006), while infrastructure development (roads, human settlements) can encourage habitat loss and degradation (Lambin and Geist, 2006). Moreover, a lack of enforcement (of law) and weak institutions contribute to the loss of forest cover (Agrawal et al., 2008; Taff et al., 2010). Challenges that face humanity include how to take account of and to understand the changes and modifications in land cover, as well as to assess the impacts of such changes on biodiversity and ecosystem services (Haines-Young, 2009).

Deforestation and forest degradation contribute up to 20 % of global greenhouse gas emissions (IPCC, 2007) and are among the prime causes of global biodiversity decline due to habitat loss (Gaston, 2005; Loiselle et al., 2010; Pimm and Raven, 2000; Sala et al., 2000). These consequences of forest cover change have manifold implications for ecosystem functioning and human well-being (Hooper et al., 2005; Millenium Assessment, 2005a). Hence, understanding the patterns and processes of forest cover change may help us better comprehend the acquisition of natural resources by humans, as well as their consequences on forest-based ecosystem services.

Yet, forest cover is also expanding in many areas around the globe. Forest increases are attributed to a variety of pathways that are reactions to changes in the exogenous boundary conditions such as industrial development or state policy measures, or are caused by endogenous reactions of land users to changing forest product scarcities (Lambin and Meyfroidt, 2010; Rudel et al., 2005). An increase in forest cover may positively affect forest-based ecosystem services by, e.g., sequestering carbon from the atmosphere, decreasing surface runoff, and altering landscape habitats. Again, the particular effects are place-specific and better knowledge of the causes that lead to changing forest cover, including the increase of forest cover, may provide valuable inputs for better targeting of conservation policies and programs.

This is especially true for Eastern Europe and the former Soviet Union, two regions that harbor significant forest resources, but experienced considerable illegal logging, clear cutting, but also significant natural expansion of forests on formerly used agricultural lands (Kuemmerle et al., 2009b; Müller and Munroe, 2008). The contraction of cropland and pastures was brought about by the declining economic competitiveness of agriculture that frequently shifted rural livelihoods toward emigration and off-farm employment (Müller and Sikor, 2006; Stahl, 2007). Yet, these countries are particularly interesting, because the collapse of socialism induced massive changes in economic, political, and institutional frameworks. This includes the decline in agricultural subsidies, which translated into decreasing input levels in agricultural production across the region, and, as a result, led to widespread land-use change (Kuemmerle et al., 2008; Lerman et al., 2004; Palang et al., 2006; Prishchepov et al., 2012; Rozelle and Swinnen, 2004). The most dominant change in land use was the decline of cultivated areas in response to the dissolution of the former socialist states, also labeled as "the most widespread and abrupt episode of land change in the twentieth century" (Henebry 2009, cited in Müller, 2012). Unfortunately, empirical studies that focus on identifying and understanding the patterns and processes of forest cover change in post-socialist countries are scarce and little is known about the pattern-process relations of land use/land cover change among different regions in Eastern Europe (Taff et al., 2010).

Our study contributes to filling this gap by investigating the determinants and forest cover change in Albania and Kosovo from 1988 until 2007 using an integrated human-environment dataset. Forest cover data was derived from high-resolution Landsat data for three points in time that allow calculating changes in forest cover for two periods. The two periods characterize distinct aspects of Albanian and Kosovan history. The period from 1988 to 2000 captures a volatile time of the rapid change from socialist regime to a market economy in 1990, associated with radical agriculture land distribution reform in 1991 that changed agricultural land ownership from cooperatives to private (Cungu and Swinnen, 1999). This time was also characterized by high migration from rural to urban areas, as well as migration abroad (Calogero et al., 2006; King, 2005), and paved the way for the post-socialist forest reform that transferred forest resource ownership from central to local government bodies. The period from 1988 to 2000 corresponds to the beginning of the collapse of former Yugoslavia and contains the Kosovo war from 1998 to 1999. The period from 2000 to 2007 corresponds to the second decade of the post-socialist period for Albania. During the same time, post-war reconstruction in Kosovo helped form a new state. These substantial political developments were potentially associated with important legacies on forest use and quality.

The choice of the two periods permitted us to infer forest cover change processes since the collapse of socialism, as well as for almost two decades of post-socialist developments in Albania and the splitting up of Kosovo from the former Yugoslavia. It was hypothesized that forest cover changes was particularly linked to political and institutional changes, regional development disparities, and outmigration of the rural population. It was further assumed that increases in forest as a result of agricultural abandonment were concentrated in areas that were less suitable for agricultural production and, as a result, were abandoned after the collapse of socialism (Taff et al., 2010). Political regime change triggered increased logging, including illegal logging for timber harvesting, fuel wood, and charcoal production in the first period, particularly in Albania. During the first decade of the post-socialism, an Albanian forest ownership transfer reform was newly introduced by the government of Albania and Kosovo war occurred. More forest regeneration was expected in the recent more stable period compared to the first period, because of decreasing pressures on forests, of the transfer of forest resource ownership reform in Albania and of post-war in Kosovo.

This study was the first spatially explicit and country-wide study of the determinants of forest cover changes for both Albania and of Kosovo. The satellite-derived forest-cover change data were integrated with a range of environmental, institutional, policy and demographic data at village level for the entire territories of both countries and the cross-border study region of Albania and Kosovo. The analysis relied on geographically weighted regression that investigated the local variation of forest cover change for the two periods and the two countries. It was specifically investigated the validity of the hypotheses of important determinants of forest cover change in Albania and Kosovo, and compared the importance of each hypothesis for the two countries. The setup of our study with two countries and two periods further suggested interesting insights into temporal variations in the determinants of forest cover and into the impact of country-level and sub-region level developments on forest cover. Thus, it was possible to infer on the differential effects of post-socialist policies and macro-economic development on forests. The insights from GWR were then used to calibrate the models for habitat suitability of large predator species, i.e., lynx, brown bear and wolf, to figure out the impact of forest cover change on changes in habitats between 2000 until today 2007. The present work considered the spatial heterogeneity of forest cover change and filled important gaps in research on the patterns and processes as well as on the ecology for flagship species of lynx in the Balkan region

Specifically, the author aimed to address the following research questions in this study:

1) What were the determinants of forest cover change in Albania and Kosovo?

2) How did the determinants of forest cover change vary over time and space?

3) What were the effects of forest cover changes on the habitat suitability of large predator species in Albania?

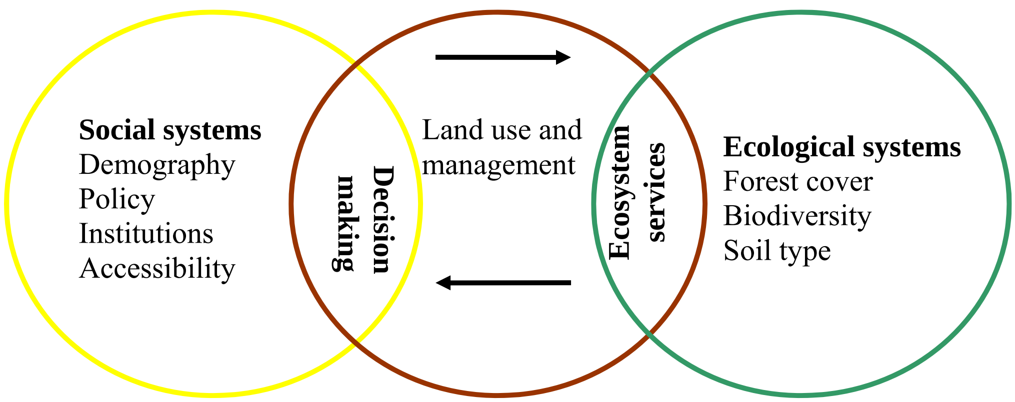
2. Theoretical background on forest cover and use

This chapter describes three theoretical themes of human and environment interactions in section 2.1, forest services in section 2.2 and forest transition in section 2.3. Methods of spatially explicit analysis and information-theoretic is in section 2.4. Hypotheses on determinants of forest cover and of deforestation and forestation are drawn based on literature, and placed in the section of 2.5.

2.1 HUMAN-ENVIRONMENT INTERACTIONS

Humans have altered most terrestrial ecosystems (Vitousek et al., 1997) and no place on the planet remains unaffected by human influence (Kareiva et al., 2007). Indeed, research has revealed the environmental impacts of land use throughout the globe, ranging from changes in atmospheric composition (e.g., climate change) to the extensive modification of Earth's ecosystems (e.g., biodiversity loss) (Foley et al., 2005). Evidence of climate change and its impacts on society and the environment have become generally accepted by scientists (IPCC, 2001; IPCC, 2007; Pearce et al., 1996), along with the importance of mitigating and adapting to climate change (Adger, 2006; Allen et al., 2009; IPCC, 2007) , though public awareness and policy changes are lagging behind (Sheppard, 2005). Changes in land and ecosystems and their implications for global environmental change and sustainability are major research challenges for human-environmental sciences (Turner II et al., 2007). Scientist studying atmosphere and climate recognized that the human dimensions of the processes they were studying in the physical sciences were not receiving adequate attention despite the clear impact of human actions on Earth's climate and atmosphere (Moran and Ostrom, 2005). As the matter of fact, earlier work of the Land Use Change (LUCC) has helped researchers, firstly, to understand the dynamics of land use change and its consequences, and secondly, to realize that our understanding of the social dynamics was still very limited (GLP, 2005). Many parts of the Planet Earth have changed and are listed as problematic; a prime example is the conversion of the Earth's land surface to man-made land use (GLP, 2005). The land system is the terrestrial component of the Earth System, and stays at the center of understanding the relationship between humans and environment (GLP, 2005). Nowadays, the focus of land use change is to measure, model and understand the coupled socioeconomic terrestrial system (henceforth referred to as the "land system"), aiming to understanding factors affecting decision making, implementation of land use and management and the impacts on social and ecological systems (Figure 2.1 adapted from GLP (2005)). This figure of 2.1 shows seven variables of social and ecological systems consisting of data of demographic, policy, institutions, accessibility (social system), and forest cover, biodiversity and soil type (ecological system), respectively, to understand the forest cover changes in this study.

Figure 2.1 Conceptual framework of land systems



Source: Adapted from (GLP, 2005)

Land cover is a biophysical label for the earth's surface. Land is typically observed with satellite remote sensing. Observations of satellite images are used to map the rates and spatial patterns of forest cover change, at multiple scales and for different time steps (Cihlar, 2000; Gutman et al., 2004; Kuemmerle et al., 2009a; Rounsevell et al., 2006). Remote sensing is particularly useful in countries where data sources and national statistics are scarce and where ground-based data sets are not existing or are inaccessible (as is the case for Albania and Kosovo) (Kuemmerle et al., 2009a). The decision of managers and users (government, villagers in Albania and Kosovo) to use, protect forests to regenerate, conserve forests (for their biodiversity designated as protected areas), to open new land for agricultural production define the patterns of forest cover that we can observe using aerial photos, satellite images. Studies using historic data of land cover presents a good opportunity to investigate how choices are made in the past that have influenced present-day landscapes; this helps introduce a longer time perspective into policy-relevant land system projection to sustainable-oriented decision-making of ecosystem services, not to misuse and mismanage ecosystem services as these services are not indefinitely abundant on Earth (GLP, 2005).

Moran and Ostrom (2005) presented the multiple scalar approach, meaning that relationships may exist at one scale but not at another, and same relationships are contingent on certain contextual variables meaning that both scale and context matters in human and environment relationships (Moran and Ostrom, 2005).

2.2 FOREST ECOSYSTEM SERVICES

The services of forest services and their importance are summarized and presented in the Millennium Assessment 2005 (Millenium Assessment, 2005a). According to Millenium Assessment (2005a) there are five classes of forest services, which are shown in the Figure 2.2 following Millenium Assessment (2005b). Forest services are resource (e.g., industrial wood, fuelwood, non-wood production), biospheric (biodiversity, climate regulation), amenities (spiritual, cultural, historical), social (sports, fishing/hunting, recreation, ecotourism) and ecological (health protection, soil protection, water protection) (Millenium Assessment, 2005b). Fuelwood, industrial wood, and biodiversity are considered in this study.

Figure 2.2 Forest services

Notes: Resource and biospheric classes of forest cover that is relevant to the study.
Source: (Millenium Assessment, 2005b)

Forests contribute about 15 % to Global Gross National Product (GNP) (Costanza et al., 1997) and have substantial biodiversity values (Costanza et al., 1997; Foley et al., 2005; Nagendra and Southworth, 2010; Naidoo and Ricketts, 2006; Pimm and Raven, 2000). The identification and categorization of forest benefits by total economic value shows the importance of forests and points out that forest loss and degradation are accompanied by a decline of forest service supplies (Millenium Assessment, 2005b). Thus, forests must be well-managed so that they meet the forest principles of 1992, which state that forest resources and forest lands shall be managed and used sustainably to fulfill the social, economic, ecological, cultural and spiritual needs of present and future generations (Millenium Assessment, 2005b). However, this is often not the case. Forests are mismanaged or logged illegally, leading to deforestation, a loss of biodiversity, climate change, and a worsening of livelihoods in rural areas (FAO, 2010a; Foley et al., 2005; Geist and Lambin, 2002; Lambin and Meyfroidt, 2010; Nagendra and Southworth, 2010).

Two United Nations Climate Change and Biodiversity Conventions show that biospheric services' importance are recognized at the global level (Millenium Assessment, 2005b). These conventions are ratified by governments, e.g., by the government of Albania, and indicate the acknowledgement of the importance of these services nationally.

2.3 FOREST TRANSITION

Forests transition theory assumes that, in the course of economic development, industrialization, and concurrent emigration from rural areas to urban centers, forest cover starts to increase after periods of decline in early development stages (Rudel, 1998). The lowest point on the curve of forest cover changes over time is named forest transition (Mather, 1992), figure 2.3.

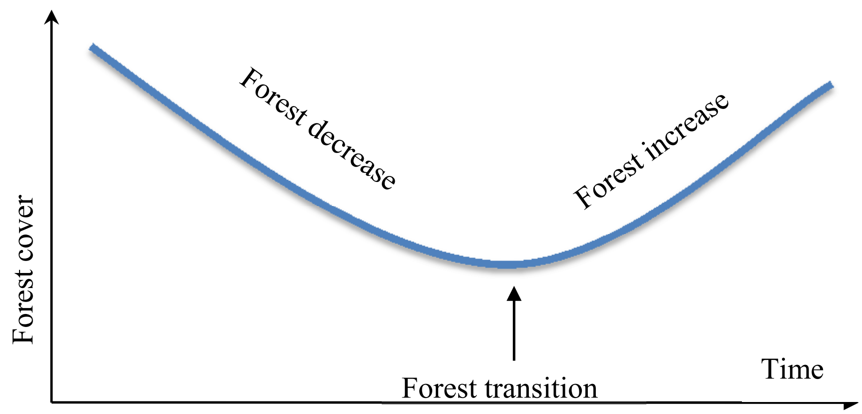


Figure 2.3 Forest transition Source: (Mather, 1992)

According to Rudel et al. (2005), there are two pathways of forest transition: forest scarcity pathway (a scarcity of forest product and/or decline in the flow of services provided to societies by forest ecosystems prompted governments and land managers to establish effective afforestation programs) and economic development (Rudel et al., 2005). According to the economic development pathway , the labor force is driven from agriculture to other economic sectors and from rural to urban areas because of economic expansion (Lambin and Meyfroidt, 2010); large areas of land that are marginally suitable for agriculture are abandoned and left to forest regeneration (Lambin and Meyfroidt, 2010; Rudel et al., 2005). Often, the forest transition also goes in hand with a switch from the dominance of agricultural institutions to that of forestry institutions (Grainger, 2010).

Meyfroidt and Lambin (2010) showed three more pathways of forest transition. They are state forest policy, tree-based land use intensification and ecological quality of forest transition, and globalization (Meyfroidt and Lambin, 2010). Globalization is a more modern version of the economic development pathway that occurs when a national economy becomes increasingly integrated into global markets for commodities, labor, capital, tourism and ideas (Rudel, 2002 cited in Lambin and Meyfroidt, 2010). State forest policy is a new national forest/land use policies aiming to modernize the economy of land use, integrate marginal social groups, promote tourism, or foreign investments, geopolitical interest in asserting control over remote territories via the creation of natural reserves, managed state forest; tree-based land use intensification is driven by innovations in farming systems rather than by forest conservation (Meyfroidt and Lambin, 2010). Ecological quality of forest transition implies that forests can change their ecological quality in each of aforementioned pathways, because they (pathways) can be associated with varying impacts on the delivery of ecosystems goods and services and with forests with different ecological qualities; for example, a country that would have depleted its primary forests and replace them by tree crop plantations could appear to undergo a forest transition (Lambin and Meyfroidt, 2010). In addition, Meyfroidt and Lambin (2010) states that forest pathways are not independent and interact in several ways, and certain forest transition pathways are more likely to lead to forest transitions with high ecological quality than others (Lambin and Meyfroidt, 2010).

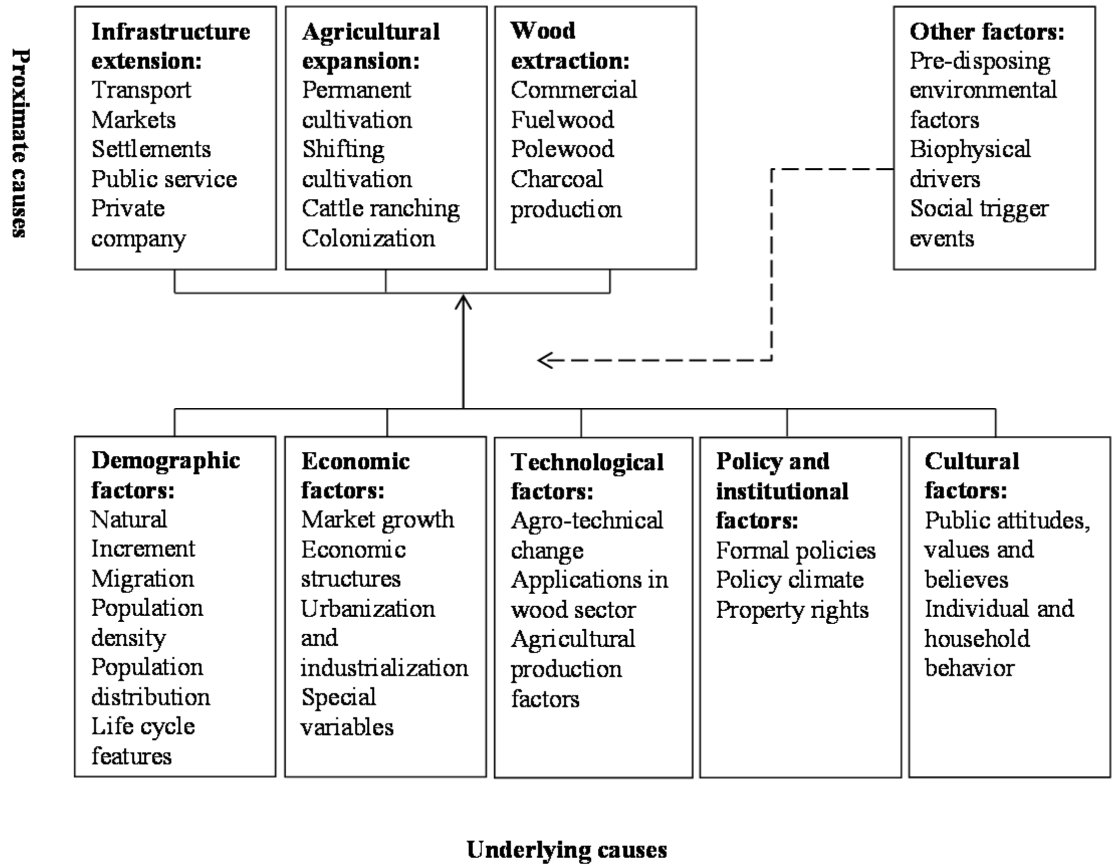
Forest transition is studied firstly in Europe (Mather, 1992; Mather and Needle, 1998) and later in Asia and other tropical forest countries (Mather, 2007; Rudel, 2010; Rudel et al., 2002). Researchers that studied forest transitions in tropical forest countries have tried to explain the factors that cause the return of forests. Agriculture expansion and wood exploitation in the uplands, driven by population growth and migration from lowlands, caused deforestation in Vietnam from the 1970s to 1980s; later periods of reforestation were accompanied by political and economic changes as a response to the economic stagnation of the country after the 1980s (Meyfroidt and Lambin, 2010).

Forest transitions occurrences were analyzed at various spatial scales. Studies characterized sub-regions within a country (Farley, 2007; Xu et al., 2007), an entire country (Bae et al., 2012; Mather et al., 1999), or several countries within a large geographical region (Rudel et al., 2005). The empirical evidence shows that forest use and, consequently, forest cover changes differ from one region to another, between countries (Redo et al., 2012), and subregions of a country (Rudel et al., 2005). Priority has been given to empirical studies for forest transition (Grainger, 2010; Mather, 2007). In this regard, post-socialist countries are interesting to study because governments might have implemented new land use and forest policies after the collapse of socialism, which could affect the occurrences of forest transition, e.g., could cause a delay of forest transition. Empirical studies could give their contributions to show the particularities of forest transition at country, but also at sub-region and region level as needed and cited from the literature of forest transition. Studies of post-socialism countries could also reveal worthy findings of forest transition occurrences from the beginning of the socialism until today. Such studies could compare the governmental interventions and policies of land use in two periods i.e., between period of socialism and post-socialism and, investigate the effects of socialism and post-socialism governmental interventions on forest services. For example, there are empirical evidences that indicate that forests in post-socialist countries experienced excessive timber extraction and including illegal logging decreased forest cover after the collapse of socialism in many countries of Eastern Europe and the former Soviet Union; subsequent forest increase, mainly in later periods of the transition, was mostly due to the natural forest succession of forests on abandoned agricultural lands (Taff et al., 2010). Also, forests in these countries have a high potential for carbon sequestration because of forest increase (Kuemmerle et al., 2011), and therefore these empirical studies show a way to tackle the climate change that has nationally, regionally and globally a positive impact to climate regulation, but also to forest biodiversity.

2.4 SPATIALLY EXPLICIT ANALYSES OF FOREST COVER CHANGE

Statistical analysis is an important tool for models of land-use change. Regression analysis, for example, helps to quantify the contribution of the individual forces that drive land-use change as demonstrated by Rietveld and Wagtendonk (2004) and Verburg et al. (2004a) thus provides the information required to appropriately calibrate models of land-use change (Koomen and Stillwell, 2006). Also, land use change models are tools for understanding and explaining the causes and consequences of land use dynamics; they facilitate the integration of both environmental and human variables (Chowdhury, 2006; GLP, 2005; Müller and Zeller, 2002; Nelson et al., 2004; Serneels and Lambin, 2001; Veldkamp, 2004; Verburg et al., 2004b). Spatially exploratory statistical analysis have been also used to uncover the underlying processes that determine forest cover and forest cover changes (Geist and Lambin, 2002; Irwin and Geoghegan, 2001; Mertens et al., 2001; Müller and Zeller, 2002). Geist and Lambin (2002), identified driving forces and proximate causes of deforestation in tropical forests consisting, respectively, of demographic (e.g., population density, population distribution, migration), economic, technological, policy (e.g., mismanagement), cultural factors (e.g., public that is unconcerned about forests), other factors (e.g., war, forest fires), infrastructure extension (e.g., road, settlements), agricultural expansion and wood extraction (commercial, fuelwood, charcoal production), for more information on the interrelations of these selected driving factors and proximate causes (see Geist and Lambin, 2002), Figure 2.4.

Figure 2.4 Causes of forest decline



Source: (Geist and Lambin, 2002)

Models of land use change and of deforestation utilize variables that are biophysical e.g., elevation, slope, soil type, rainfall, socioeconomic e.g., demographic (Chowdhury, 2006; Müller and Zeller, 2002; Nelson and Hellerstein, 1997), urban growth (Long et al., 2007), and policy (Agrawal and Chhatre, 2006; Deininger and Minten, 2002; Geist and Lambin, 2002; Lambin et al., 1999) e.g., accessibility variables (Chowdhury, 2006; Müller and Zeller, 2002), protected areas (Deininger and Minten, 2002).

2.5 DETERMINANTS OF FOREST COVER CHANGE AND PROCESSES

"The importance of the related concepts of the centrality of location and the influence of neighbors parallels the centrality of constrained (by resource or budget) utility maximization concepts for economists" (Nelson, 2002). Agricultural markets are used "to illustrate the importance of location and its corresponding transport costs to a central market when determining production (land use choices) at various locations and the resulting land rent" (Nelson, 2002), namely the theory of agriculture location von Thünen, which has still influence on nowadays research on land use despite the theory was formulated in 1826 (Moran and Ostrom, 2005). The vicinity of forests to markets, the presence of roads are all used as determinants that have an impact on deforestation (Deininger and Minten, 2002; Mertens et al., 2001; Nelson and Hellerstein, 1997). "Distance and travel times to road and markets serve as a proxy for prices and transaction costs (Deininger and Minten, 2002) and access to political centers" (Müller, 2003) and "lower values of these variables might be associated with lower forest cover because of higher producer prices, lower input prices and lower transaction costs compared to remote locations" (Müller, 2003). Higher lagged population is often cited as a major factor influencing deforestation (Deininger and Minten, 2002; Müller and Zeller, 2002). Forests in protected areas are better-protected from the deforestation, which means that less deforestation occurs in protected areas forests (Deininger and Minten, 2002; Geist and Lambin, 2002).

Deforestation is caused by logging activities in areas accessible by roads. The government of Albania planned to rehabilitate forest roads for legal logging but the intervention of government to improve the forest roads encouraged the collection of wood that was not legal (the World Bank, 2004; the World Bank, 2007a). The long-term forest resources assessment database of European Forest Institute (EFI) showed that fuel wood and industrial wood were mostly used during socialism (from 1953 until 1990) in Albania and the Former Yugoslavia (where Kosovo was part) (European Forest Institute, 2009). From 1990 until 2005, the removals of forests are still in statistics as "industrial round wood removals and wood fuel removals" FAO (2010b), i.e., wood were extracted as industrial and fuel-wood in Albania. Also, the author got confirmation that fuel wood and industrial wood were still important in Albania during the data collection in 2008. After the collapse of socialism in Albania, charcoal production and grazing in forests have caused forest degradation (the World Bank, 2011) and own observations. Forest fires are usually set by local people mainly for the increasing the productivity of pasture (observed during my work experience in Albania). The number of forest fires increased from 342 in 1996 to 1,182 in 2007 in Albania (FAO, 2010b). Agriculture statistics of Kosovo showed that fuel wood is important in rural areas of Kosovo for heating (Statistical Office of Kosovo, 2008). In sum, deforestation may be caused by wood extraction for firewood by local people, industrial wood in Albania and Kosovo and charcoal production, and forest fires in Albania, Table 2.1.

Table 2.1 Determinants of forest cover change processes based on the literature and knowledge on Albania and Kosovo

Determinants of forest cover change	Process	Reference
Extraction of wood: for firewood for charcoal production for export Forest fires	Deforestation	(European Forest Institute, 2009; Müller and Sikor, 2006; Statistical Office of Kosovo, 2008), own observations
Cropland abandonment in Albania Forests regeneration in commune forests in Albania Mined-areas and Unexploded Objects of Kosovo war	Forestation	(Machlis and Hanson, 2008; Müller and Munroe, 2008; Taff et al., 2010; the World Bank, 2002) own observations

Albania and Kosovo have experienced high outmigration of population from rural to urban areas as well as abroad (Calogero et al., 2006; United Nations Development Program of Kosovo, 2004), which could mean less pressure to forests and allow forests to regrow. The post-socialism reform of agriculture in 1992 was associated with the refuse of marginalized and non-high quality agricultural land in Albania (the World Bank, 2002). The decline of agricultural cultivation may potentially lead to the natural expansion of forests in Albania and therefore to the increase of forest cover (Müller and Munroe, 2008; Taff et al., 2010). The new forestry reform started to be implemented in 1994 in the post-socialism Albania, where local people and government were allowed to manage forests (the World Bank, 2011). Years of establishment of communal forest administration are expected to be positively correlated with forest cover, because more forests may grow naturally since local people let forests regenerate (Agrawal and Chhatre, 2006; the World Bank, 2004; the World Bank, 2011) as well as some villages planted trees to protect soil from the erosion (the World Bank, 2011). Therefore, natural regeneration of forests and afforestation in communal forests could lead to the increase of forest cover. Forests in surrounding and inside of some of protected areas have experienced intensive illegal logging leading to the decrease of forest cover (the World Bank, 2004), which indicates that new institution of forest management and environmental protection failed to protect forests in some of protected areas. The forests near Unexploited Objects and Mines (UXOM) sites could be abandoned because they might be still dangerous to use them, (e.g. Machlis and Hanson, 2008). The author observed land abandonment in previous mined areas of the conflict 1998-1999 in Kosovo in border with Albania (during my work experience in Kosovo).

Hypotheses of determinants of forest cover (change)

Literature shows that relationships between variables vary across space (spatial heterogeneity). For example, the relationships between variables of environment and vegetation (Kupfer and Farris, 2007), socioeconomic and vegetation (Ogneva-Himmelberger et al., 2009), accessibility to infrastructure and forests varied (Deininger and Minten, 2002). In this study, relationships between forest cover change and population, the distance to nearest roads, to human settlement, to protected areas and to forest edge are assumed to vary from one area to another in the study area. The sign of these relationships is ambiguous, Table 2.2.

Table 2.2 Hypotheses of determinants based on the literature of forests, land use change, climate change

Model	Determinants	Forest cover	Reference
Biophysical	Elevation	+	(Agrotec.SpA.Consortium, 2004; Deininger and Minten, 2002; Müller and Zeller, 2002)
	Soil type	+	(Deininger and Minten, 2002)
	Village centroid (X, Y)	+	(IPCC, 2001; Thuiller et al., 2005)
	Ecological regions	+	(FAO, 2000)
Demographic	Population, population density	ambiguous	(Deininger and Minten, 2002; Müller and Zeller, 2002)
Political-institutional	Distance to nearest roads Distance to nearest human settlements Distance to nearest city and commune center	ambiguous	(Deininger and Minten, 2002; Müller and Zeller, 2002; the World Bank, 2004; the World Bank, 2007a)
	Communal forests	+	(Agrawal and Chhatre, 2006)
	Protected areas	+	(Deininger and Minten, 2002; Geist and Lambin, 2002)
	Distance to nearest protected areas	ambiguous	
	Distance to nearest UXOM	-	(Machlis and Hanson, 2008)
	Distance to nearest forest edge Accessibility of forests at the beginning of period	ambiguous	(Deininger and Minten, 2002; Müller and Zeller, 2002)

Elevation and soil type are expected to be positively correlated to the forest occurrences; the higher the elevation, the higher the forest occurrences (Deininger and Minten, 2002; Müller and Zeller, 2002). Certain types of forests, for example, beech grows naturally in certain soils, in higher elevation than oak forests (Agrotec.SpA.Consortium, 2004). Hence, the variables capturing soil types are expected to be statistically significant for forest cover (changes) in some regions. But the direction of influence is unclear a priori, because the forest cover change data does not contain information on the composition of forest species that may have allowed anticipating the effect of soil types.

The geographic location of villages, measured as the centroid coordinates of a village, serve as proxies for climatic conditions. Albania has a Mediterranean climate in the west and south and a more continental climate in the east and northeast. Therefore, villages further north (larger Y coordinates) and villages further east (larger X coordinates) tend to have a cooler (lower temperature) and a more humid climate (more rainfall) than villages further in the south (smaller Y) and the west (smaller X). Differences and changes in climate conditions affect forests. For instance hotter and drier climate (i.e., smaller X and Y of a village) will result in increased risk of forest fires that negatively affect forest (cover), the forest ecosystem productivity and lead to biodiversity loss (likely of forests of a village) (IPCC, 2001; Thuiller et al., 2005). Therefore, it is expected that villages in south of Albania could have more changes of forest cover (more deforested area) than those in northern Albania because of the increasing occurrences of forest fires caused by hotter climate (increasing temperature) and drier (fewer rainfall events) condition during the summer but also because of the changes of temperature and rainfalls caused by the climate change.

Ecological zones are useful information to provide insights on the changes of forest resources based on the natural features of vegetation (sometimes a vegetation can cover more than one country area) at large-scale, region level (FAO, 2000). Forests in Albania and Kosovo are subtropical dry forests “dominated by evergreen oak species” and “temperate continental forest ecological zones” consisting of different deciduous broadleaved forests, which are represented by “oak, mixed oak-hornbeam and mixed lime-oak forests” according to FAO (2000). Therefore, more broadleaved forests are expected to grow naturally in subtropical dry forests and temperate continental forest ecological zones.

A human settlement (point data) represent a larger populated area (town, commune where market and institutions exist), or village (consisting of a number of households). The distance to nearest human settlements is an accessibility determinant of forests by populated areas. Forests are accessed for fuel-wood (mainly by local people) and industrial wood (by licensed companies) to sell them in the market, for protection, managing and controlling forests any illegal and legal activity in forests by institutions. The sign of the distance to nearest human settlements, distance to nearest commune and city center, distance to nearest forest edge, the accessibility to forests from the beginning of the period with forest cover (change) on forest cover change is ambiguous, because accessible remote high forests could be extracted near villages, but also far from them (high remote forests are old-growth forests located in high elevated and far from populated areas). Evidences shows that most of logging (either legal or illegal) activities happened in high remote forests (Müller and Sikor, 2006; the World Bank, 2004).

3. Methodology

This chapter describes the methodological approach that was used in the current study. Geographically weighted regression (GWR) is described in this chapter. GWR is used to uncover the local nonstationarity of the relationships between forest cover change and its determinants. The selection of GWR model is based on the minimization of the Corrected Akaike's Information Criterion. The calculation of the variance of local coefficients and Monte Carlo test are used to set-up a hierarchy of determinants to map the spatially explicit coefficients of determinants that are statistically significant and explain most of local variations of forest cover change.

3.1 GEOGRAPHICALLY WEIGHTED REGRESSION (GWR)

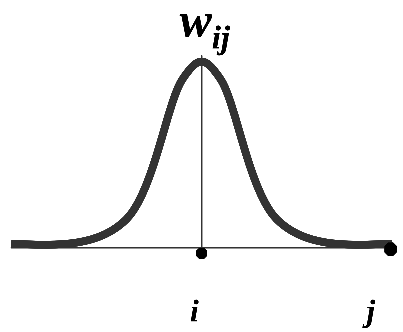
Spatial analysis is useful because it allows reduce large datasets to smaller amounts of more meaningful information suggest hypotheses or examine the presence of outliers through exploratory techniques; examine the role of randomness in generating observed spatial patterns; and test hypotheses about such patterns and modeling of the spatial processes (Fotheringham et al., 2000). Spatial analysis applications appear in economics, geography, the social sciences, archeology, epidemiology, geology, the health sciences (Fotheringham et al., 2000), as well as in urban and regional planning (Yu, 2006), and ecology (Kupfer and Farris, 2007; Moran and Ostrom, 2005; Osborne et al., 2007), poverty analysis (Epprecht et al., 2008).

Spatial effects are spatial heterogeneity and spatial dependency. Differences of location across space is known as the spatial heterogeneity effect, and similarities of locations are known as the spatial dependency effect (Anselin, 1988 2006). Identifying and understanding differences across space (rather than similarities) is one of the many reasons to use GWR (Fotheringham et al., 2002). In addition, local statistics measure spatial dependency through spatial autocorrelation or Moran's I (Anselin, 1995; Fotheringham et al., 2002). GWR was developed as an exploratory technique for examining data for their accuracy and robustness and suggesting hypotheses to test (also termed as pre-modeling) as well as for post-modeling exploration to examine the model accuracy and robustness (e.g., the mapping of the residuals from a model) (Fotheringham et al., 2000). GWR has been used to study the spatial nonstationarity and scale-dependency in the relationships between species richness and environmental determinants for sub-Saharan endemic avifauna (Foody, 2004). The impact of nonstationarity on model prediction of the distributions of wildlife in Spain, Great Britain was the focus of the study carried out by Osborne et al. (2007); they used GWR arguing that GWR (local method in which there are as many GWR coefficients values as observations) is complementary to GLMs, OLS (global method in which OLS coefficients have one value for all observations) revealing details of habitat associations and the properties of data, which global methods miss (Osborne et al., 2007). The comparison of GWR and ordinary least squares (OLS) was made to predict patterns of *Pinus ponderosa* (pine tree) in Saguaro National Park, AZ, USA, using topography and fire history variables (Kupfer and Farris, 2007). The authors of this paper showed that local regression coefficients displayed significant local variation for four out of the five environmental variables and "GWR model consequently described the vegetation-environment data significantly better…and reduced observed spatial autocorrelation of the model residuals" (Kupfer and Farris, 2007). GWR is also used to discover spatial variation in the relationship between socio-economic and green vegetation land cover in urban, suburban and rural areas (Ogneva-Himmelberger et al., 2009). The major finding of this paper is that GWR (not ordinary least squares technique), ought to be used for regional scale spatial analysis, because GWR can account for local effects and displays geographical variation in the strength of relationship (Ogneva-Himmelberger et al., 2009).

Contrary to most conventional econometric methods, GWR allows to discover the local nonstationarity, which could be otherwise neglected when most conventional econometric methods are employed such as ordinary linear regression (OLS) (Fotheringham and Brunsdon, 2004; Fotheringham et al., 2002; Kamar et al., 2007; Ogneva-Himmelberger et al., 2009; Yu, 2006). In contrast to global models (e.g., OLS), local statistical methods such as GWR allow derive spatially explicit coefficients and goodness-of-fit statistics that can be mapped (Fotheringham et al., 2000; Fotheringham et al., 2002).

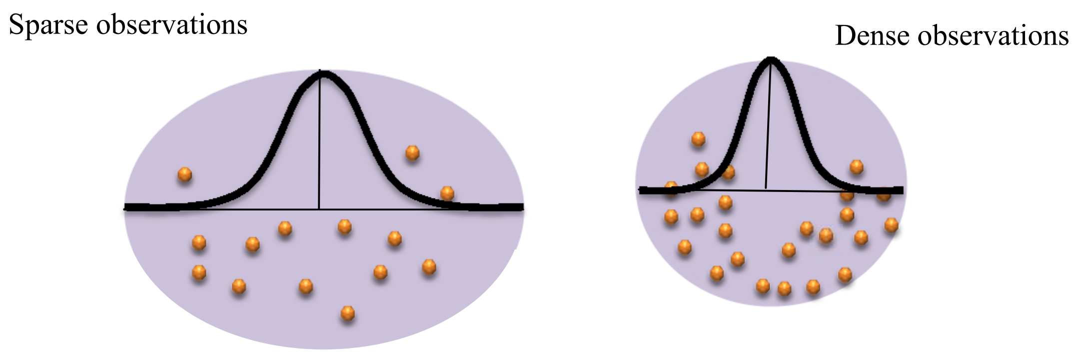
GWR has two major advantages to spatial expansion, spatially adaptive filtering, multilevel modeling, random coefficient models, and spatial regression models that also tend to study local variation. It (GWR) is based on the traditional regression framework and it incorporates local spatial relationships into the regression framework and uses decay function that "weights" more neighborhood observations that are closer to the regression point (i) than those further far from the regression point (Fotheringham et al., 2000). The weighted function or decay function bases on two regression kernel approaches: the fixed kernel and adaptive kernel. By default the kernel is a Gaussian function, Figure 3.1a.

Figure 3.1 GWR spatial fixed and adaptive kernel



a) distance decay function for a kernel

b) adaptive kernel



Note:
w_{ij} the decay function
i the regression point observation
j the neighborhood observation
Observations close to the regression point of *i* receive a higher weight than observations more distant from the regression point *i*, e.g., *j*. Thus, the GWR measures the relationships inherent in the model around each location i.e., regression point *i*. Each neighborhood observation *j* is weighted by the distance from the regression point *i* (Fotheringham et al., 2002).
Source: Adaptive from (Fotheringham et al., 2002) and (Epprecht, 2003)

The observation *i* is the regression point and *j* is a neighborhood observation. Each neighborhood observation (*j*) is weighted by its distance from the regression point (*i*) by a fixed bandwidths kernel in the fixed kernel approach (Fotheringham et al., 2002). The adaptive kernel is used when the data are not uniformly distributed shown in the Figure 3.1b following Fotheringham et al. (2002). Therefore, the distance from the regression point *i* to neighborhood observation *j* varies, because "kernel adapt themselves in size to variations in the data density… the kernels have larger bandwidths where the data are sparse, and smaller bandwidths where the data are dense" (Fotheringham et al., 2000; Fotheringham et al., 2002) Figure 3.1b. Local spatial relationship is calculated by GWR for all observations in both fixed and adaptive kernel approaches. Furthermore, "the estimated local coefficients are a function of the bandwidth of the spatial kernel selected" (Kupfer and Farris, 2007) for the model or a function of the number of neighbors of the spatial kernel selected if the data are not uniformly dispersed. When bandwidth increases then the distance decay decreases, in this case GWR results are closer to that of the OLS regression solutions (Kupfer and Farris, 2007). The steeper the decay function the more local coefficients are depending on the observations that are closer to the regression point *i* (Foody, 2004; Kupfer and Farris, 2007) for example decay function in the right is steeper than in the left of the Figure 3.1b.

A Corrected Akaike's Information Criterion (AICc) is used to compare global local models to test which model performs better and to study the local patterns of relationships e.g., Ponderosa pine basal area and aspect (Kupfer and Farris, 2007). The comparison of GWR and OLS, GWR and GLMs is used in studies to investigate patterns of relationship between specie-environment (Kupfer and Farris, 2007), distribution of wildlife (Osborne et al., 2007), regional analysis (Kamar et al., 2007). These studies showed that information provided by OLS model was not sufficient because OLS model lacked the patterns of relationships. GWR was a very good technique to use because GWR model provided information on local patterns and GWR model performed better than OLS model.

Model-fit for GWR are Corrected Akaike's Information and R-square. According to Kupfer and Farris (2007), the model R-square is not meaningful metric for selecting the best models or for comparing the models of GWR and OLS because a model with many variables will have a very good fit to the data, but may have few degrees of freedom; the over-fitting of the data and low predictive ability comes as the result (Jetz, 2005 cited in Kupfer and Farris, 2007). Furthermore, the best model is the one with the lowest AICc value because the model with the lowest AICc "explains correctly the data" (Kupfer and Farris, 2007) and is "the best approximating models" of the reality (Burnham and Anderson, 2002). The minimization of the AIC is used also to calibrate a kernel (Fotheringham et al., 2002), which is another reason of using AICc as a model-fit measure in GWR studies (see e.g. Bickford and Laffan, 2006; Kupfer and Farris, 2007; Osborne et al., 2007). Two good comparable models have a difference of AICc values less than 3 (Fotheringham et al., 2002). Robustness relates to the presence of outliers in GWR likewise in ordinary regression (e.g., OLS). Outliers are removed from the data and models are then often compared with and without outliers, but in case of

GWR, outliers are harder to be identified. This is because GWR "downweights some less extreme "near-outliers" because of the shape of the decay function", even if the outliers are excluded from the analysis (Fotheringham et al., 2002). In this study, I focused on the investigation of local variation between forest cover change and determinants using GWR, because this method (GWR) is frequently used for studies of spatial heterogeneity of vegetation. GWR was used to study temporally and spatially differences of forest cover change in two countries and made a comparison with OLS models based on the hypotheses of three models (of forest cover change).

Local variation is questioned and tested in GWR applications i.e., whether it occurs by chance or not. Monte Carlo test is suggested and used commonly in GWR studies (Foody, 2004; Fotheringham et al., 1998; Fotheringham et al., 2002; Kupfer and Farris, 2007). However, Monte Carlo test is very computer-intensive (Kamar et al., 2007). A second approach to detect the spatial nonstationarity of relationships is "by comparing the range of values of the local coefficients between the lower and upper quartile with the range of values at ±1 standard deviations" of the global coefficients (Charlton et al., 2003) that are obtained by OLS for the same model as GWR. Decomposed local variations was used and further explained in the section 3.1.3. This investigates if local variation was explained by local coefficients estimated by GWR based on the similar work of Kamar et al. (2007) and to find out the determinant explaining the observed changes of forest cover in the study area.

3.1.1 MODELS

Information-theoretic method is used in natural sciences (e.g., ecology, biology, and statistics) to find a parsimonious model as the primary philosophy of statistical inference (Burnham and Anderson, 1998; Burnham and Anderson, 2002). Roots of theory are based on a formal relationship that Akaike found "between Boltzmann's entropy and Kullback - Leibler information (dominant paradigms in information and coding theory) and maximum likelihood (the dominant paradigm in statistics). This finding makes it possible to combine estimation (point and interval estimation) and model selection under a single theoretical framework: optimization" (Burnham and Anderson, 2002). According to Burnham and Anderson (2002), "reasonable data and a *good* model" allow a separation of "information" from "noise". Here, "information relates to the structure of relationships, estimates of model parameters, and components of variance" (Burnham and Anderson, 2002). The principle of parsimony requires "a set of candidate models that involves professional judgment and representation of the scientific hypotheses into the model" (Burnham and Anderson, 2002). The principle of parsimony allows select the best fitted model based on the information criterion, which are Akaike Information Criterion, Corrected Akaike Information criterion and Akaike weights (Burnham and Anderson, 2002). Therefore, it is assumed that best model is sufficient for "making inferences from the data" (Burnham and Anderson, 2004).

Hypotheses of three models are set a priory describing on plausible driving factors of the processes of forest cover change based on an extensive literature review of land use change, of deforestation, of land use and forests for Albania (as well as I refer to data of the European Forest Institute (EFI), own work experiences in forestry in my homeland and data collection in the study area in 2008). Data used for the current study were set into three separate models consisting of biophysical, demographic and policy determinants. In this study, biophysical determinants were elevation, soil type, ecological zones, village locations. Demographic determinants consisted of population. Policy determinants composed of political and institutional determinants that were protected areas, years of establishment of Albanian communal forest administration, distance and cost distance for Albania and distance variables and protected areas for Kosovo. The scope of the current work is to find the determinants that explain the changes of forest cover and therefore the causes of the decrease and increase of forests.

Biophysical determinants were thought to be surrogate of natural growth of forests assuming forests were extracted by people because of their abundance, naturally old-growth mostly as firewood for heating and industrial wood for profits (Jansen et al., 2006; Millenium Assessment, 2005a; Müller and Sikor, 2006); socioeconomic model (demographic model) , assumed that people used forests for firewood (European Forest Institute, 2009) and grazing (own observations). Model of political-institutional determinants assumed that people utilized more accessible, abundant and naturally well-grown forests for fuel-wood (i.e., firewood and charcoal to sell), and for industrial-wood (legal and including illegal logging) for profits (Müller and Munroe, 2008; Müller and Sikor, 2006; the World Bank, 2004).

Models of political and institutional determinants included policy variables consisting of the distance to nearest roads, distance to nearest human settlements and distance to nearest mined and contaminated sites of Kosovo war. Institutional determinants consisted of the new administrations established in the post-socialism, specifically, commune administration and the establishment of forest user associations, new forest administration concerned the management of forests in protected areas, and new environmental agencies concerned the protection of environment and biodiversity in protected areas and environmental protection in forests. The setting-up of new post-socialist institutions (of communal forests and protected areas) is interlinked to the change of political regime. Years of establishment of communal forest administration is an institutional variable, which also implies a political decision to give forests from central to local government and local people to manage forests. Protected areas entails the institution that are established to plan, design, establish and manage existing and new protected areas and it also implies the political decision for the planning, management and the expansion of protected areas. For this reason, policy and institutional variables are labeled political-institutional model.

3.1.2 GWR EQUATIONS

The GWR approach relaxes the assumption of the OLS approach (equation 1), namely, that the relationship between the response and determinants has to be spatially constant (Fotheringham and Brunsdon, 2004; Fotheringham et al., 2000):

$$y_i = \beta_0 + \sum_{k=1}^{p} \beta_i x_i + \varepsilon_i \qquad (1)$$

where β_0 is a constant, βi is the coefficient, x is the value of the independent variable and ε is the error, y is the dependent variable, i is the observation, p total number of observations, k is the index of observations. .

This is done by considering the spatial location of the sample points for fitting the regression coefficients (equation 2):

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_i(u_i, v_i) x_i + \varepsilon_i \qquad (2)$$

where (u_i, v_i) reflects the spatial coordinates of the sample in space, and (u_i, v_i) represents the centroid of each village, β_0 is a constant, βi is the (GWR) local coefficient, x is the value of the independent variable and ε is the error, y is the dependent variable, i is the observation, p total number of observations, k is the index of observations. This approach allows the consideration of spatially varying effects of determinants on forest cover change. GWR fits OLS models based on a subset of spatial proximate sample observations. This means that the regression coefficients are estimated for a specific location (u_i, v_i) based on a number of sample observations. The influence of each observation in the regression model is thereby dependent on its distance towards the regression point (i.e., *i*) to be estimated. In other words, a weighted least squares regression is performed, and the weights are based on the distance to the regression point *i* at which the response is to be estimated. This leads to parameter estimation equation 4, which is a slight modification of the related OLS parameter estimation equation 3:

$$\hat{\beta} = (X^T X)^{-1} X^T y \tag{3}$$

$$\hat{\beta}_i = (X^T W_i X)^{-1} X^T W_i y \tag{4}$$

where W_i is a weight matrix in which off-diagonal elements are set to zero (i.e. non-correlated errors), $\hat{\beta}$ represents the vector of global parameters (eq. 3) to be estimated, $\hat{\beta}_i$ is the vector of local parameters (eq. 4), X is the matrix of independent variables with the elements of the first column set to 1 and *y* represents a vector of observations on the dependent variable (Fotheringham et al., 2000). The calculation of the weights is based on a kernel regression approach. The default Gaussian weight, which is used in the current study, for the adaptive kernel are calculated using equation 5 for different neighborhoods:

$$w_{ij} = \begin{cases} \left(1 - \left(\dfrac{d_{ij}}{h_i}\right)^2\right)^2 & \text{if } d_{ij} \le h_i \\ 0 & \text{if } d_{ij} > h_i \end{cases} \tag{5}$$

where h_i defines the bandwidth of the kernel for regression observation *i*, which depends on the number of nearest neighbors selected and d_{ij} is the distance between regression point (observation) *i* and neighborhood observation *j*.

3.1.3 DECOMPOSITION OF LOCAL VARIATION

The variance of the expected impact of a coefficient is based on the effect of the spatially-varying determinant values, as well as on the spatially-varying coefficients. Since both effects might be correlated, this needs to be reflected in the equation (Kamar et al., 2007) that was based on Kmeta's equation (Kmeta, 1986) (equation 6). For determinant *k*, the equation reads as follows:

$$Var(z_k = \beta_k X_k) = \left(\frac{\delta z_k}{\delta X_k}\right)^2 Var(X_k) + \left(\frac{\delta z_k}{\delta \beta_k}\right)^2 Var(\beta_k) + 2Cov(\beta_k, X_k)\left(\frac{\delta z_k}{\delta X_k}\right)\left(\frac{\delta z_k}{\delta \beta_k}\right) \quad (6)$$

where β is the local coefficient, x is the value of independent variable, z is the β multiplied by x. Since both variables are known in z_k, calculating the partials simplifies as follows: the first partial equals the mean of the squared β_k (or local coefficients obtained by GWR) values, the second partial equals the mean of the squared X_k values (or explanatory variable X values) and the third partial equals the product of the mean of β_k and X_k values. A cut-off of 0.50 is defined for the values of the variance of local coefficients (Kamar et al., 2007). This cut-off help distinguish considerable determinants (the value of variance of GWR coefficients above 0.50) from non-considerable determinants (the value of variance of GWR coefficients below 0.50). A determinant with a variance of the local coefficient above 0.60 is considered important, and a determinant with a variance of the local coefficient above 0.70 is considered highly important.

3.1.4 PRINCIPLE COMPONENTS ANALYSIS (PCA)

"The main purpose of PCA is to condense the information contained in a large number of original variables into a smaller set of new composite dimensions, with a minimum loss of information. It reduces the *P* original dimensions of data set, where each dimension is defined by one variable, into fewer new dimensions, where each new dimension is defined by a linear combination of the original *P* variables. These linear combinations are called *principal component*…Principal components analysis creates new composite variables (or components) out of the original variables that maximize the variation among sampling entities along their axes…principal components are weighted linear combinations of the original variables that represents gradients of maximum variation within the dataset" (McGarigal et al., 2000). "Principal components analysis assumes that variables change linearly along underlying gradients" and to assess the linearity assumption of principal components by graphing principal components that show "maximum amount of variation possible in a single dimension" to another the "second principal component that is constrained by orthogonality and maximization of the remaining variance" (McGarigal et al., 2000). For example, if one has five principal components in an analysis where two principal components display most of variation, which let say component one and two then one makes a graph of the principal component one versus principal component two and see how the graph looks like. The linearity assumption is difficult for many relationships because the relationship can be nonlinear e.g., it is "particularly troublesome when attempting to ordinate species in environmental space" because the relationship between "frequency distribution of specie" show a Gaussian relationship (i.e., non-linear) with an environmental gradient; in such a case "detrended correspondence analysis" is used to explain nonlinear relationships (McGarigal et al., 2000) not PCA.

3.1.5 GENERALIZED LEAST SQUARES (GLS)

The spatial relationships of observations are nonlinear in GWR, because observation nearer a regression point *i* are weighted more than those far from it (i.e., regression point) (see section 3.1). Generalized least square (GLS) is used to proof that spatial relationships of observations are non-linear in the data of this study used. GLS is also used to study the heterogeneity of the relationships of the response variable and determinants, and identify the most significant determinants for the relationships (Zuur et al., 2009). Firstly, the assumption of homogeneity is tested, by running a linear regression model, plotting the residuals using the restricted maximum likelihood estimation (REML) (Zuur et al., 2009). Null hypothesis is the homogeneity exists between forest cover change and determinants. If residuals are not normally distributed with a mean of zero and a variance of σ^2 (in a graph), then null hypothesis is not true. The GLS analysis is used to study the spatial heterogeneity (Zuur et al., 2009). In this GLS analysis, four variance structure functions are used consisting of fixed, power, exponential, constant plus power of the variance covariate following Zuur et al. (2009). "A GLS without weights is the same model as a linear regression model" (Zuur et al., 2009). GLS is run once with weights and once without weights to compare the Akaike's Information Criterion (AIC) values of GLS models to check which model performs better. "A fixed variance structure allows for larger residuals spread" if the distance to nearest human settlement increases (eq.7)

$$\mathrm{var}(\varepsilon_{ij}) = \sigma^2 x \text{ distance to nearest human settlements}_i \qquad (7)$$

where sigma (σ) is the residual standard error, var (ε_{ij}) is the variance structure, distance to nearest human settlement is a determinant.

Weights of the power variance structure are specified as in equation 8:

$$\mathrm{var}(\varepsilon_{ij}) = \sigma^2 x \left|\text{distance to nearest human settlements}_{ij}\right|^{2\delta} \qquad (8)$$

"The variance of residuals is modeled as σ^2, multiplied with the power of the absolute value of the variance covariate" (Zuur et al., 2009) i.e., of the distance to nearest human settlement.

The parameter δ is firstly calculated. If the value of the variance of distance to nearest human settlements is zero, then, the exponential variance structure is used instead and not the power variance structure (Zuur et al., 2009). The exponential variance structure is as in equation 9:

$$\mathrm{var}(\varepsilon_{ij}) = \sigma^2 \ x \exp\left(2\delta \ x \ \text{distance to nearest human settlements}_{\mathrm{i}}\right) \tag{9}$$

The exponential variance structure models the variance of the residuals as σ^2 multiplied by the exponential function of the variance covariate of the distance to nearest human settlements) and the parameter δ is still to be calculated. In this case, "this structure allows a decrease of spread of values" of the distance to nearest human settlements in the case of a negative value of δ_i (Zuur et al., 2009).

The fourth model is the constant plus power of the variance covariant function, equation 10:

$$\mathrm{var}(\varepsilon_{ij}) = \sigma^2 \ x \ \left(\delta_1 + \left|\text{distance to nearest human settlement s}_{\mathrm{ij}}\right|^{\delta 2}\right)^2 \tag{10}$$

"If δ1 and δ2 are zero" then one has a linear regression model, "if not then the variance is proportional to a constant plus the power of the variance covariance" (i.e., of distance to nearest human settlements) (Zuur et al., 2009). The final model and the variance structure is selected by minimizing the AIC (Zuur et al., 2009). Determinants with the largest variance within nested models ("two models are nested if one model can be obtained from the other model by setting specific parameters equal to zero" (Zuur et al., 2009)) are selected, with the best model that is run once more with the "REML" method ("to find the optimal residual variance structure") (Zuur et al., 2009); coefficients and sigma (σ) or the residual standard error are calculated. The determinant with the largest variance is the determinant that has the highest coefficient value in absolute terms and is multiplied by sigma (σ) in square. The largest variance value is the highest product value of these two. In the case of two good comparable nested models, the product values for each determinant per nested best models are compared; the largest product value shows the largest variance determinant (Zuur et al., 2009). The author uses likelihood test for a full model and a nested model using maximum likelihood (ML) (Zuur et al., 2009), to find the best fixed component, and distinguish the significant variables from non-significant variables. The ANOVAs with the full and nested model (one determinant is dropped) is run to calculate the likelihood ratio and p-values of the models (Zuur et al., 2009). If the p-value is statistically significant at p-value <0.05 or below, the determinant remains in the model; otherwise the determinant is dropped. The statistically significant p-values (and the value of the likelihood ratio) between full and nested models determine which determinants is significant for the relationship of forest cover change and determinants.

Synergies between GWR, PCA, and GLS

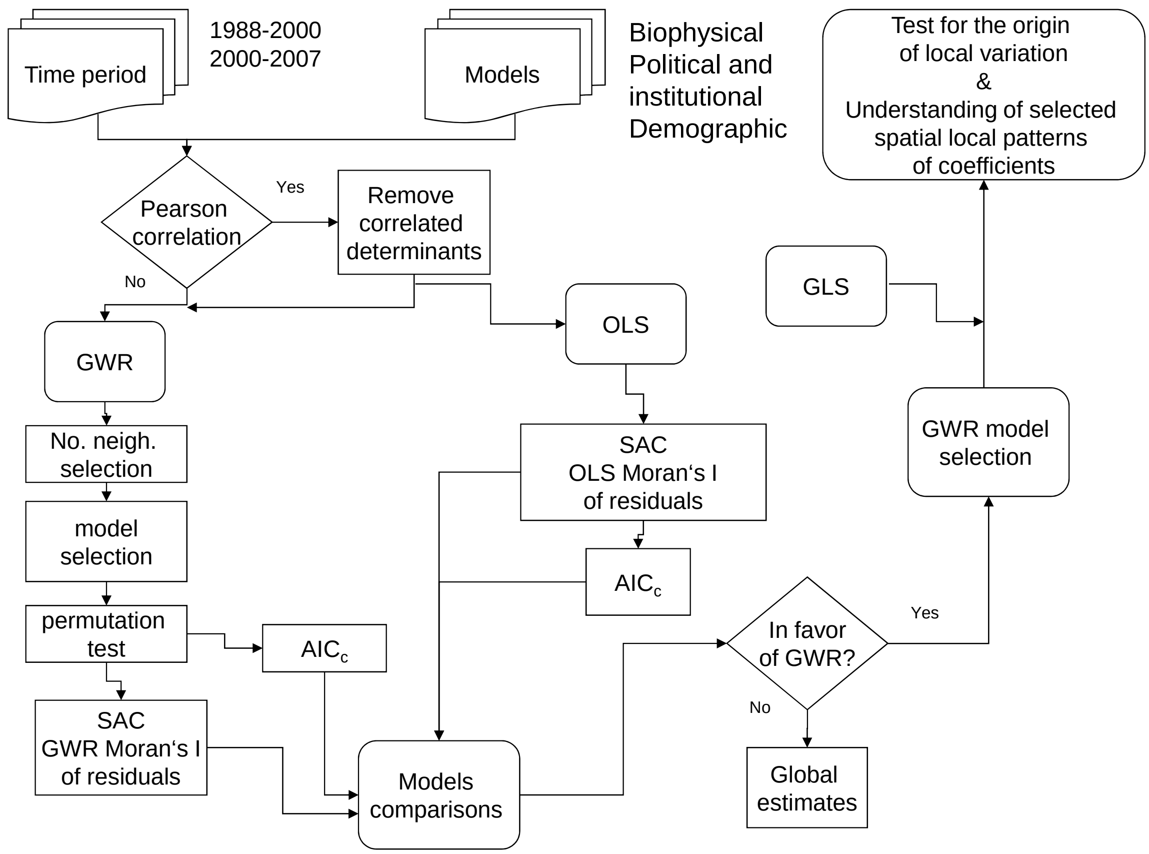
GWR is a linear regression between the response and independent variables with a non-linear Gaussian decay function of villages. GLS helps investigate the nonlinearity of spatial relationships among villages by checking the variance structure function (exponential, power, fixed variance and constant plus power). If the variance structure function is a nonlinear function, then this is strong evidence in favor of the application GWR to infer the data and pattern-processes of forest cover change. The assumptions of linearity between principal components (that show the largest amount of variation of the dataset), are checked using PCA. All three methods of GWR, PCA and GLS are used to explore the heterogeneity of relationship between forest cover change and determinants for the GWR final models.

3.1.6 GWR ANALYSIS FLOWCHART

The flow of the conducted analysis is in Figure 3.2. The analysis is composed of four phases, the first of which is the transfer of the Albania dataset from ArcGIS Arc Map 9.3 to R 2.9.

The dataset has the village code, which is used to join the GWR results with the Albania dataset to map out the results. Multivariate analysis between forest cover change and the determinants is programmed in R (Appendix A3). The Pearson correlation test was used to remove variables that were highly globally correlated ($r > 0.70$). GWR local coefficients were calculated using the adaptive kernel approach (because of non-uniformity of data) with the number of neighborhoods of 30, 60, 90, 150, and 350. Local patterns were more evident with the number of neighbors 30 and 60. The number of neighbors was selected approximately 1 % of observations in Albania and Kosovo datasets, and approximately 1 0% of the observations for the Albania-Kosovo cross-border area; because the model fit values of the Corrected Akaike's Information Criterion-AICc of GWR models tend to be lower with the number of neighbors 1 % (at country level) and 10 % (at cross-border level).

Figure 3.2 GWR analysis flowchart



Source: adapted from Sven Lautenbach

A spatial weights matrix was created, using a queen's contiguity neighbor, first order for the spatial autocorrelation of residuals (SAC in Fig. 3.2), in Geoda095i to calculate the Moran's I of residuals (Moran, 1948) in GWR and OLS. A Leung test was calculated to show the improvements of GWR towards OLS per model. Monte Carlo test for the final models of GWR was used to test the spatial variation with the permutation of 99 for the aggregated dataset of Albania, the Kosovan dataset and the cross-border Albania-Kosovo datasets, and the permutation of 9 with the Albanian disaggregated dataset because the Monte Carlo test with the Albanian disaggregated dataset was very computer-intensive. However, to double check the results for Albanian disaggregated dataset, the author also used the second approach used in GWR software by Charlton et al. (2003).

The model with the lowest value of AICc was selected as the final model. GWR with response variable and all determinants of selected biophysical, political-institutional and demographic models was also run. The next phase was the analysis of generalized least squares

(GLS) and principal components analysis (PCA) of the GWR's final models. The fourth and final phase (of the GWR methodological approach) was the calculation of the decomposition of local variation that was the test for the origin of local variation of the relationships between determinants and the response variable of GWR's selected models. A determinant showed a strong local influence variation when the Monte Carlo test was statistically significant at p-value < 0.05 or below, and the variance of local coefficients was at and above a cut-off level of 0.5 (the cut-off level of 0.5 was decided based on previous study of Kamar et al. (2007)). A determinant that had statistically significant value of Monte Carlo test (p-value < 0.05) and the variance of local coefficients above 0.7 was selected as the determinant to explain the changes of forest cover. The final stage of the analysis was the mapping of GWR results. Spatial local patterns of relationships between the response variable and the selected determinants from the final model were mapped out and discussed.

3.1.7 ADDED VALUE OF THIS RESEARCH

The GWR technique is used to explore the relationships of dependent and independent variable at the village level and shows how the relationships vary across the villages.

Spatial heterogeneity is investigated using fine resolution data of forest cover and three distinctive datasets. The first datasets are composed largely of disaggregated determinants for Albania and Kosovo. The second dataset is made of aggregated and more complex determinants i.e., cost distance determinants for Albania. The datasets of the cross-border study region of Albania-Kosovo are extracted from Albanian and Kosovan disaggregated determinant datasets. For the first time, the heterogeneity of the relationships between the forest cover change and determinants are studied in two different periods from 1988 to 2000 and from 2000 to 2007 at country and region levels for Albania and Kosovo. The selected model is found by using the concept of inference statistics of the parsimonious model (henceforth "final model") (see the section of models) and the decomposition of the local variation (of forest cover change and determinant relationship) to find determinants that explain the strong patterns of the changes of forest cover. Determinants that have high values of the variance of GWR coefficients are at the top of the hierarchy of determinants. Deductively, I focused my interpretation and discussion around the results of these determinants. The analysis of generalized least squares (GLS) identified most significant determinants that had the largest value of variance of the relationships at the country level. This study focused not simply to identify patterns of forest cover change, explore local variation, but also to identify determinants of forest cover change that exhibited the highest local variation, and focuses the discussion on these determinants.

This study provides a clear and new workflow of a GWR application focusing on spatially and temporarily changes of forest cover change at country and regional level for two under-studied post-socialist countries and a post-war country. This work can help identify future research on forests for the study area. The entire methodological approach used in this study is different from studies on forests and from GWR application (to my knowledge), can be replicated for forests worldwide.

Descriptive statistics of forest cover change

The raster layers depicting elevation, slope, distance to nearest human settlements, distance to nearest roads, distance to nearest town and commune center, distance to nearest major roads, distance to nearest protected areas, distance to nearest asphalted roads is transformed into a set of new layers by applying a "reclassification" operation in ArcGIS. This involves recalculating the value of a given focal cell into five quintiles (0 %, 25 %, 50 %, 75 %, 100 %). The input raster layer of forest cover change from 1988 to 2000 (and forest cover change from 2000 to 2007) overlaid to new layers of these explanatory variables (elevation, slope, distance to nearest human settlements, distance to nearest roads, distance to nearest town and commune center, distance to nearest major roads, distance to nearest protected areas, distance to nearest asphalted roads) to calculate the percent of forest cover change to five quintiles using "cell statistics" in ArcGIS. This involved recalculating the value of a given cell based on the mean value of forest cover in five quintiles (ESRI, 2009). This allows the number of forest pixels (in a quintile) to be multiplied by the resolution of forest pixels of 28.5 m and divided by the total number of forest pixels (see section 4).

The vector layers depicting soil type, protected areas, and ecological zones were intersected with forest raster layers using "Zonal histogram" operation in ArcGIS. This involved forest cells intersected soil vector data generating a histogram, which was an output table consisting of a number of forest pixels for each soil type. This operation (Zonal histogram) is applied to calculate the percentage of deforestation and forestation to years of establishment of commune administration.

3.2 GENERALIZED LINEAR MODELS (GLMs)

Models are fitted using the Generalized Linear Models (GLMs) with a logit-link and binomial error structure for Albania-Kosovo cross-border analysis and habitat suitability modeling. “GLM is an extension of classic linear regression models that allow the analysis of non-linear effects among variables and non-normal distribution of the independent variables” (McCullagh and Nelder, 1989). The Kruskall-Wallis non-parametric test is used before the analysis of GLMs. Independent variables are selected if they show statistically significant values with the dependent variables ($p < 0.05$). The remaining explanatory variables are checked with a Pearson correlation test to exclude highly correlated variables (Pearson’s correlation value $r > 0.70$) from the GLMs analysis. The predictive accuracy of fitted models is assessed using two approaches. The first approach is a cross-validation to validate the accuracy of the results. The cross-validation is calculated for the selected models. Cross-validation is used to avoid the over-fitting in the model(Fernández et al., 2003; Kanagaraj et al., 2011). The second approach is the explained deviance (D^2) and the area under a Receiver Operating Characteristic Curve (AUC). A high value of AUC (i.e. > 90%) is “outstanding prediction” of the pair of presence-absence (Hosmer and Lemeshow, 2000). The spatial autocorrelation of dependent variable jeopardize the results (Naves et al., 2003), for this reason spatial autocorrelation of the dependent variable was checked using Geoda095i. Spatial weights matrix was created, using a queen’s contiguity neighbor first order.

3.2.1 HABITAT SUITABILITY MODELING

Endangered species present the “compositional diversity” for forest biodiversity (Millenium Assessment, 2005b). The biodiversity in forests is very important element of global biological diversity, because biodiversity help sustain forest ecosystem functioning supporting other forest services (Millenium Assessment, 2005b), e.g., recreation (see Chapter 2). Today, an extinction of a threatened species and or an endangered species is not only a loss of biodiversity at global-level, but also a decline of diversity (at different scale) in genetic, ecosystem and landscape (Millenium Assessment, 2005b). Therefore, an extinction of endangered large carnivorous species is a straightforward loss of biodiversity in forests.

Umbrella specie are at the top of the food web, and their presence is studied because they occupy areas of high biodiversity (Ricketts et al., 1999). They also act as umbrella species for the “requirements of sympatric species” (Berger, 1997), and can help locating and planning protected areas (Caro and O'Doherty, 1999). Brown bear, Eurasian lynx and wolf are three top-food web, forest-dependent and protected species in Europe (Breitenmoser et al., 2005). Researches on umbrella species are made to specify breeding habitat (Fernández et al., 2003), habitat quality (Falcucci et al., 2009), habitat differentiation (May et al., 2008), habitat conservation (Nielsen et al., 2006) , the risk of species extinction (Naves et al., 2003; Wiegand et al., 1998) and species reintroduction in fragmented or human landscapes (Kramer-Schadt et al., 2004; Wiegand et al., 2004).

This thesis identifies suitable habitats for the critically endangered species of *Lynx lynx martinoi* (henceforth, “the lynx”), protected species of *Ursus arctos* (brown bear) and *Canis lupus lupus* (wolf) in Albania. *Lynx lynx martinoi* is a subspecies of Eurasian Lynx at a high risk of extinction with a population at the threshold of approximately 100 individuals distributed in Albania, Macedonia, Montenegro and Kosovo; 75 % of the population is expected to be only in Albania and Macedonia (Arx et al., 2004; Breitenmoser et al., 2008; Large carnivores on the Balkan, 2004). Nature conservation organizations such as International Union for Nature Conservation (IUCN), Coordinated Research Projects for the Conservation and Management of Carnivores in Switzerland (KORA), and European Nature Heritage Fund (EURONATUR) are involved in conserving its habitat and maintaining its population (Breitenmoser-Würsten and Breitenmoser, 2001; Breitenmoser et al., 2008; Breitenmoser et al., 2005; Large carnivores on the Balkan, 2004). Forest and landscape degradation, illegal killings and low prey populations are some crucial factors that threaten the lynx (Breitenmoser-Würsten and Breitenmoser, 2001; Breitenmoser et al., 2008; Breitenmoser et al., 2005; Large carnivores on the Balkan, 2004). Landscape change activities and degradation are noted by specie experts as a genuine issue in Albania (Breitenmoser et al., 2008).

Single specie ecological modeling at multiple scales is a natural-human habitat model that helps classify habitat quality and core areas of high conservation values such as brown bear in Spain, where natural models determine nutritional conditions and reproductive rate, and human models define carnivore mortality due to human disturbances (Naves et al., 2003; Nielsen et al., 2006). Further this study employs fine-scale geographical data and breaks up natural models into landscape, prey, refuge, and prey and refuge sub-models to understand whether prey, refuge, or both, or fine-scale heterogeneous landscape determines specie presence, as is the case of the endangered Iberian Lynx in Spain (Fernández et al., 2006; Fernández et al., 2003).

A set of *a priori* hypotheses on habitat selection of species are identified describing different natural conditions and resources required for refuge, food and breeding of these species based on the ecology and biology that exists for the lynx and Eurasian lynx, brown bear and wolf. For example, these three species need elevated topography, stable, undisturbed, well-connected broadleaved, evergreen and mixed forests as a refuge and to breed and to search for food (Naves et al., 2003), Table 3.1.

Table 3.1 Hypothesis based on the literature for lynx, bear and wolf and their biology knowledge

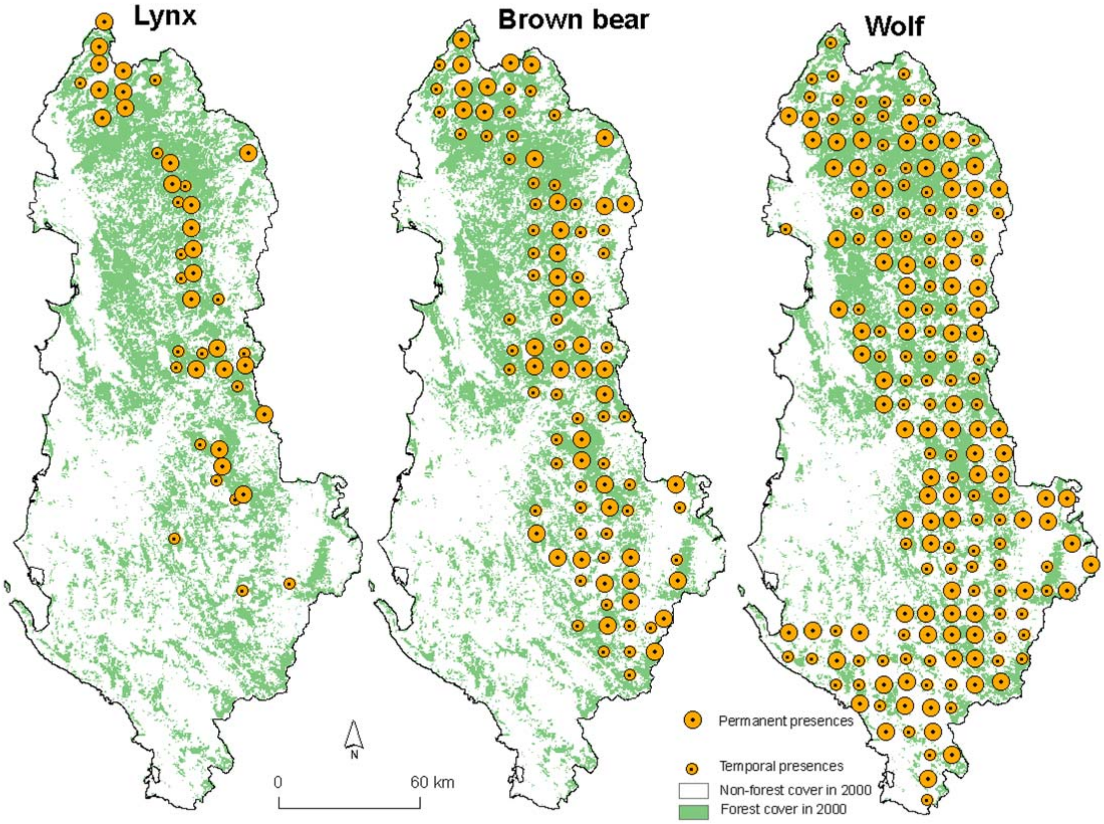
Model hypothesis	Description	Reference
Landscape	Three species require dense, high, stable and undisturbed forests and high elevation to refuge, breed and search for food	(Fernández et al., 2006; May et al., 2008; Naves et al., 2003; Wiegand et al., 2008)
Refuge and food	Brown bear rely on oak and beech forests for food, in course waters for fish as well as and lynx on bare rocks for breeding	(Balkan Lynx Strategy Group, 2008; Fernández et al., 2003)
Human disturbance	Three species stay away from human settlement, roads, and areas with loss of forest cover, because they cause higher mortality, higher disturbance and lower habitat quality for breeding, refuge and food	(Kramer-Schadt et al., 2005; Naves et al., 2003)
Natural	Three species need areas of forests and land that provide suitable habitats for refuge, breed and food; it combines the landscape, refuge and food hypothesis	

Natural and human variables are grouped with respect to these hypotheses. These species stay away from roads, villages, urban areas, highly disturbed forested land (e.g., from logging), because of lower quality of habitat (Kramer-Schadt et al., 2005). Thus, variables are split into two categories, which are labeled ‘natural’ and ‘human’. Natural variables are thought to be surrogates for ‘reproduction and survival’ of these species and human factors are thought to affect mortality of species, following Naves et al. (2003). Natural factors are further divided into categories of ‘landscape’, ‘refuge’, ‘food’, ‘refuge and food’ to further understand factors that explained the observed presences of these species. The landscape variables consist of forest cover, elevation and the terrain ruggedness index. Refuge and food consists of beech pure and mixed with coniferous forests, mixed broadleaved forests, coniferous forests, bare rocks and soil, oak forests, forest cover connectivity, forest and woodland cover and distance to nearest forest cover. The human variables include village density, distance to nearest asphalted road, distance to nearest well-kept road, distance to nearest seasonal road, distance to nearest dwelling road and distance to nearest village (Table A4.5). This study supports the draft-strategy for lynx conservation in Albania and the FYR of Macedonia (Balkan Lynx Strategy Group, 2008), providing needed scientific information on the home-range of the lynx. For example, previous studies in 1980s state that lynx have an average home-range of 38 km^2 (Bojovič, 1978). These are probably underestimated figures. Nowadays, the lynx monitoring in the FYR of Macedonia indicates a home-range of 100 km^2 (Balkan Lynx Strategy Group, 2008). This analysis attempts also to provide additional scientific information on factors that determinate the species presence considering effects of forest cover changes on species distribution in Albania.

3.2.2 FLOWCHART OF THE HABITAT SUITABILITY MODELING ANALYSIS

The distribution of Emerald species by bio-geographical regions as well as distribution maps for selected fauna species were made between 2005 and 2006 (Council of Europe and Ministry of Environment Forests and Water Adminsitration, 2006). Methods used by biologists to collect data consisting of the survey of lynx track on soft ground, snow and faeces, and the interviewing of local people as shepherds, hunters and foresters (Bego, 2001). Photographs of the tracks and faeces were taken, and GPS (Global Position System) was used to collect the coordinates of presences of lynx and Emerald species (Bego, 2000). Presence locations of the lynx in Albania 2001 were provided by Lynx compendium (CATS, 2011). Lynx distribution in Albania in 2001 marked presences as constantly occupied area (considered as permanent presences in our study) and single observation confirmed (considered as temporal presences in our study). The occurrences into two groups are based on the permanent and temporal use of habitats by carnivores. Permanent and temporal presences are summed up as our main dependent variable. These presences are mostly encountered in forested and high elevation areas, and in total these occurrences are of 24 and 19 for lynx, 41 and 54 for brown bear, 93 and 89 for wolf in the permanent and temporal categories, respectively (Figure 3.3).

Figure 3.3 Presences of lynx, brown bear, wolf and forest cover in 2000 in Albania



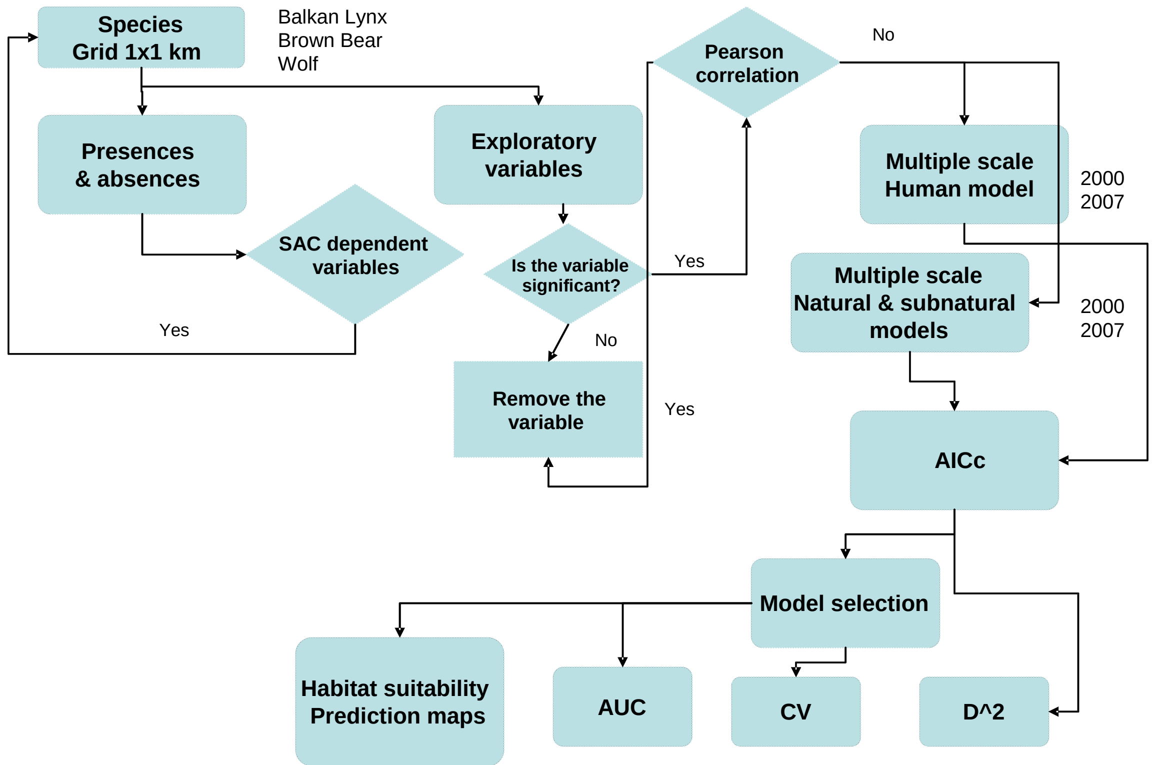
Source: EMERALD project and Lynx compendium of (CATS, 2011)

This study uses pseudo-absences that are chosen randomly using the Hawths Tools (an extension in GIS), and are the same number as the numbers of permanent and temporal presences per species. There are two conditions of pseudo-absences selection: 1. Only one location is selected within spatial resolution of 1 km^2, 2- pseudo-absences are to be located in forest areas and preferably within specie-suitable habitats because generating pseudo-absences further away from the optimum established by presence data may increase over-prediction of the model (Chefaoui and Lobo, 2008; Kanagaraj et al., 2011).

The spatial resolution of 1 km^2 (Fig. 3.4) is selected as the unit of analysis based on the previous studies on Eurasian lynx (Kramer-Schadt et al., 2005; May et al., 2008). The analysis is conducted at the resolution of 1 km × 1 km grid. All the variables are calculated using the extensions available in ArcGIS 9.3 (ESRI, Redlands, California USA). For a list of variables used in the analysis (see Table A4.5).

The presences-pseudo-absences response variable is run with all variables for a given neighborhood scale that remained after variable reduction from combining the landscape, refuge and food, and the human variables ("global" model).

Figure 3.4 Flowchart of habitat suitability modeling



The model of GLMs is selected from the complete set of candidate models for a given hypothesis using AICc. The uncertainty on this selection is measured by weighting AIC scores by the score of the best model (w_i). Model in year 2000 is the basis year of the study that is approximately the midpoint of the period of study and compared with model in year 2007. The predictions of habitat-best models are mapped out and the potential core areas for habitat conservations are identified per specie (Figure 3.4).

Neighborhood variables are included in the analysis. This is because the presence of a specie could be determined by the amount of forested and semi-natural areas within a neighborhood corresponding to the scale of a specie's home-range, e.g., the Eurasian lynx female home-range (Schadt et al., 2002 cited in Kanagaraj et al., 2011). A species moves within their home-range to meet its needs for food, refuge and reproduction. The brown bear's and wolf's home-range is alike and larger than a lynx's; therefore, the neighborhood variables are at larger scale for bear and wolf than lynx. .

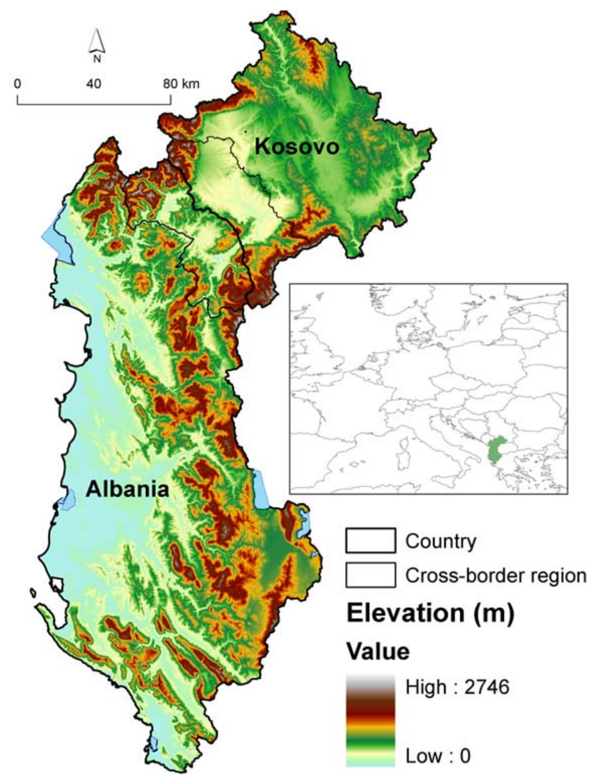
4. Data

Chapter 4 describes the data used in the analyses. The first section of the current chapter provides general information on the study area, Albania and Kosovo and the cross-border Albania and Kosovo. Section 4.2 shows the sources of fine-scale forest data. Sources of biophysical, demographic and political-institutional data-determinants are in Section 4.3. Section 4.4 describes explanatory variables that are used for the habitat modeling.

4.1 STUDY AREA

Albania is situated in the Mediterranean Sea basin, and has an area of 28,748 km^2 and a population of 3.1 million (Census 2001). Altitude varies from 0 m to 2,751 m above sea level (Figure 4.1) with mostly Mediterranean and continental climate.

Figure 4.1 Study area of Albania, Kosovo, the cross-border study region and the geographic position of the study area



Source: ELPA, MAFR, ESRI

Albania has approximately 21,096 km of asphalt, well-kept and seasonal roads, 2,884 villages with a population mean of 591 inhabitants per village (SD=663.26). From 1989 to 2001, the rural population decreased by a village average of -91 inhabitants causing the depopulation of rural areas. Agricultural land is suitable in the lowlands, which comprises 25 % of the country, while 75 % of the country is hilly and mountainous and marginally useful for productive agriculture (Ministry of Environment Forests and Water Adminsitration, 2006).

Elevated areas in northern and eastern Albania have a very low level of arable land allocation per capita in rural areas (the World Bank, 2002), and have less accessibility to infrastructure compared to western Albania. The regions of Kukës, Dibër, Elbasan, Lezhë and Shkodër have high rates of poverty and are among the regions with the highest unemployment rate, as well as the highest rural population outmigration rate (Ministry of Economy Trade and Energy of Albania, 2007; the World Bank, 2002). The Korça and Vlora regions have a more diversified economy, sources of employment and higher remittances (the World Bank, 2002).

Forests and woodland comprise approximately 27% of Albania's land area (Suess, 2010). Forests and pastureland were state-owned during socialism. In 2005, the forests consisted of public-owned forests (98 %) and private-owned forests (2 %) (FAO, 2010b). The change of forest ownership from the state to private and from the central government to local government started after the collapse of socialism. Commune forests entails commune to administer forests and villagers to use forests aiming the regeneration of forests. This forest reform started in in 1996 in Albania (the World Bank, 2011). In total, 364 villages have used forests and pastures from year 1996 to 2000.

The network of protected areas is approximately 10 % of Albania's total area in 2006. Albania has high forest biodiversity (FAO, 2005). Albania has five forest types: Mediterranean shrub, oak woodland, beech forests, Mediterranean fir and alpine zone (FAO and Dida, 2003). Mediterranean shrub, found mainly in the southern mountainous region, consists primarily of evergreen shrubs (e.g., *Quercus ilex, Q. coccifera, Arbutus unedo,* and *Myrtus communis*), deciduous shrubs and Mediterranean trees. Broadleaved trees such as Beech (*Fagus sylvatica*) and *Quercus spp*. are common tree species in Albania. Fir (*Abies alba*) replaces beech forests in the southern part of the country. Mountain pine occurs above the beech and fir forests under conditions of harsh climate and poor soils, at elevations of 1,600 to 2,100 m in the north and from 1,700 to 2,300m in the south; the three main specie are *Pinus leucodermis, Pinus peuce* and *Pinus heldreichii* (FAO and Dida, 2003).

The multiple uses of oak and beech forests, and the deforestation caused by clearing land for agriculture, have caused their massive degradation, the reduction of biodiversity and severe soil erosion (FAO and Dida, 2003; Meta, 1993). Illegal logging is common in high forests, which have high economic and ecology values. This was particularly true in the late-1990s onward, as industrial wood used for export and/or charcoal production, as well as grazing and fuel wood used for heating in rural areas, could have contributed to the increase of deforested areas in high forests.

Kosovo is a landlocked country with an area of 10,917 km^2 (Figure 4.1). Its population is estimated to be approximately 2 million (Statistical Office of Kosovo, 2007b); the last population census occurred in year 1981. Altitude varies from about 200 m to 2,656 m above sea level, and the climate is Mediterranean and continental. Kosovo has about 8,232 km of highway, first and secondary roads, and about 2,195 human settlements; there are 30 communes and 7 regions, where communes are administrative local government units (Statistical Office of Kosovo, 2007b).

According to the Statistical Office of Kosovo, arable land comprises 53 % of Kosovo's total area, forestland 41 %, water areas 1 %, and other areas 5 % (Statistical Office of Kosovo, 2007a). According to the Agricultural Household Survey 2006, 47.7 % of arable land plots were sized from 0.1 to 2 ha (Statistical Office of Kosovo, 2008).

Migration is highest in Gjakovë, Gjilan, Mitrovicë and Prizren, while Prishtinë and Ferizaj have experienced a population increase (United Nations Development Program of Kosovo, 2004). The highest disparities between rural and urban areas exist in education, lifetime and income per head in Kosovo (the World Bank, 2007b; United Nations Development Program of Kosovo, 2004). According to the Agricultural Household Survey 2006, most households in Mitrovicë, Prishtinë, Ferizaj, Prizren and Gjilan (see Fig. 5.2 for names and locations of these communes) rely on forests for firewood (Statistical Office of Kosovo, 2008).

In 2007, forest land comprised 40.3 % of Kosovo (Suess, 2010). Broadleaved forests occupy about 93 % (oak, beech and mixed oak/beech forests), with conifers making up the remaining of 7 % total forested land. Ownership of forestlands are, approximately: 41 % public and 33 % private, and 26 % unknown based on the Forest Inventory 2003 (Ministry of Agriculture Forestry and Rural development of Kosovo, 2007; Statistical Office of Kosovo, 2008); 8.3 % of the total area is protected. National parks make up about 84 % of total protected areas, natural monuments 10 %, natural zones 2 %, and preserved landscapes 4 % (Statistical Office of Kosovo, 2007a). Kosovo experienced conflict from 1998-1999, which can be phased into the preparation of war in 1998, conflict in 1999, and a post-conflict period, all of which produced residual unexploded ordnance (UXO), potential chemical contamination, landscape cratering, vegetation removal, soil erosion and socioeconomic disruption (Machlis and Hanson, 2008). Mine clearing started immediately after the conflict and lasted for several years. The conflict led to high migration to neighboring countries such as Albania, Macedonia, Montenegro and Serbia (International Campaign to Ban Landmines, 2000a; International Campaign to Ban Landmines, 2000b), and also led to a reduction of agriculture production (Ogden, 2000).

The cross-border study region of Albania and Kosovo is defined by the border of Albania and Kosovo. This area is approximately of radii of 25 km from the border to select villages of Albania and Kosovo. The entire cross-border study region is of 4,917.7 km^2 (Figure 4.1)

The Albanian part is 2,413.5 km^2 and it includes the Region of Kukës. Kosovo part is 2,504.2 km^2 and includes the Peja and Prizreni regions, and three urban areas of Pejë, Gjakovë and Prizren (Figure 4.1). The Albanian villages have a higher elevation (of 814 m above sea level), and are located at larger distance to road (mean distance to nearest road is of 802 m) and to protected areas (mean distance to nearest protected areas is 12,180 m) compared to Kosovan villages (mean elevation of 688m above sea level, the mean distance to nearest road is 587 m, the mean distance to nearest protected areas 10,108 m, respectively). Distance to nearest human settlement is comparable for villages in both country sub-regions (distance to nearest human settlement is of 1,247 m for Albania and of 1,101 m for Kosovo, all are mean values of determinants).

4.2 FOREST COVER CHANGE

Forest data of resolution 28.5 m derived from Landsat TM and ETM+ satellite images for ~1988, 2000 and 2007 were processed in the Geomatics Lab at the Humboldt University of Berlin with an overall accuracy of 93% and a kappa indices agreement of 0.85, and were provided by Stefan Suess (2010). The forest class consisted of forest patches greater than 7 pixels of Landsat. This class was composed of deciduous forests, coniferous forests and shrubs (with a height of greater than 3 m) and covering above the 50 % of a Landsat pixel. The non-forest class consisted of all non-forest land cover (urban land, agriculture land, pastureland, waters) (Suess, 2010), Table 4.1.

Table 4.1 Description of land cover classes

Class name	Description
Forest	(Semi-) natural terrestrial vegetation (broadleaved evergreen forest, broad-leaved deciduous forest, coniferous forest and mixed forest), cultivated terres-trial (broadleaved arboriculture, fruit trees, orchards, groves, nurseries, vine-yards) and shrub forest
Non-forest	All others: built up areas, urban and industrial areas, artificial and natural perennial water bodies, aquatic vegetation, beaches, bare rocks/soils, sparse trees and shrubs; rock outcrops, (herbaceous) crops, vegetated urban areas, grassland

Source: (Suess, 2010)

The sources of images were Eurimage and the Global Land Cover Facility (GLCF) of the University of Maryland. The GLCF provided large blocks of orthorectied and geodetically accurate global land data sets of the National Aeronautics and Space Administration (NASA). These data had a geodetic inaccuracy less than 15 m (Suess, 2010). A ground truth data were collected by Suess (2010) in August and September 2008 in the study area for training and validation purpose measuring approximately 600 control points using the Global Positioning System (GPS) and photographing these spots. To validate the results of satellite images, Suess (2010) used the Quickbird images of resolution of less than 3 m, and the Google Earth. Topographic maps of the scale of 1:50 000 of the University of California were partly geo-referenced for the land cover of Albania in 1980s (Suess, 2010). He used the approach of Support Vector Machine (SVM) chain classification approach (Knorn et al., 2009) for the satellite images of 1988, 2000 and 2007. The SVMs represent a group of non-parametric al-gorithms (Huang et al., 2002), and is considered as one of the most recent developments in the field of machine learning (Janz et al., 2007). All images and vector layers were projected to UTM Zone 34 N, datum WGS84.

The masks of the analysis are the country boundary of Albania and Kosovo. This allows the data within the country boundary to be processed (ESRI, 2011). The forest and non-forest pixels are reclassified as ‘1’ and ‘0’, respectively. The pixels (forests, non-forests) are inter-sected with the village boundaries to count the number of forest pixels for each village. The number of forest pixels is multiplied by the pixel resolution (28.5 m) and divided by 10,000 to give the forest cover in hectares for 1988, 2000 and 2007 (eq. 11). The forest cover 1988 is subtracted from the forest cover 2000 presenting the forest cover change from 1988 to 2000 in hectares (eq. 12). The forest cover 2000 is subtracted from the forest cover 2007 presenting the forest cover change from 2000 to 2007 in hectares (eq.13) (Fig. 5.3).

The same calculation is made for non-forest pixels (equation 14); the total number of pixels represents the land cover consisting of the sum of forest and non-forest pixels per village (equation 15). Calculations for forest cover of 1988, 2000 and 2007 in km^2 (equation 16), forest cover in percentage (equation 17), are as follows:

$$FCHA_{ij} = (NFP_{ij} x\ 28.5\ x\ 28.5)/10\ 000 \quad (11)$$

$$FCCHA00_j = FCHA00_j - FCHA88_j \quad (12)$$

$$FCCHA07\ j = FCHA\ 07\ j - FCHA\ 00\ j \quad (13)$$

$$NFCKM^2_{ij} = (NNFP_{ij} x\ 28.5\ x\ 28.5)/1\ 000\ 000 \quad \textit{(14)}$$

$$TLCKM^2 ij = NFPij + NNFPij \quad (15)$$

$$FCKM^2 ij = (NFPij x\ \ 28.5\ x\ 28.5)/1\ 000\ 000 \quad \textit{(16)}$$

$$FCPER_{ij} = FCKM^2_{ij}/TFCKM^2_{ij} \quad (17)$$

where i is the time step of forest data i=1988, 2000, 2007 ; j is the number of observations j=1…3055 for Albania or j=1…1298 for Kosovo. $TLCKM^2$ is the total land cover in km^2, $FCKM^2$ is forest cover in square km, $NFCKM^2$ is non-forest cover in square km, FCPER is forest cover in percentage, FCHA is the forest cover in hectares, FCCHA00 is the forest cover change in hectares from 1988 to 2000 and FCCHA07 is the forest cover change in hectares from 2000 to 2007 (Appendix Table A4.1, A4.2, A4.3).

The forest cover change had negative and positive values. The negative values of the forest cover change presents a change of land cover from forests to non-forests, a forest decrease (designated as “deforestation” process of the forest cover change) and the positive values of the forest cover change presents a change of land cover from non-forests to forests, a forest increase (designated as “forestation” process of the forest cover change in this study). Forestation consisted of afforestation, reforestation and the natural expansion of forests (FAO, 2000) in this study.

4.3 DETERMINANTS OF FOREST COVER CHANGE

Determinants are secondary geographic data that were collected from 2008 to 2009. Geographic data are vector, shape files and raster data. Albanian data were projected in a Gauss - Kruger coordinate system, Kosovan geographic data are in coordinate system of WGS 1984 UTM Zone 34 N. Albanian geographic data are re-projected from Gauss - Kruger to the WGS 1984 UTM Zone 34 N coordinate system, because this is the working coordinate system for all data.

Human settlement, roads, ecological regions and Digital Elevation Model (DEM) for Albania and for Kosovo are provided by the Environmental Legislation and Planning Albania (ELPA) and the Ministry of Agriculture, Forestry and Rural Development (MAFR). Protected areas are from the Institute for Nature Conservation, Albania, and the Kosovo Agency for Environmental Protection. Forest types and land use categories are taken from the Albania National Forest Inventory (ANFI) (Agrotec.SpA.Consortium, 2004). Brown bear, wolf and *Lutra lutra* (European otter) presence data are from the Ministry of Environment, Forestry and Water Administration in Albania EMERALD project (Council of Europe and Ministry of Environment Forests and Water Adminsitration, 2006). Lynx compendium are from internet source (CATS, 2011).

Population data of Kosovo are taken from the Kosovo Statistical Office (SOK) publications. Soil data are provided by the European Soil Database (Panagos et al., 2012), uranium and mined coordinates are from the United Nations Environmental Program (UNEP, 2001), International Campaign to Ban Landmines in Kosovo and Albania publications (International Campaign to Ban Landmines, 2000a; International Campaign to Ban Landmines, 2000b).

Vector and raster data are all aggregated at village level using GIS software before starting GWR the analysis. The resolution of DEM is 25 m for Albania and 50 m for Kosovo. The output cells of determinants are 25 m for Albania and 50 m for Kosovo. As opposed to pixel, which is an abstract term, the village has a socioeconomic feature, because it presents a group of villagers that make decision on forests (use, protect, conserve forests) shaping forested landscape and defining forest patterns (see Chapter 2). This helps also identify area within which villagers alter their village landscape (Crawford, 2002; Rindfuss et al., 2003; Walsh et al., 1999 cited in Evans et al., 2005). Technically, the GWR analysis is possible with village as unit of analysis. In case of pixel as analysis unit, the GWR analysis could have been very time and computer-resource demanding.

Albania dataset has a total of 3,055 observations and Kosovan dataset has 1,298 observations. Albania's cross-border dataset has 183 observations and Kosovo's set has 286 observations (extracted from the Albanian and Kosovan datasets).

There are two types of determinants: categorical and continuous. Protected areas, soil type, communal forests and ecological zones are categorical determinants generated from vector data. The distance to nearest roads, the distance to nearest human settlement, the distance to nearest forest edge, the distance to nearest UXOM, the distance to nearest protected areas is calculated as the straight line distance to the nearest road for each village (ESRI, 2011). The accessibility of forest at the beginning of the period (i.e., in 1988 for the first period and 2000 for the second period) is calculated by using the cost distance algorithm. "It is conceptually similar to the Euclidean allocation function, in which each cell is assigned to its nearest source cell" (ESRI, 2011). However, "near" is expressed "in terms of accumulated travel cost" (ESRI, 2011). Algorithms used for dataset preparation appear in Appendix A4.4

4.3.1 BIOPHYSICAL DETERMINANTS

Elevation and slope are derived from DEM provided by ELPA and MAFR, respectively. Ecological regions are provided by ELPA for Albania, and are as follows: the Pindus Mountain Forests, Balkan Mixed Forests, Dinaric Mountains Mixed Forests and Illyrian Forests. Soil types provided by the European Soil Database for Albania are Eutric Regosol, Calcaric Regosol, Cambic Arenosol, Eutric Cambisol, Regosol and Cambisol. Ecological regions provided by ELPA for Kosovo are the Pindus Mountain Forests, Balkan Mixed Forests, and Dinaric Mountains Mixed Forests. Soil types provided by the European Soil Database are Dystric Planosol, Luvisol and Ranker for Kosovo (Appendix Table A4.1 and A4.2).

Humic Cambisols, Chromic Luvisols, Eutric Cambisols, Eutric Regosols, and Haplic Phaeozems are soil types used for Albanian cross-border region. Soil types of Phaeozems, Luvisols, Renzinas and Rankers are aggregated and used for Kosovo cross-border region. Pindus Mountain Forests, Dinaric Mountain Mixed and Balkan Mixed Forest ecological zones are used for Albania and Kosovo cross-border region (Appendix A4.3).

4.3.2 DEMOGRAPHIC DETERMINANTS

There were approximately 100 villages without population data in Albania. Population data is entered in these records by equally distributing the commune's population (to its villages); this assumption is made to run the analysis with all observations.

The Kosovan population estimation from 1991 has an accuracy of 90 % at the village level (personal communication with the staff of the Statistical Office of Kosovo during the data collection in 2008). There are 1,446 human settlement records in the population estimation from 1991, and 1,298 observations (i.e., villages, town) from the cadastral data. Village names of the population estimation in 1991 were firstly translated from Serbian in Albanian. Names of villages in the population estimation in 1991 with the names of observations were carefully checked. Cadastral data were named after the human settlement names in 1991. The author assumed that the names of the human settlement boundaries would match the names of the villages in the population estimation from 1991. If the name of the observation matched the name of human settlements in the 1991 population estimation, the value of the population estimation in 1991 was manually entered to the respective village name in the dataset. In case of no match, "n. a." – no data was entered.

The projected 2004 population at the commune level is used to obtain the 2004 population data at the village level. The projected 2004 village population is estimated as in equations 18 and 19.

$$VPOP_{1991} = (CPOP_{1991} / NOV_{1991}) \quad (18)$$

$$VPPOP_j = \left(\left(CPPOP_k / (\textstyle\sum_k VEPOPj) \right) x VEPOP_j \right. \quad (19)$$

where k is the number of communes k=1…30, j is the number of observations j=1…1298 for Kosovo. VPOP1991 is the population of villages of Kosovo in 1991; VPPOP is the projected population of villages of Kosovo in 2004.

4.3.3 POLITICAL-INSTITUTIONAL DETERMINANTS

Human settlements include cities, suburban areas and villages. Roads consist of three types: main, major, and seasonal village roads in Albania. They are of three types in Kosovo: highway, first and secondary roads. There are six protected area categories according to IUCN (International Union for Nature Conservation) in Albania, and two in Kosovo. Protected areas are as follows: Strictly protected areas – category 1; National parks –category 2; Natural monuments – category 3; Nature resource management – category 4; Landscape protection – category 5; Managed Resource Protected Area – 6. There are two aggregated protected areas as follows: protected areas from categories 1-4 and protected areas from categories 5-6 (figure 7, 8).

"Years of establishment of communal forest administration" is the number that shows the difference between the year the communal forest was established (e.g., 2000) and the initial year of the forest reform in 1996. Forests of 364 villages that were transferred from the central to the local communes from 1996 to 2000 are considered in the analysis. Forests of a total of 14 villages were transferred from central to local government in 1996, of 4 villages in 1997, of 18 villages in 1998, of 185 villages in 1999, and of 143 villages in 2000.

Unexploded ordnance and mines (UXOM) include depleted uranium bombs and mines remaining from the 1998-1999 Kosovo Conflict. The coordinates of approximate bombed areas are geo-referenced (see UNEP, 2001). Mines (point data) are geo-referenced from the reports on mine clearance in cross-border Albania-Kosovo and Kosovo-Macedonia (International Campaign to Ban Landmines, 2000a; International Campaign to Ban Landmines, 2000b) (Appendix Table A4.1, A4.2, A4.3)

4.4 HABITAT SUITABILITY VARIABLES

There are 24 permanent and 19 temporal presences of lynx, 41 permanent and 54 temporal presences of brown bear, and 93 permanent and 89 temporal presences of wolf. Lynx presences are geo-referenced from lynx compendium (CATS, 2011). Land use classes are grouped into eight categories: beech, oak, broadleaved deciduous forests, coniferous forests, cultivated areas, Mediterranean shrub areas, bare and rock areas, urban and industrial areas from (Agrotec.SpA.Consortium, 2004). *Lutra Lutra* (European otter) presences are added as a biological indicator. *Lutra Lutra* relies on fish and its occurrences help to define (fish) food habitats of lynx and bear because they consume fish (Balkan Lynx Strategy Group, 2008). A neighborhood variable was the mean value of the original variable within a specified neighborhood radius around the target cell of 1 km^2 (moving window in GIS). In total, 5 different radii (3, 4, 5, 10 and 15 km) are used representing areas of 28.3 km^2, 50.2 km^2, 78.5 km^2, 314 km^2, and 706.5 km^2, respectively for the lynx and 7 radii (3, 4, 5, 10, 15, 20 and 25 km) representing areas of 28.3 km^2, 50.2 km^2, 78.5 km^2, 314 km^2, 706.5 km^2, 1256 km^2 and 1962.5 km^2, respectively for brown bear and wolf (Table A4.5).

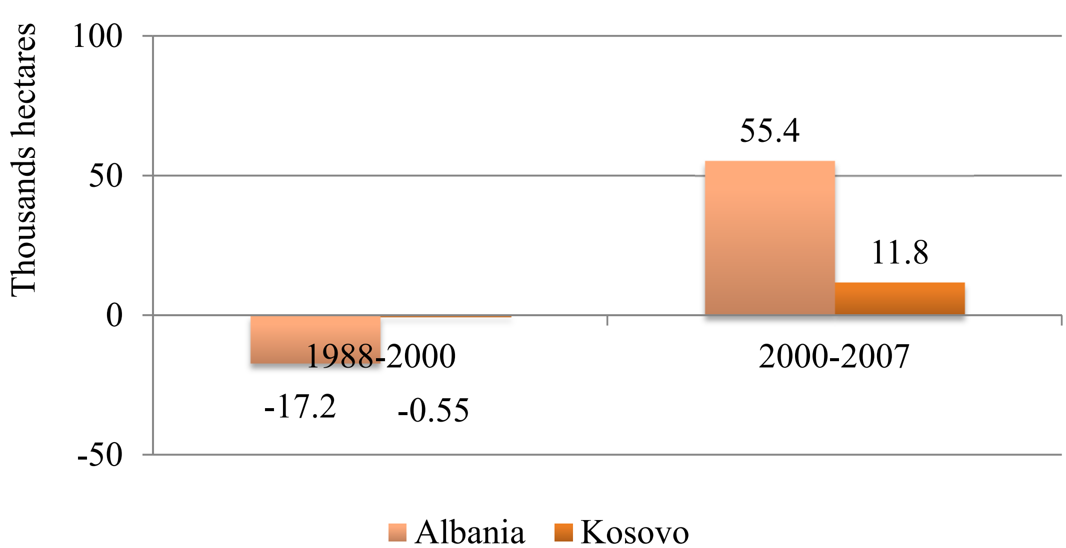
5. Results

The patterns and processes of forest cover change are presented in section 5.1. The results of descriptive analysis are in section 5.2 and of GWR regression analysis in section 5.3. Differences between Albania and Kosovo at country level and sub-region level and the synergies between GWR and GLMs are shown in this section. Discussion is focused on the results obtained by GWR that are patterns and processes of forest cover change. Results of the modeling of habitat suitability are shown in section 5.4.

5.1 PATTERNS AND PROCESSES OF FOREST COVER CHANGE

Albania shows more absolute changes of forest cover from the first to the second period compared to Kosovo. Deforestation dominates in the first period and forestation in the second period in both countries (Figure 5.1).

Figure 5.1 Forest cover change in Albania and Kosovo



Note: Forest data are provided by (Suess, 2010)
Source: own calculation

Three observations of forest cover in 1988, 2000 and 2007 show a slight increase of forest cover for Albania, the cross-border Albania and Kosovo (87,000, 88,000 and 90,000 hectares for Albanian cross-border part and 82,000, 84,000 and 88,000 hectares for Kosovan cross-border part for 1988, 2000 and 2007 respectively), and no increase of forest cover in Kosovo, Table 5.1. This conclusion bases on these time steps observations of forest cover (1988, 2000 and 2007). In fact more observations are needed to see how the trajectory of forest cover and forest transition changes for each country, i.e., whether it goes up or down. In this regard, it is also worthy to have observations of forests after 2007, i.e., from 2008 until today (2012) to see if forest transition is occurring indeed or not in Albania and Kosovo. Observations of forests should be based on the same source that is the satellite-based-observation and the same methodological approach of processing of forest data should be used, in order to have solid forest data over time.

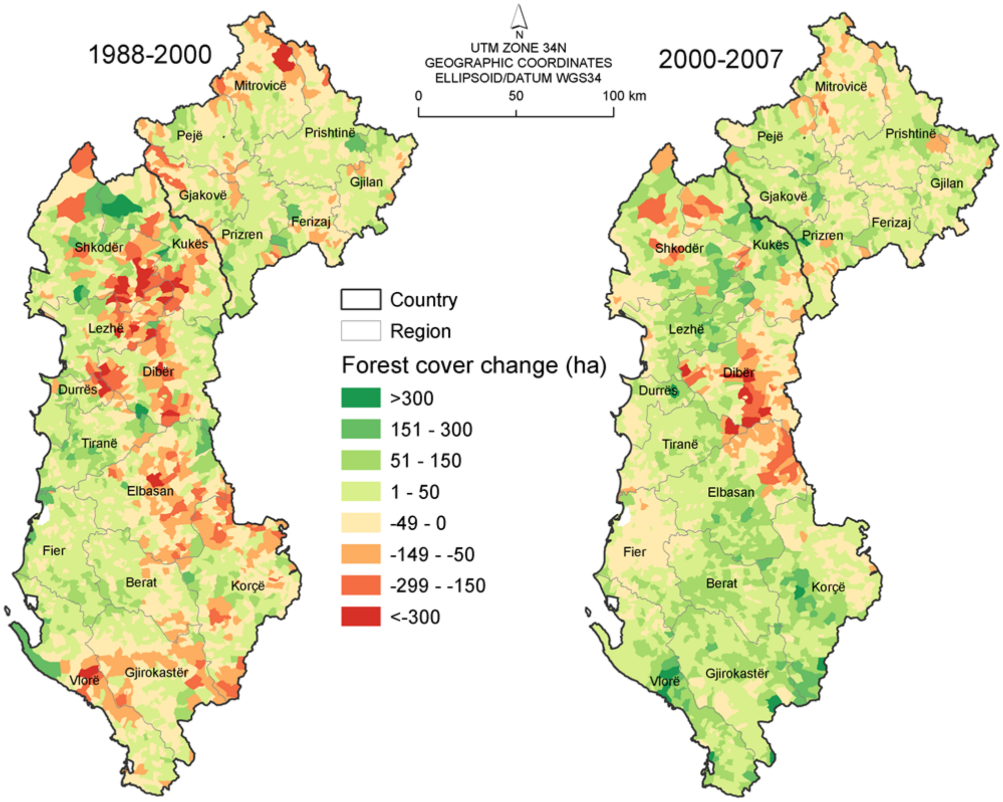
Table 5.1 Forest transition occurrence in Albania, the delay in Kosovo

Year		**1988**	**2000**	**2007**
Forest cover change	Albania	767	750	805
in ha (000)	Kosovo	445	433	433

Note: Forest data are provided by (Suess, 2010)
Source: own calculation

Fig. 5.2 shows forest cover changes using forest data of Suess (2010), aggregated to the village level. Patterns of forest cover change alter from 1988-200 to 2000-2007. Deforestation (red color) is spread from the northern to southern Albania and northern and western Kosovo in the first period (1998-2000), while concentrated in the northern and eastern and western Albania and the northern and central and southern Kosovo in the second period (2000-2007).

Figure 5.2 Forest cover change in Albania and Kosovo at village level



Source: own calculation

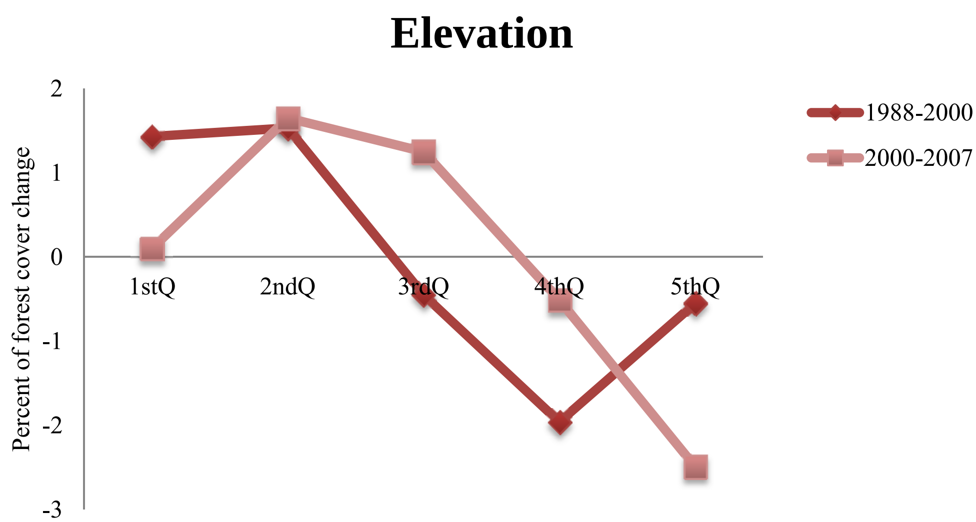
Forest has increased (in green color) in the western Albania and eastern and southern Kosovo in the first period as well as in central and southern Albania and western and eastern Kosovo in the second period (Fig. 5.2).

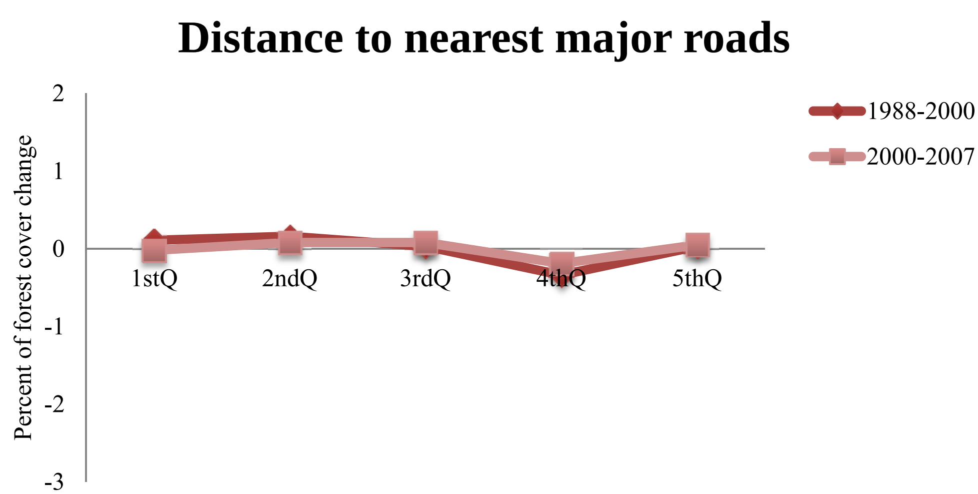
5.2 DESCRIPTIVE ANALYSIS OF FOREST COVER CHANGE

5.2.1 ALBANIA

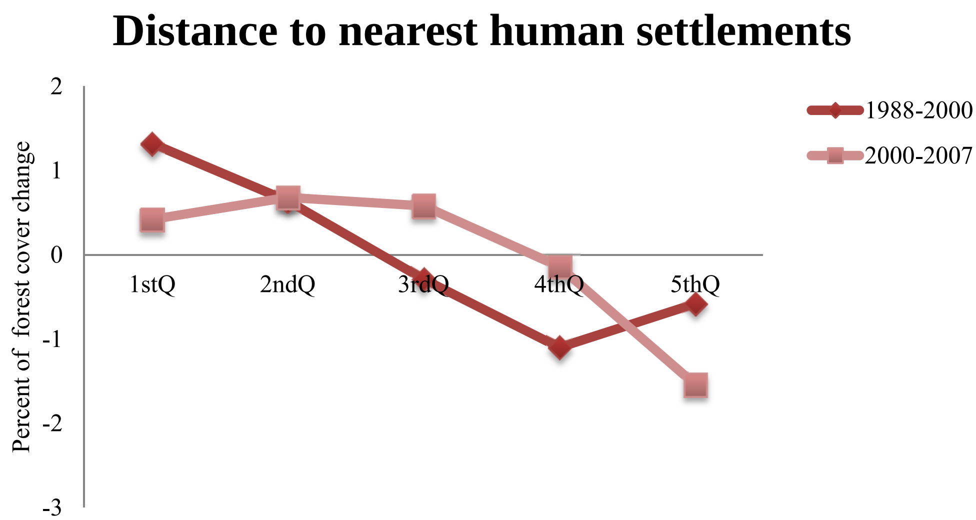
Positive values of forest cover change in the determinant quintiles represent forestation and negative values deforestation. Forest cover change is in percentage to five quintiles of determinants. Forest of the first quintile is forest in low elevation; forest of the third quintile is forest in middle (range) elevation and forest of the fifth quintile is forest in high elevation, remote forest. For distance to nearest roads, forest of the first quintile is forest located near roads, of the third quintile is forest located in middle distance from road and forest of the fifth quintile is located at far distance from the roads. Forest of the fifth quintile of roads, human settlements is a remote (area) forest. In Albania, deforestation is stronger and more spread in higher elevations and long-distance accessibility areas or in remote areas (far from roads and/or human settlements). Forestation is higher in low elevations, and close to roads, and human settlements (Figure 5.3).

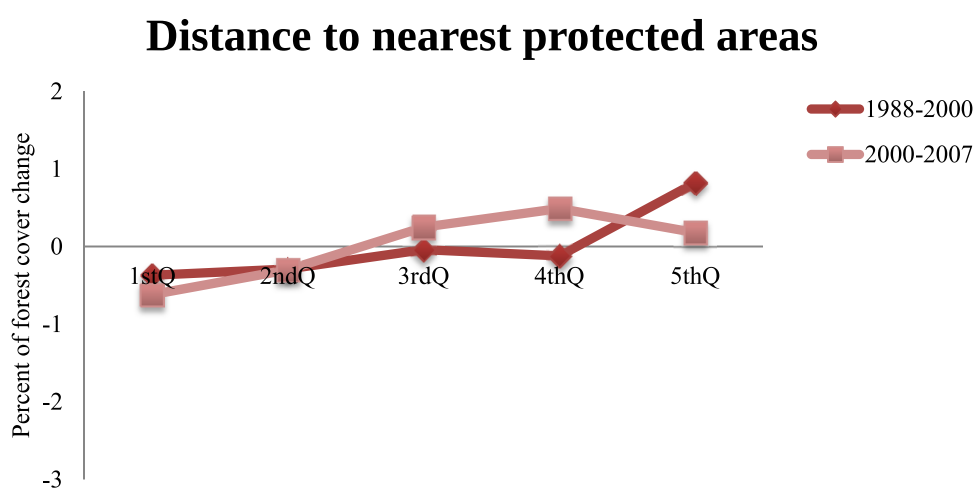
Figure 5.3 Percent of forest cover change to five quintiles of determinants, Albania

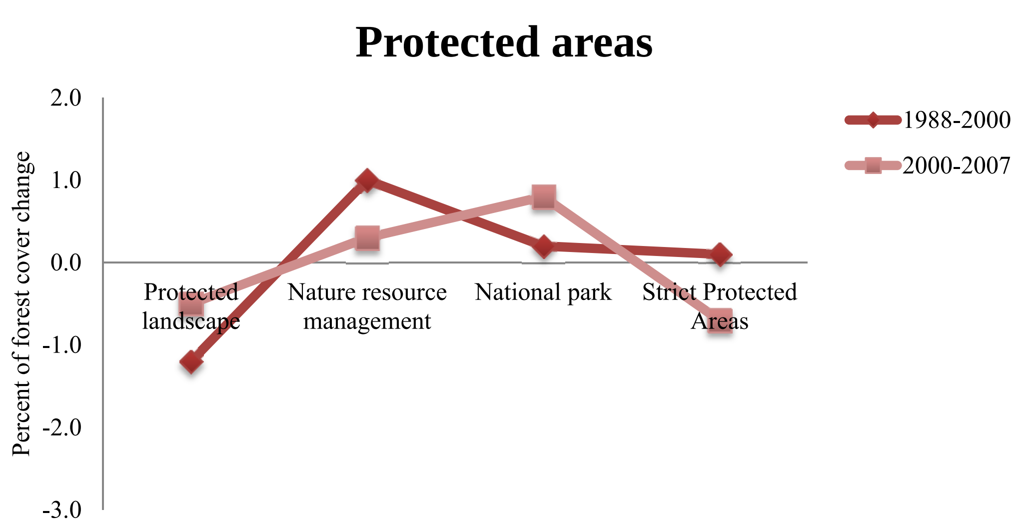




\







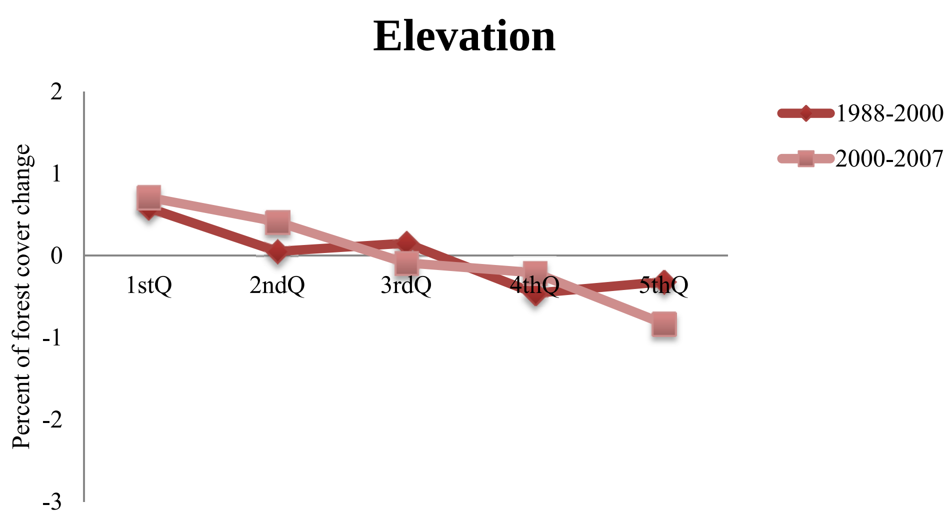
Source: own calculation

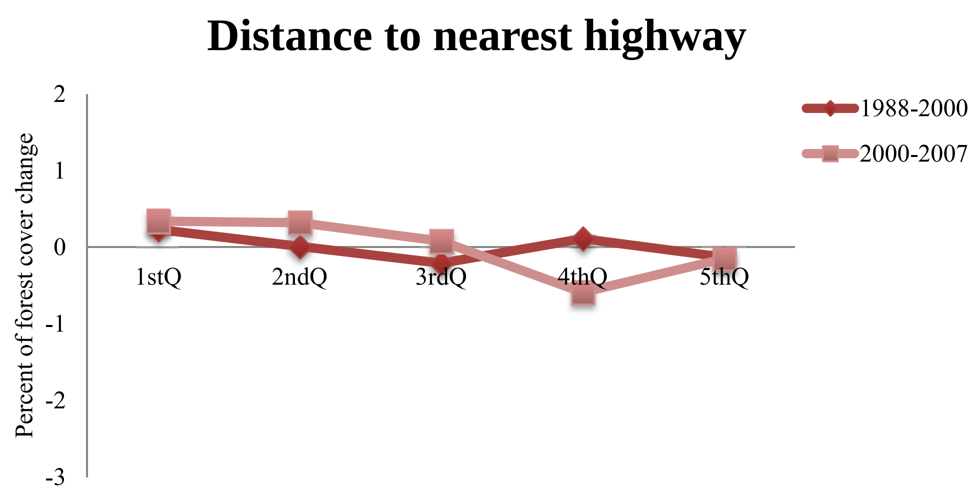
Forests close to protected areas and in protected landscape are cut as well as in strict protected areas (from 2000-2007). Forests tend to increase in large-distance from protected areas, and national parks (Fig. 5.3). Therefore, the remote areas (located in high elevation and far from human settlements) have experienced deforestation. Forestation and deforestation is present in commune forests. Deforestation has higher values from 1988-2000 compared to 2000-2007. The forestation process dominates from 1996-2000, while its values are higher from 2000-2007 than from 1988-2000. (Table A5.1: Forest cover change in commune forests).

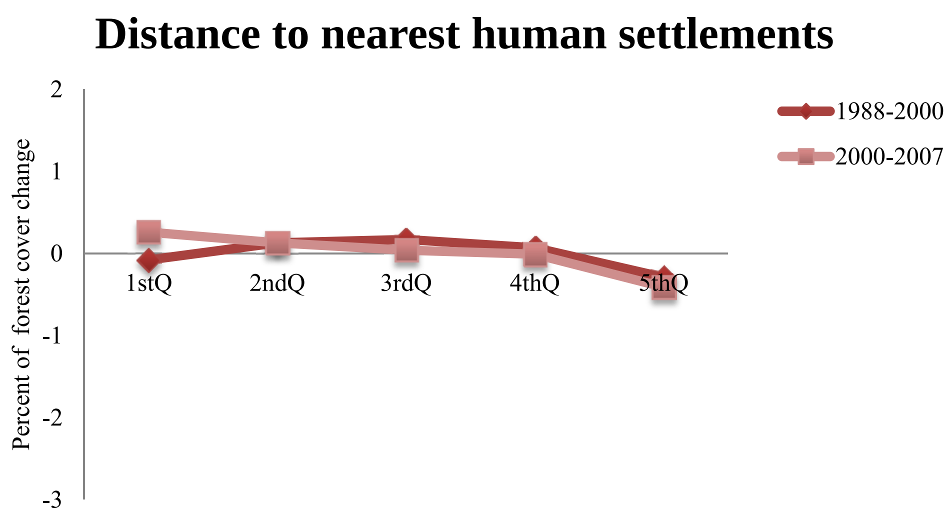
5.2.2 KOSOVO

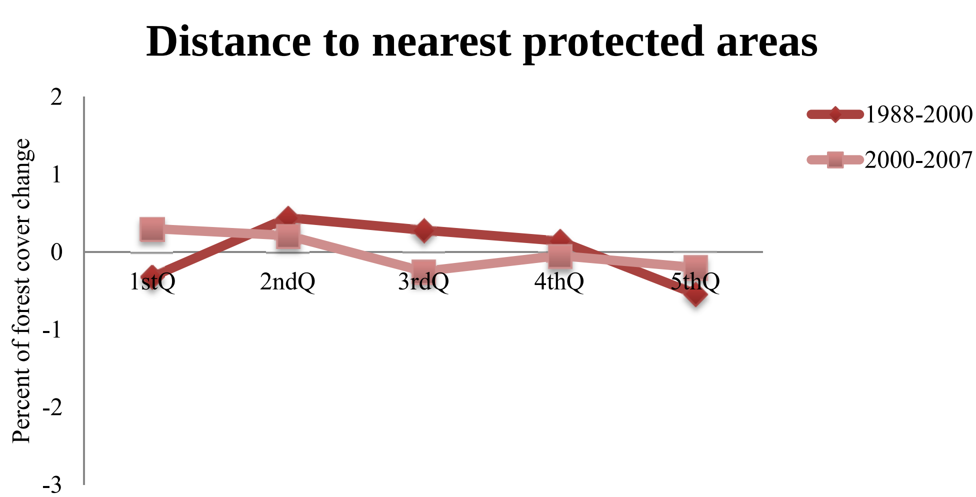
Deforestation is encountered in high elevations, far from human settlements, highway, protected areas, and UXOM sites. Deforestation is encountered in the first quintiles of the nearest distance to protected areas, and human settlements from 1988-2000. Forestation occurs in low elevations, close to human settlements, highway, protected areas, and UXOM from 2000 to 2007 (Figure 5.4).

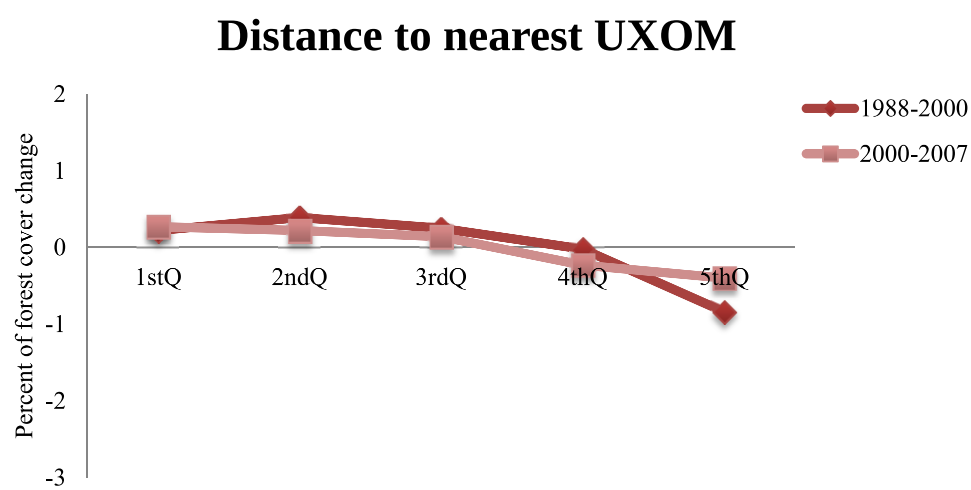
Figure 5.4 Percent of forest cover change to five quintiles of determinants, Kosovo

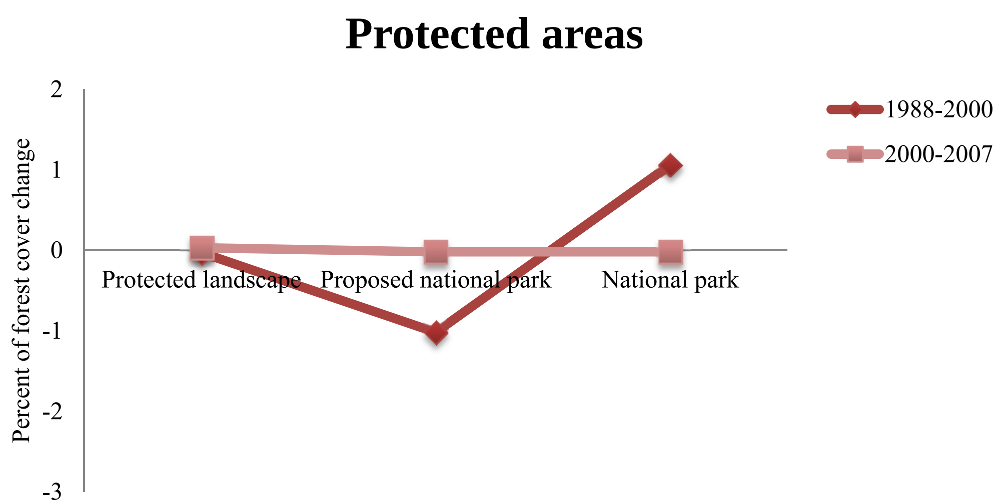



Distance to nearest highway
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007


Distance to nearest human settlements
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007


Distance to nearest protected areas
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007





Source: own calculation

The highest value of deforestation is of -0.84 from 1988 to 2000 of the distance to nearest UXOM sites and of -0.83 from 2000 to 2007 of elevation. The highest value of forestation is observed in the low elevation (of 0.58 from 1988-2000, and 0.71 from 2000-2007, respectively) (Figure 5.4).

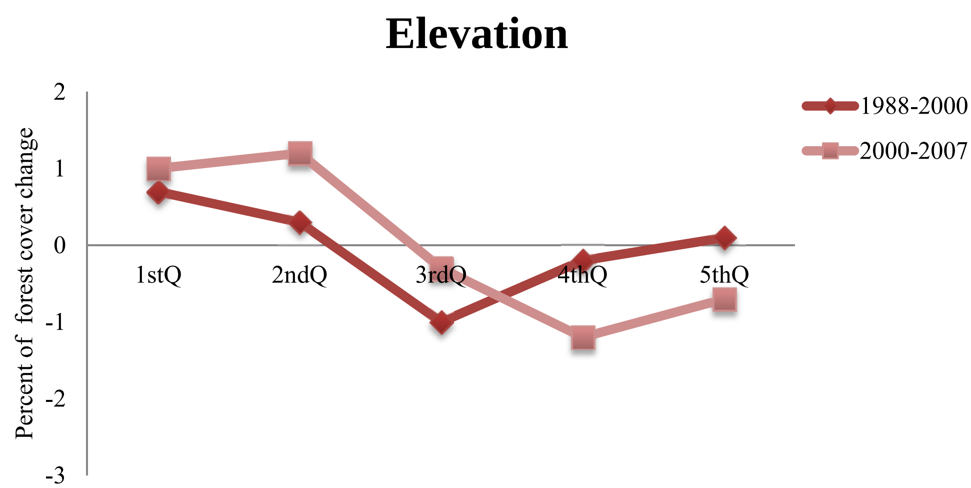
5.2.3 THE CROSS-BORDER STUDY REGION OF ALBANIA – KOSOVO

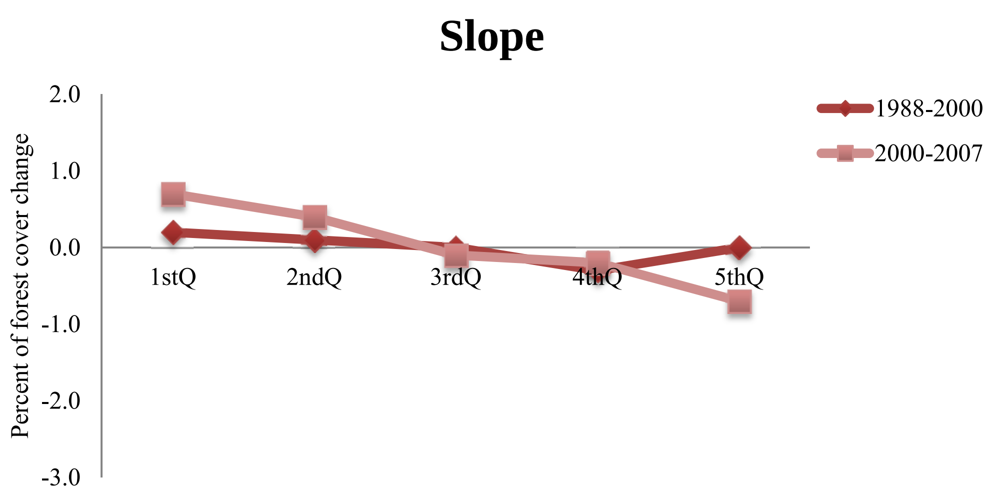
Deforestation is estimated in all quintiles of variables in Albania and mostly in the fourth and fifth quintiles in Kosovo (Fig. 5.5). Forestation is observed mostly in the first and second quintiles of variables in Albania, and in the first, second and third quintiles of variables in Kosovo.

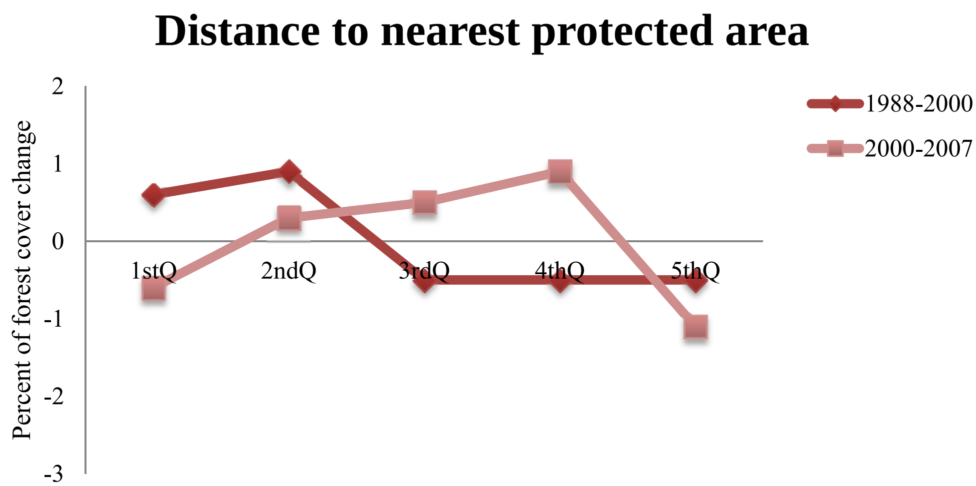
In Albania, deforestation takes place in the middle and high elevations, in steep slopes, far from protected areas, far from the populated areas and UXOM of Albania. Deforestation is observed in high elevations, steep slopes, and areas that are hardly accessible from roads, close to protected areas, large distance human settlements, and UXOM sites in Kosovo in both periods. Forestation occurs mostly in low elevations, gentle slopes, and areas accessible from roads, close to UXOM and in middle distance from protected areas, and human settlements from 2000 to 2007 in both countries (Figure 5.5).

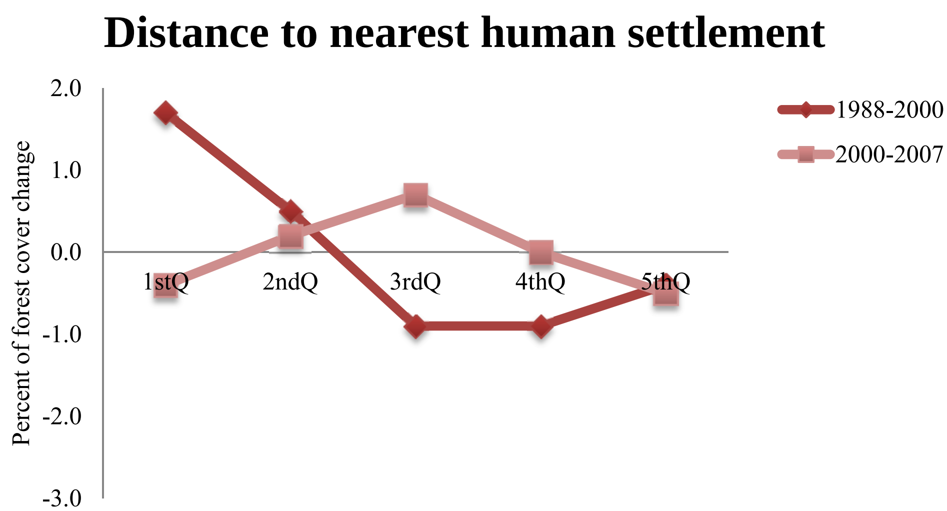
Figure 5.5 Percent of forest cover change to five quintiles of determinants, the cross-border study region

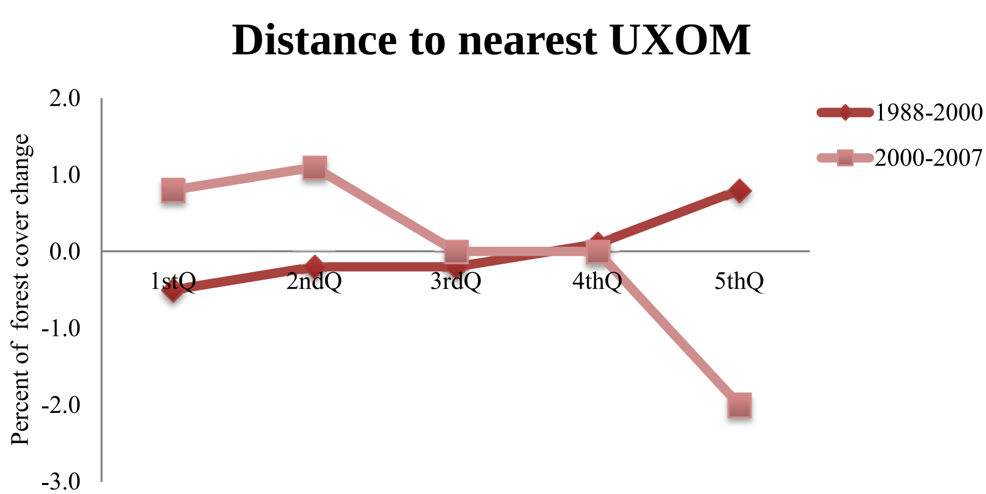
ALBANIA

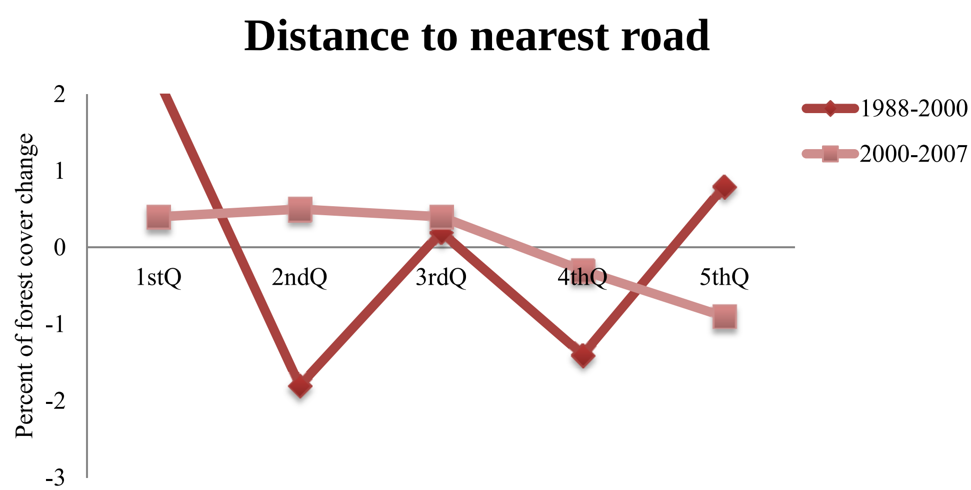




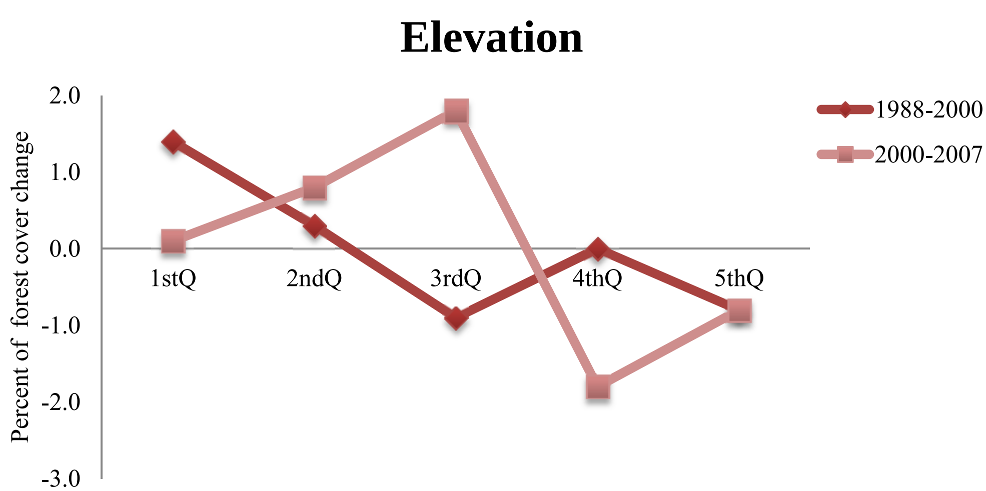

Distance to nearest protected area
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007

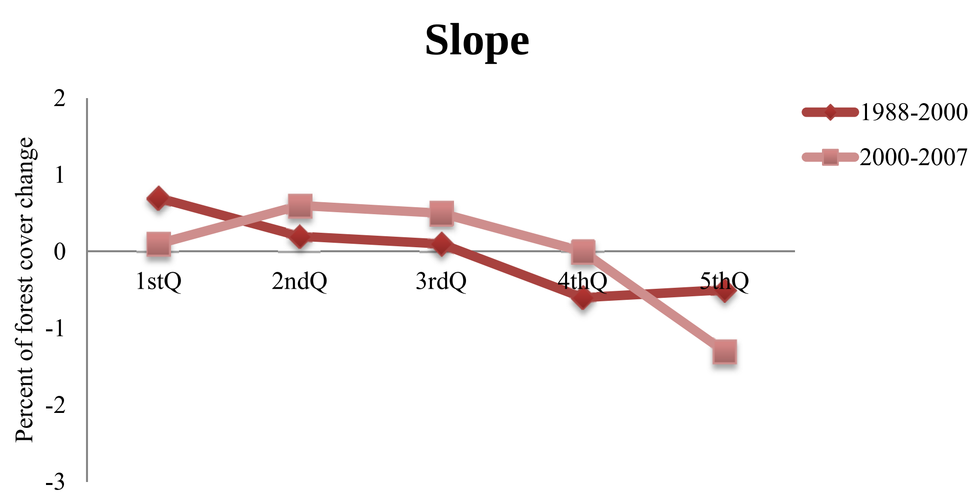

Distance to nearest human settlement
Percent of forest cover change
2.0
1.0
0.0
-1.0
-2.0
-3.0
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007


Distance to nearest UXOM
Percent of forest cover change
2.0
1.0
0.0
-1.0
-2.0
-3.0
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007

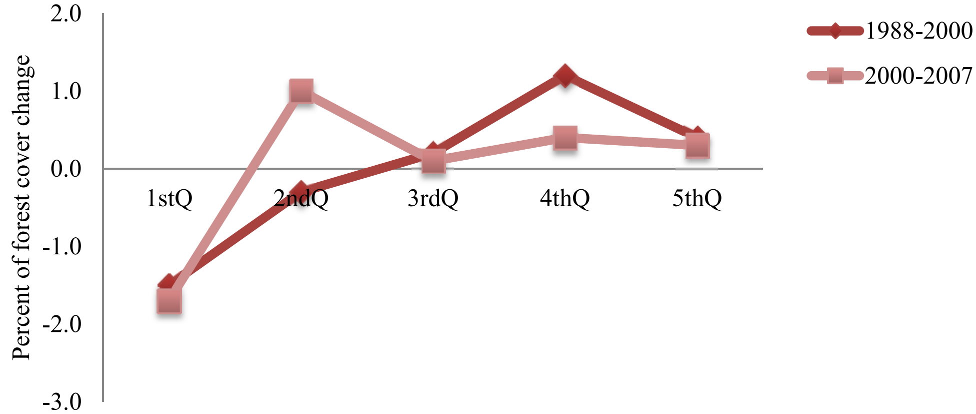

Distance to nearest road
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007

KOSOVO

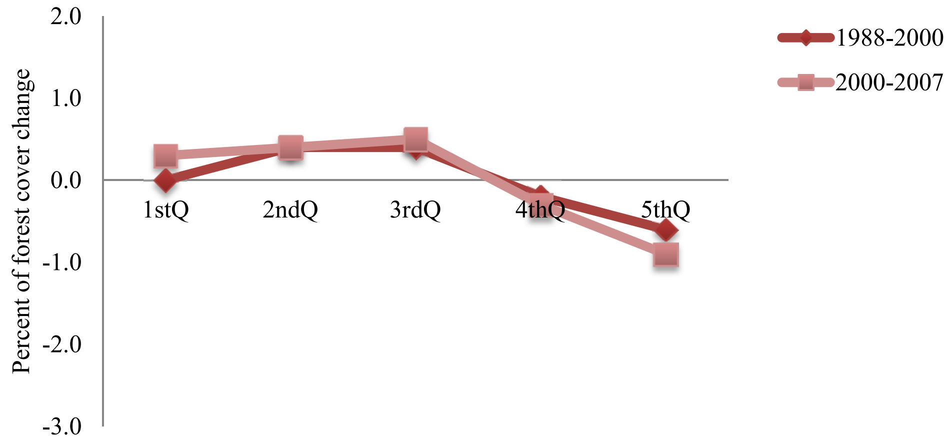

Elevation
Percent of forest cover change
2.0
1.0
0.0
-1.0
-2.0
-3.0
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007


Slope
Percent of forest cover change
2
1
0
-1
-2
-3
1stQ
2ndQ
3rdQ
4thQ
5thQ
1988-2000
2000-2007

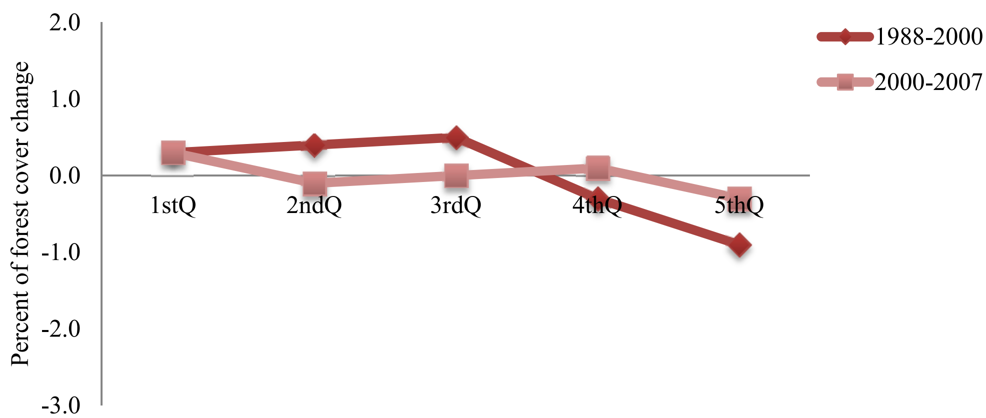
Distance to nearest protected areas

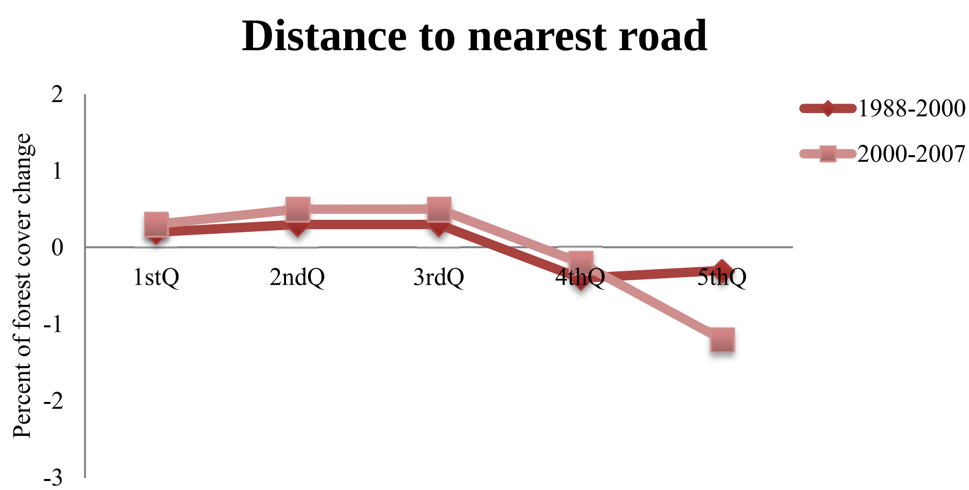


Distance to nearest human settlements



Distance to nearest UXOM





Source: own calculation

Comparison between Albania and Kosovo Forestation is mostly observed in low elevations, close to human settlements, and easily accessible areas in Albania and Kosovo from 1988-2007. Deforestation occurs close to protected areas in Albania (Fig. 5.3), but not in Kosovo from 2000-2007 (Fig. 5.4). In addition, calculation of forest cover in the protected areas shows that forest loss occurs inside protected areas (Fig. 5.3). Forest cover change generally has a higher value, either positive or negative, in Albania compared to Kosovo (Figure 5.5). Forest cover change processes (deforestation, forestation) appear almost in all quintiles of determinants in Albania (Figure 5.3 and Figure 5.5) while deforestation is mostly concentrated in remote areas and forestation in accessible areas in Kosovo (Figure 5.4 and Figure 5.5). Despite forestation dominating in the second period, deforestation is present in both countries.

5.2.4 INTERPRETATION AND DISCUSSION OF DESCRIPTIVE ANALYSIS OF FOREST COVER CHANGE

Forest loss occurs within protected areas and close to protected areas (Figure 5.3., 5.4., 5.5) showing that high pressure exists on protected forests despite their status of protection. The protection of forests within protected areas is a responsibility of forestry, environmental protection and nature conservation institutions. Deforestation within these protected areas show that new institutions are unable to monitor forest activities in protected areas, tackle deforestation activities within them and control pressure inside and in the surrounding areas of protected areas. This supports the author’s assumption and literature on forests that protected area could ensure better protection for forests, but cannot guarantee a full protection and halt entirely the deforestation within them (Deininger and Minten, 2002).

Interestingly, forests close to mined areas have not been used by people as expected from 1988-2000. People began to use these forests (forests close to UXOM areas), from 2000-2007, when they were cleared from mines and became safer. In the case of Albania cross-border, it is different. Forests were used before the conflict of Kosovo (1998-1999). After the conflict (from 2000 to 2007 in this study), forests were used in far-distance from mined areas (Fig. 5.5).

Deforestation occurs in almost all quintiles of the accessibility determinants of distance to nearest roads and human settlements in Albania compared to Kosovo at country and cross-border study region level. This shows that forests accessed by roads and human settlements tend to be used more in Albania compared to Kosovo. Roads make forests accessible for use. Forests at measured distance from human settlements are used regardless of the presence of an institution in commune, municipalities (human settlement). Observation and descriptive analysis of forest cover change (Figure 5.1 and Figure 5.3, 5.5) show that forests are reduced particularly in the first period, which indicates that firewood collection and logging have been intensive and new institutions have not been able to halt the spread of forest cutting activities.

Forests in large-distance from human settlements are reduced. Deforestation has happened in the fourth and fifth quintiles of the distance to nearest human settlement in Kosovo and Albania at the country and cross-border study region level. In the second period, forest loss is encountered in the highest quintiles of the distance to nearest human settlement and elevation, indicating that forests in high elevations and remote areas are utilized for firewood and industrial wood. The distance to nearest road and human settlement are very much associated with deforestation at high quintiles in Kosovo, which shows that firewood collection is still important for remote areas, as indicated by Statistical Office of Kosovo (2008).

Forest has generally increased in low elevations, close to human settlements in Albania and Kosovo from 1988-2000 and from 2000-2007. Potentially, forests close to roads and human settlements are less used because people tend to use forests in higher elevation that are more abundant and well-growth. Forests nearby the protected areas were used from 1988 to 2000 in Kosovo and Albania showing the high pressure to forests in surrounding areas of protected forests in this period. These forests located in surrounding areas of protected areas increased in Kosovo, but not in Albania and in the cross-border study region of Albania and Kosovo from 2000-2007. Forest has increased in commune forests for every year of establishment of the commune administration, showing that forest reform contributes, overall, to forestation (Fig. 5.3). However, there is an uncertainty if forests continue to increase overtime and if these forests and woodlands are used sustainably in all communes.

5.3 GWR MODELING RESULTS

5.3.1 ALBANIA

The global correlation is high between the Pindus Mountain Forests and Illyrian Forests ecological zones (> 0.70). The Pindus Mountain Forest ecological zone was selected because the largest part of forests grown in this ecological zone.

The final model consists of 'political-institutional' determinants of GWR for forest cover change from 1988 to 2000 and from 2000 to 2007, based on the lowest AICc (Corrected Akaike's Information Criterion) and contains fourteen determinants of Euclidean distances, protected areas and years of establishment of communal forest administration, Table 5.2.

Table 5.2 Comparison between OLS and GWR models with disaggregated variables, Albania

Model	AICc	AICc	Moran's I of the residuals	
1988-2000	OLS	GWR	OLS	GWR
Biophysical	34298	33320	0.38	0.18
Biophysical including climate determinants	34285	33209	0.38	0.15
Demographic	34566	33926	0.44	0.26
Political-institutional	34462	33176	0.48	0.14
2000-2007	OLS	GWR	OLS	GWR
Biophysical	33121	31886	0.48	0.20
Biophysical including climate determinants	33046	31748	0.46	0.15
Demographic	33259	32250	0.50	0.26
Political-institutional	33178	31650	0.48	0.13

Note: Model selection estimator: Corrected Akaike Information (AICc), Moran' I of the residuals
Source: own calculation

Values of R^2 of the final model of political-institutional determinants range up to 0.80 for the first period and 0.72 for the second period, indicating the presence of the high local variation of the political-institutional determinants and forest cover change in both periods. Maps of R^2 are displayed in the appendix Figure A5.3.

GWR model models perform better than OLS because GWR models have a lower value of AICc and lower Moran's I of the residuals compared to OLS, Table 5.1.

The final models of political-institutional determinants, Table 5.2, explain forest cover change in Albania from 1988-2007 and from 2000 to 2007. The GWR models perform better than OLS model showing that patterns of the relationship exist between forest cover change and political-institutional determinants. The estimations of the decomposition of local variation and Monte Carlo test for fourteen determinants of the final models of 1988-2000 and nine determinants of final models of 2000-2007, respectively, show statistically significant values of Monte Carlo test (p-value < 0.01), the variance of local coefficients indicating the presence of the spatial variation in the relationships between forest cover change and GWR coefficients (Table 5.3).

Table 5.3 Results of GWR models, Monte Carlo test p-value and the variance of local coefficients, Albania

		1988-2000		2000-2007	
Model	Determinant	Variance of local coefficient	Monte Carlo test p-value	Variance of local coefficient	Monte Carlo test p-value
Biophysical					
	Elevation	0.69	0.0	0.66	< 0.01
	Pindus Mountain Forests	0.60	0.0	0.61	< 0.01
	Balkan Mixed Forests	0.49	0.0	0.45	< 0.01
	Cambisol soil type	0.56	0.0	0.56	< 0.01
	Regosol soil type	0.58	0.0	0.56	< 0.01
	Cambic Aerosols soil type	0.50	0.1	0.50	< 0.01
Demographic					
	Population 2001			0.47	0.06
	Population 1989	0.53	0.02		
Political-institutional	Years of establishment of commune forest administration	0.53	0.0	0.52	0.0
	Strict Nature Reserve	0.47	0.6		
	National parks	0.50	0.0		
	Natural monuments	0.48	0.5	0.51	0.0
	Habitat or Species Management Area	0.50	0.0		
	Protected Landscape or Seascape	0.51	0.0		
	Managed Resource Protected Area	0.50	0.0	0.48	0.0
	Distance to nearest road			0.69	0.2

Distance to nearest major road	0.67	0.0	0.68	0.0
Distance to nearest asphalt road	0.67	0.0		
Distance to nearest human settlement	0.79	0.0	0.83	0.0
Distance to nearest city and commune center	0.86	0.9	0.80	0.9
Distance to nearest forest edge in the beginning of the period	0.60	0.0	0.58	0.0
Distance to nearest protected areas	0.74	0.0	0.74	0.0

Note: Levels of significance for Monte Carlo test p-value: <0.05; high local variation is above the cut-off value of 0.5 for variance of local coefficient
Source: own calculation

Decomposition of local spatial variation of relationships for final models is calculated based on the function presented in the methodology chapter equation 6 and values are shown in Table 5.3. If the location variation has a higher value i.e., above 0.5 then location variation of the relationship between forest cover change and determinants is caused by local coefficient. If the location variation has a lower value i.e., under the cut-off value of 0.5 then the local variation is caused by the values of determinants. In the final GWR model (of political-institutional determinants from 2000 to 2007), 8 out of 9 determinants, show that local spatial variation is caused by their local coefficients (distance to nearest human settlements, distance to nearest city and commune center, and distance to nearest protected areas). These determinants have considerable high local influence variance values (0.83, 0.80, and 0.74, respectively). Distance to nearest roads and distance to nearest major roads, distance to nearest forest edge in 2000 show a high local influence variance value (0.69, 0.68, and 0.60). Years of establishment of the commune forest administration and the aggregated protected area categories from one to four has a modest value of the local influence variance (0.51). Aggregated protected areas categories five and six display a value below 0.50 of the local coefficient variance (Table 5.3). Elevation and Pindus Mountain Forest ecological zones show the highest values of local coefficient variance of local coefficients from 2000-2007.

The final GWR model of cost distance and aggregated variable dataset of Albania

GWR models with aggregated and cost distance determinant datasets have better results than OLS models. Political-institutional models are the final selected models of GWR, because they obtained the lowest value of AICc. The final selected political-institutional model contains village area, road density, protected areas, accessibility of forest from the beginning of the period and years of establishment of communal forest administration, Table 5.4. Table 5.5 shows the scores of Monte Carlo test and of the variance of local coefficient for the final models of Table 5.4.

Table 5.4 Comparison between OLS and GWR models of cost distance and aggregated variables

Model	AICc	AICc	Moran's I of the residuals	
1988-2000	OLS	GWR	OLS	GWR
Biophysical	34155	32996	0.38	0.16
Biophysical including village locations	34094	32889	0.36	0.13
Demographic	34566	33906	0.44	0.26
Political-institutional	34450	32849	0.5	0.21
2000-2007	OLS	GWR	OLS	GWR
Biophysical	33114	31641	0.48	0.17
Biophysical including climate determinants	33008	31574	0.46	0.14
Demographic	33261	32245	0.50	0.26
Political-institutional	33173	31007	0.50	0.21

Note: Model selection estimator: Corrected Akaike Information (AICc), Moran'I of the residuals
Source: own calculation

Table 5.5 Results of GWR models, Monte Carlo test p-value and the variance of local coefficients of cost distance and aggregated variables

Model	Determinant	1988-2000 Variance of local coefficient	Monte Carlo test	2000-2007 Variance of local coefficient	Monte Carlo test
Biophysical	Elevation	0.70	< 0.01	0.70	< 0.01
	Pindus Mountain Forests	0.59	< 0.01	-	
	Cambisol soil type	0.53	< 0.01	0.57	< 0.01
	Regosol soil type	0.57	< 0.01	0.55	< 0.01
	Forest cover at the beginning of the period	0.66	< 0.01	0.67	< 0.01
Demographic	Population density 2001			0.60	0.06
	Population density 1989	0.50	0.02		
Political-institutional	Village area	0.66	< 0.01	0.62	< 0.01
	Road density	0.71	0.03	0.67	< 0.01
	Protected areas	0.50	< 0.01	0.50	< 0.01
	Accessibility of forest at the beginning of the period	0.66	< 0.01	0.67	< 0.01
	Years of establishment of commune forest administration	-		0.53	< 0.01

Note: Levels of significance for Monte Carlo test p-value: <0.05; high local variation is above the cut-off value of 0.5 for variance of local coefficient
Source: own calculation

It is noticed here that Monte Carlo test is statistically significant for all biophysical and political-institutional determinants ($p < 0.01$) compared to the Euclidean distance-determinants (see Table 5.2). Accessibility of forest at the beginning of the period, village area and road density shows the highest values of the variance of local coefficients.

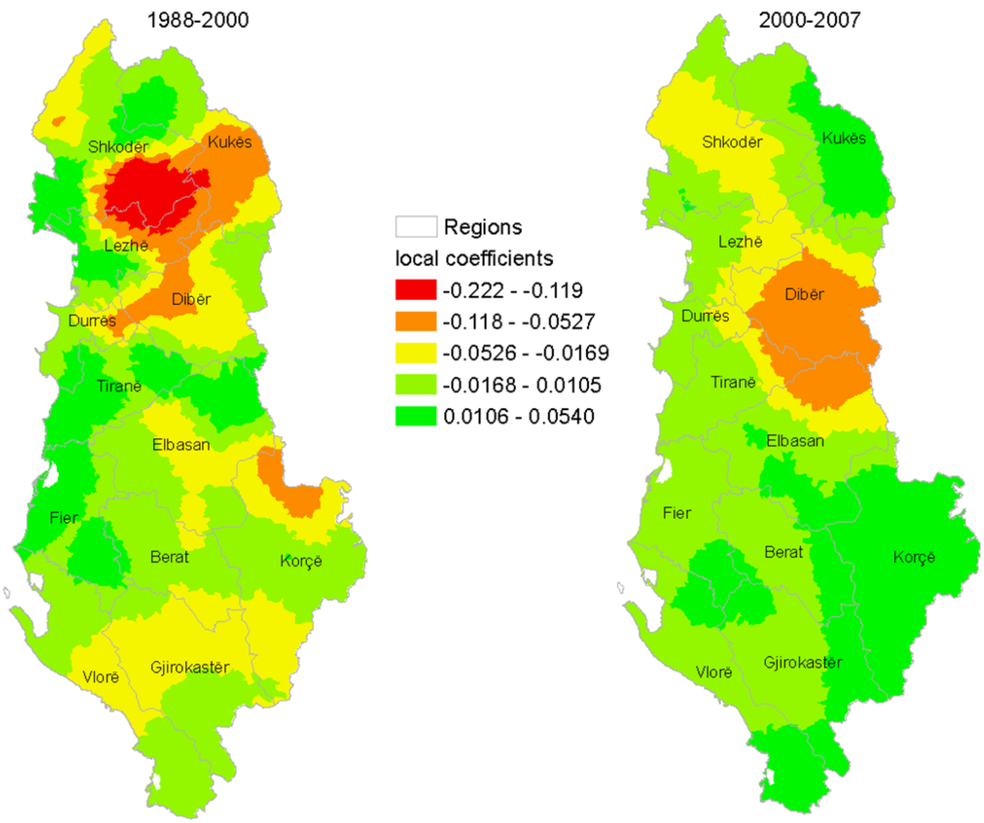
5.3.1.1 THE SPATIAL DISTRIBUTION OF THE GWR COEFFICIENTS

The relationships of forest cover changes and determinants of the final political-institutional determinants changes across Albania and it is not the same from north to south, from west to east. The patterns of distance to nearest human settlement, distance to nearest major road, road density and accessibility to forests in Figure 5.6 helps to highlight regions where deforestation or forestation is more concentrated that could be important for recommendation of the improvement or designing of new policy on management of forest and environmental protection.

The determinant of the distance to nearest human settlement is the determinant of forest cover change. This determinant explains the variation of the forest cover changes in village-level. The changes of forest cover are higher in villages located closer to human settlements (villages, towns) in Shkoder, Kukës, Dibër, Elbasan, Gjirokastër from 1988 to 2000 and Dibër, Shkoder, Lezhë from 2000 to 2007. By contrast, the changes of forest cover are lower in villages farther from human settlements in Tiranë, Fier from 1988 to 2000 and in Korçë, Kukës from 2000-2007 (Fig. 5.6A). The distance to nearest human settlements exhibits negative influence patterns in Shkodër, Dibër, Elbasan and Fier, and positive influence patterns in the south of Albania and Kukës in the second period. Forestation occurs farther from human settlements in the south and Kukës and deforestation closer to human settlements in Shkodër, Dibër, Elbasan and Fier. Forests are thus likely increased in remote forests in the south and Kukës and decreased in the north and east of Albania during the second period.

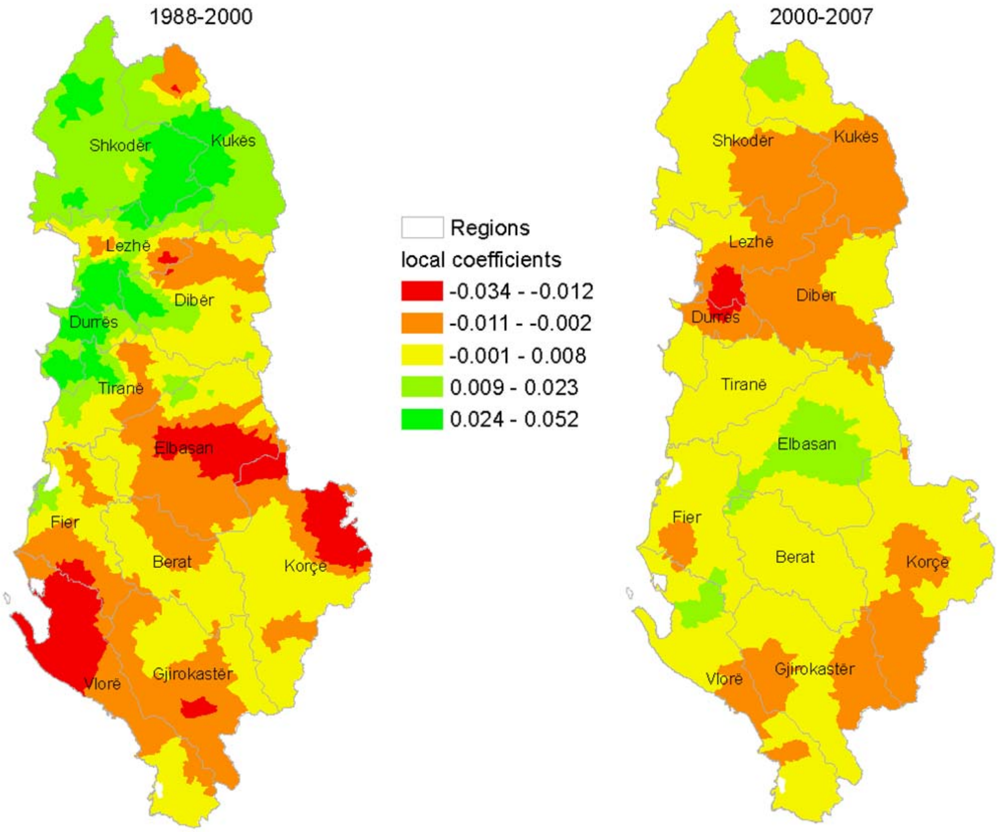
Figure 5.6 The spatial distribution of the local coefficients of the determinants, Albania

A) Distance to nearest human settlements



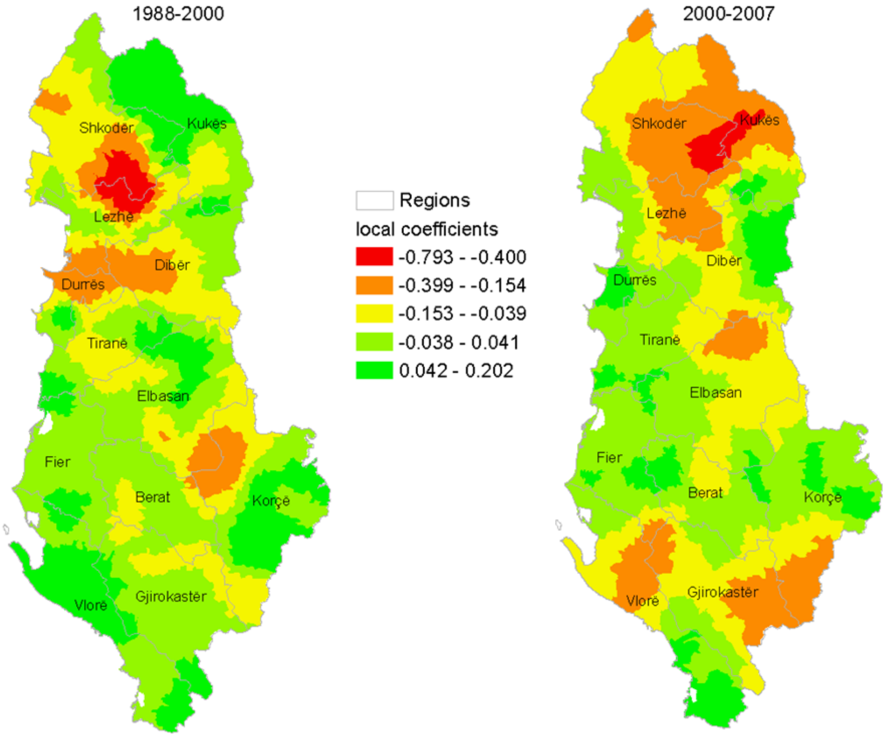
The GWR coefficients of the distance to nearest major roads (negative GWR coefficients) reveals that forest cover located in villages closer to major roads changed (deforested) in southern Albania than northern Albania from 1988 to 2000. Forestation is higher in villages located far from major roads in positive patterns concentrated in extreme north and middle part of Albania compared to southern Albania from 1988 to 2000. In the second period, the changes of forest cover are higher in villages located closer to major roads concentrated in northern Albania. Forestation is likely in villages located farther from major roads more in southern Albania compared to northern Albania (Fig. 5.6B)

B) Distance to nearest major roads

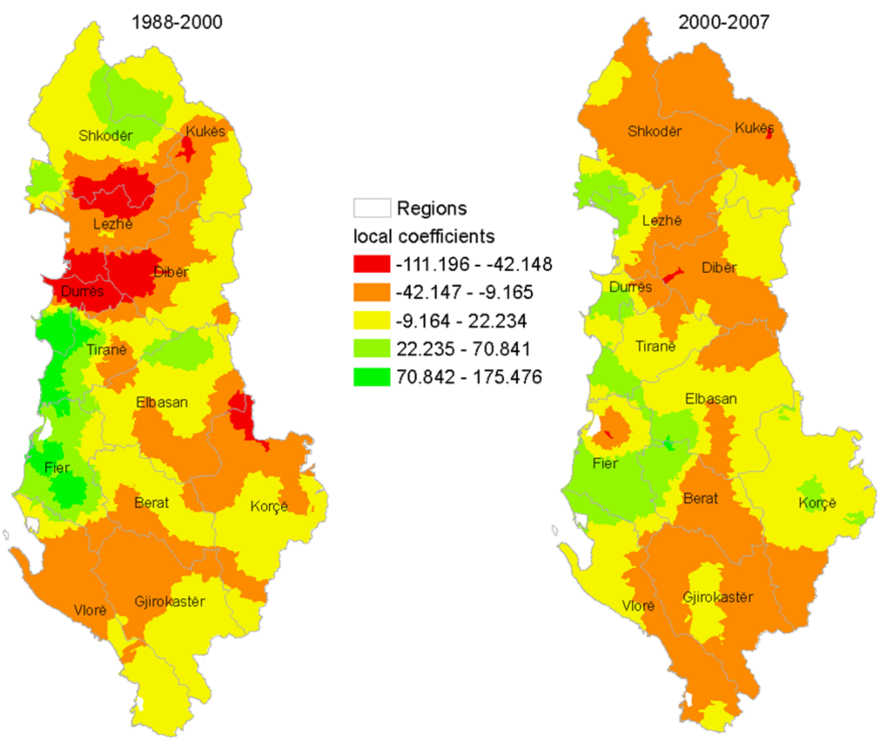


The negative GWR coefficients of road density from 1988-2000 are concentrated in the north and some in the south (with a road density of 9,000 per km^2 in village average). The higher density of roads in the west, south and Kukës, the higher the changes (loss) of forest cover are likely encountered (deforestation is observed in these villages). The positive GWR coefficients of road density in western and southern Albania are associated with more changes of forest cover (forestation) compared to northern Albania from 2000-2007 (Fig. 5.6C).

C) Road density



D) Accessibility of forest at the beginning of the period



Note: Classification of local coefficients for all maps presented in this study is in natural breaks (Jenks).
Source: own calculation

Deforestation is associated with negative patterns of accessibility to forest at the beginning of the period from 1988-2000. These negative GWR coefficients are concentrated in the north and south (these patterns have a density of roads of 8,400 km per km^2 and elevation of 600 m in village average). Forestation is associated with positive influence patterns and concentrated in villages located in hilly and flat topography, more urbanized areas with more roads in western Albania. By contrary, deforestation is in villages located in closer to human settlements in north and south of Albania. The patterns of negative estimated GWR coefficients of forest accessibility at the beginning of the period from 2000-2007 show that forest tends to decrease in northern (where the largest forest cover exists in these mountainous areas) and southern Albania.

5.3.1.2 INTERPRETATION AND DISCUSSION OF ALBANIAN FOREST COVER CHANGE

Why there is deforestation and forestation in one part and not in another part of Albania is discussed by the assumption of models, deforestation, forestation and determinants. Political-institutional models of forest cover change from 1988 to 2000 and from 2000 to 2007 were the final models to explain the forest cover change of Albania, because these political-institutional models performed better than biophysical and demographic models. Forests were widely under pressure in Albania from 1988 to 2000. Distances to nearest human settlements, distances to nearest major roads and road density have largely negatively influenced forest cover. Well-grown forests that are closer to human settlements, to major roads in Kukës, Dibër, Lezhë, Shkodër, Gjirokastër, Vlorë, Elbasan, and Korçë are used more for firewood, industrial wood, and charcoal than other parts of the country during the first period. Forestation occurs likely in large-distance from the human settlements, in the western part. Villagers in the west leave forests grow because well-grown forests are not abundant in the west compared to the north. Rural depopulation and the abandonment of agriculture in these areas could have caused less pressure on forests during the first period.

Forestation is a dominant process associated with the patterns of estimated GWR coefficient from 2000-2007. More forestation is likely in larger-distance from settlements in the west, in some other areas (e.g., Dibër, and Korça) and closer to villages in north (i.e., Shkodër, Kukës, Lezhë, Dibër), and the south (Berat, Gjirokastër, Vlorë). Forestation happens closer to settlements in north (i.e., Kukës, Dibër, Lezhë, Shkodër), and the south (Berat, Gjirokastër, Vlorë). Because of the decline of forest abundance, people of these regions most likely let the forest grow naturally and do not use them for firewood and industrial wood during the second period.

Forest increased in villages located in the west and in some villages of Dibër and Korça, indicating that pressure for firewood and industrial wood is less in these areas. Forestation in the extreme north, which has a rough topography and a low road density and does have protected forests, did not likely happen in this period, showing that forest users have utilized forests in protected areas and their surroundings. This also indicates that old-growth forests located in rough topography, elevated areas and steeply sloped forests are still attractive to users. Despite forestation occurring in the second period, deforestation is clearly observed, and a number of villagers have cut forests. Also, less forestation occurs at larger-distance from major roads (results show also in higher elevation) where high forests grow naturally. This indicates that forests are continuously under pressure for firewood and industrial wood.

Distance to nearest major roads shows negative relationships to forestation. This is because forests are easier to be harvested. Distance to nearest human settlements and major roads are assumed to be proxy determinants to markets and institutions in communes and larger urban areas and local institutions. These determinants help to identify which groups of villagers share similar attitude to forest use by shaping the forest landscape within villages and surrounding areas. A group of villages that places less pressure on forests for wood, fuel-wood, and charcoal production would encourage forest protection and thus forest increase. Results of estimated local coefficients show that some villagers are encouraged to use forests more than some others. Local patterns of the Euclidean distance human settlement show that more deforestation is likely from 1988-2000 in smaller-distance to human settlement forests and forestation is likely closer to human settlements with either difficult access to forests due to topography (extreme north) or with less pressure on forests because of rural depopulation or merely less interest in forests in general by the villagers. Deforestation has likely happened in villages in north (located in Shkodër, Kukës, Lezhë, Dibër), and the south (located in Berat, Gjirokastër, Vlorë), because people were potentially active in their forest use in the first period, but passive in the second period. Local institutions that should manage well forests, protect them and forest environment in general were likely passive, weak and could not halt deforestation and misuse of forests instead of sustainably management and protection of forests of forests.

Forestation far from settlements in the west is more likely to continue in Albania. The abandonment of agriculture could be the most likely reason of forest expansion in the first period; the increase of agriculture and/or urban development in the second period in the west could explain forest loss near settlements.

Positive and negative relationship patterns of protected area accessibility determinants are associated with deforestation from 1988-2000. Therefore, close proximity to protected areas (in positive relationship patterns) results in a greater likelihood of deforestation in average (per village) as expected; greater distance from protected areas (in negative relationship patterns) results in less deforestation in average from 1988-2000, which is not expected. One argument is that protected areas could contain harsh environmental conditions, e.g., steep slopes (the extreme north), and thus hardly be accessible by people, or local institutions could be active in their protection and surrounding nearby forests than in their use, which presents a good example of the management of protected forests. Another argument could be that local people put less pressure on forests for fuel-wood, or grazing due to depopulation, or be interested in forest protection e.g., in nearby commune forests. Forest increases is correlated positively with villages located in larger-distance than in closer distance to protected areas, indicating that forests surrounding protected areas are more under pressure than forests that are not close to protected forests.

5.3.2 KOSOVO

Global correlation is high between Pindus Mountain Forests and Balkan Mixed Forests ecological zones (> 0.70). Pindus Mountain Forests are considered in this analysis. The value of correlation between Rankers (soil type) and elevation as well as between distance to nearest road and distance to nearest human settlement is of 0.71, respectively. These determinants are included in this GWR analysis. Two categories of protected areas, all soil types of Rankers, and Luvisols are aggregated as protected areas, Rankers and Luvisols, respectively.

The final models are selected from the 'political-institutional model' hypothesis of GWR for both periods i.e., from 1988 to 2000 and from 2000 to 2007, because of the lowest value of AICc and low Moran' I. Maps of R^2 of final models for the final models of political-institutional determinants are displayed in Appendix A5.3 The GWR models perform better than OLS models (Table 5.6).

Table 5.6 Comparison between GWR and OLS models with disaggregated variables, Kosovo

Model	AICc	AICc	Moran's I of the residuals	
1988-2000	OLS	GWR	OLS	GWR
Biophysical	12894	12474	0.39	0.06
Biophysical including climate determinants	12826	12456	0.31	0.03
Demographic	12991	12655	0.41	0.16
Political-institutional	12908	12358	0.36	0.0004
2000-2007	OLS	GWR	OLS	GWR
Biophysical	12694	12395	0.30	0.08
Biophysical including proxy climate determinants	12687	12370	0.29	0.046
Demographic	12720	12440	0.33	0.16
Political-institutional	12722	12317	0.32	0.03

Note: Model selection estimator are Corrected Akaike Information (AICc) and Moran'I of residuals
Source: own calculation

The selected political-institutional models were composed of the distance to nearest road, highway, human settlement, protected areas and UXOM and the amount of protected areas, Table 5.7. Monte Carlo test results with GWR final models appear in Table 5.7. A large part of political-institutional determinants that is eleven (five for the forest cover change 1988 to 2000 and six for the forest cover change from 2000 to 2007) out of twelve have statistically significant Monte Carlo test values (p-value < 0.05), indicating that spatial variation between estimated local coefficients of political-institutional determinants and forest cover change is present. Monte Carlo test confirms thus that local variation does not occur by chance in the relationships of forest cover change and determinants.

Table 5.7 Results of GWR models, Monte Carlo test p-value and the variance of local coefficients, Kosovo

		1988-2000		2000-2007	
Model	Determinant	Variance of local coefficient	Monte Carlo test p-value	Variance of local coefficient	Monte Carlo test p-value
Biophysical					
	Elevation	0.89	<0.01	0.87	<0.01
	Pindus Mountain Forests	0.49	<0.01	0.47	<0.01
	Dystric Planosol soil type	0.49	<0.01	0.44	0.06
	Luvisol soil type	0.51	0.04		
	Ranker soil type	0.48	<0.01	0.52	<0.01
	Dinaric Mountain Forests	0.50	<0.01		
Demographic					
	Population estimation 1991	0.51	0.99		

	Population projection 2004			0.40	0.92
Political-institutional					
	Protected areas	0.49	0.01	0.51	<0.01
	Distance to nearest road	0.67	0.36	0.69	<0.01
	Distance to nearest highway	0.70	0.00	0.71	<0.01
	Distance to nearest human settlement	0.86	0.02	0.86	<0.01
	Distance to nearest protected areas	0.75	0.00	0.73	<0.01
	Distance to nearest UXOM	0.70	0.00	0.70	<0.01

Note: Model selection estimator: corrected Akaike Information (AICc) and Moran'I of residuals. Levels of significance for Monte Carlo test p-value<0.05, the cut-off value of the variance of local coefficient of 0.5
Source: own calculation

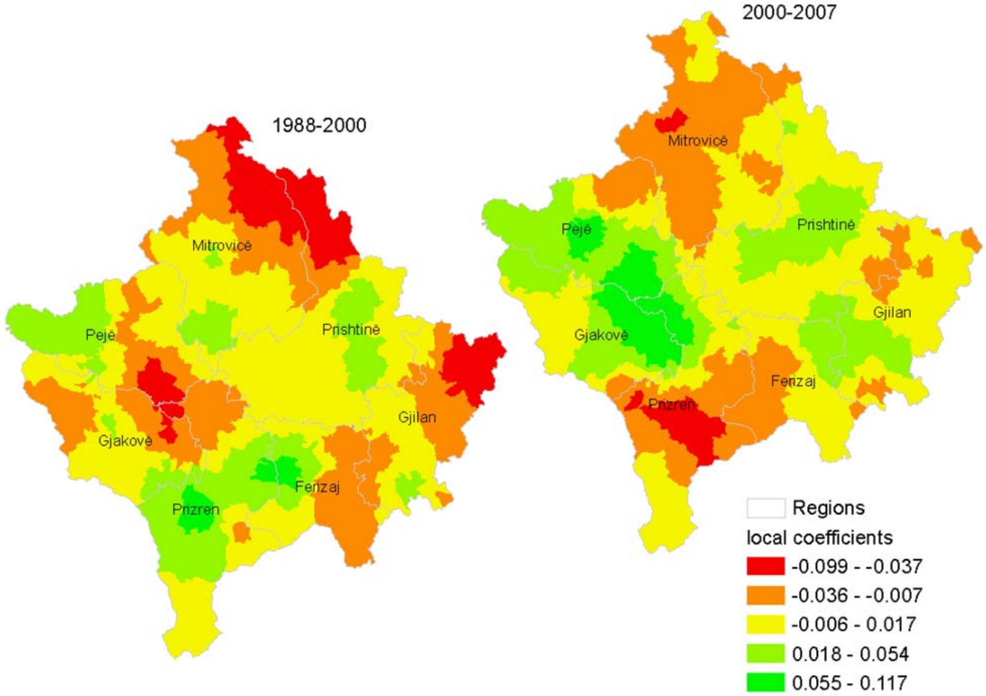
The determinants of the distance to nearest human settlements, to protected areas, highway and UXOM of the final political-institutional model shows a considerably high value of the variance of GWR coefficient of above 0.70 indicating that these determinants explain the variation of forest cover changes in village level to a large extent. Protected areas have a non-considerable value of the variance of estimated GWR coefficients indicating that this variable is not significant to explain the changes of forest cover. Elevation is also a significant determinant with a value of the variance of GWR coefficient of 0.89 and 0.87, respectively (Table 5.7).

5.3.2.1 THE SPATIAL DISTRIBUTION OF THE LOCAL COEFFICIENTS OF THE DETERMINANTS

Fig. 5.7 shows the spatial patterns of the relationships of forest cover change with the distance to nearest human settlements (A). The changes of forest cover are higher in villages closer to human settlements located in the north (Mitrovicë), east (Gjilan and Ferizaj) and southwest (Gjakovë) from 1988 to 2000 and in the north (Mitrovicë) and south (Prizren) from 2000 to 2007. Spatial patterns of GWR coefficients of positive values are concentrated in west (Pejë) and south (Prizren) from 1988 to 2000, and in southwest (Pejë and Gjakovë) of Kosovo from 2000 to 2007, indicating the changes of forest cover are higher in villages located far from human settlements (Fig. 5.7A). Spatial patterns of negative value GWR coefficients of this determinant are associated with observed deforestation and positive relationship patterns with observed forestation from 1988-2000 and observed forestation from 2000 to 2007 in average (per village).

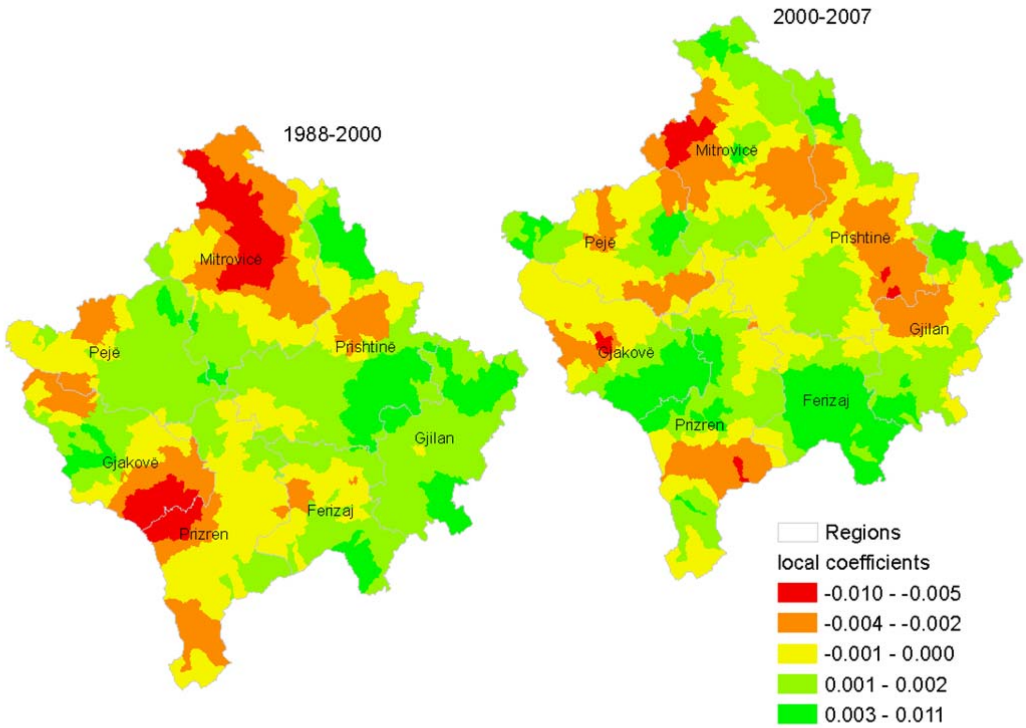
Figure 5.7 The spatial distribution of the local coefficients of the determinants, Kosovo

A) Distance to nearest human settlement

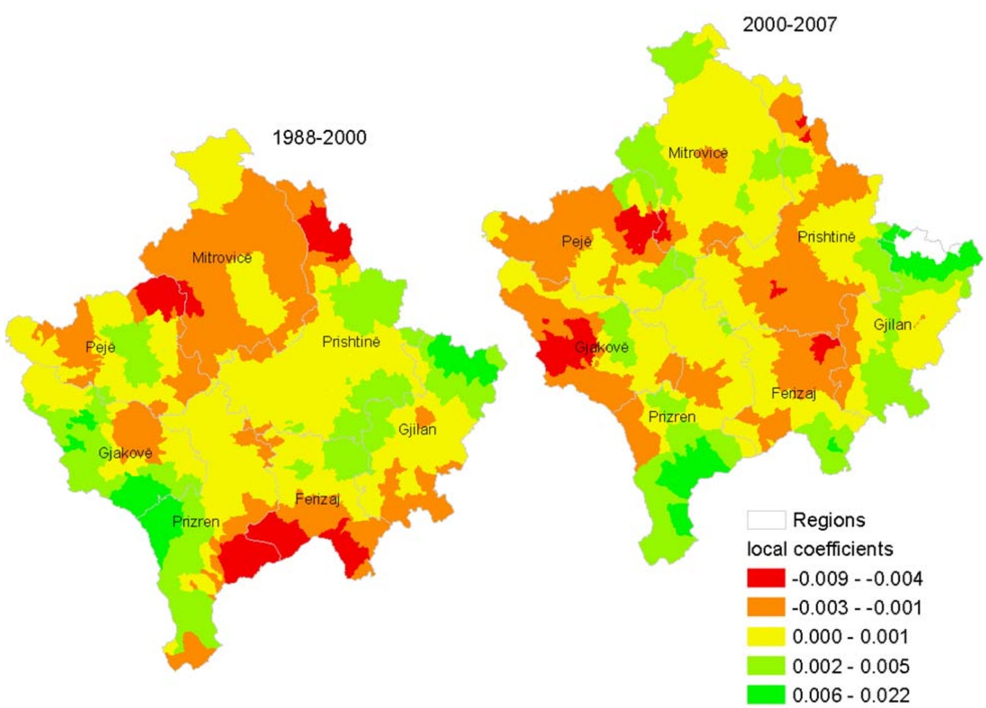


Spatial patterns of negative coefficients of GWR of the distance to nearest highway are concentrated in the north (Mitrovicë, Prishtinë) and south (Gjakovë, Prizren, Pejë) of Kosovo from 1988 to 2000 (Figure 5.7B), indicating that the changes of forest cover (deforestation) are higher in villages located closer to highway (in these patterns). By contrast, the changes of forest cover (forestation) are higher in villages located away from highway in central part of Kosovo in the first period and the extreme north and south of Kosovo in the second period.

B) Distance to nearest highway



C) Distance to nearest UXOM



Source: own calculation
Note: Classification of local coefficients for all maps presented in this study is in natural breaks (Jenks).

Spatial patterns of negative values of GWR coefficients of the distance to the nearest UXOM appear in the north and southeast, showing the changes of forest cover (deforestation) are higher in villages located closer to identified objects and mined areas in north (Mitrovicë), south (Prizren and Gjakovë) in the first period and north, east and southwest of Kosovo in the second period. Spatial patterns of positive values of GWR coefficients are in southwest and east of Kosovo from 1988 to 2000 and the extreme south and east of Kosovo from 2000 to 2007 showing that the changes of forest cover (forestation) are higher in villages located in higher distance from UXOM. These spatial patterns are associated also with observed forestation from 2000 to 2007 (Figure 5.7C).

5.3.2.2 INTERPRETATION AND DISCUSSION OF KOSOVAN FOREST COVER CHANGE

Summarizing, the determinant of distance to human settlement is the determinant of the forest cover change for Kosovo in both periods. The information of local patterns of selected determinants from the final selected political-institutional model, deforestation likely occurs closer to highways, human settlements, protected areas and UXOM areas in the first period. For the same period, forestation occurs far from roads, human settlements, UXOM and in higher elevations. During the second period, forest is likely to increase in large-distance from roads, human settlements, protected areas, UXOM and higher elevation. Villages in Mitrovicë, Gjilan, Ferizaj, and Gjakovë have used more forests closer to their settlements during the first period than in the other parts of the country. Deforestation is likely closer to highways in Mitrovicë, Prizren, Gjakovë, Pejë, Ferizaj and the capital city area than in other parts of the country because people use more forests there, for firewood, construction and industrial wood. Secondary data sources show that people rely much on forests for firewood in Mitrovicë, Prishtinë, Ferizaj Prizren and Gjilan, which support the GWR findings.

The negative relationship patterns are extended more in Mitrovicë, Gjilan, Ferizaj and Prizren and less in Gjakovë during the second period; more forestation is likely closer to the settlements in these regions than in other parts of Kosovo from 2000-2007. Potentially, people have used forests up during the first period and left them (forests) to regenerate in the second; they likely start using forests that are farther from their homes for firewood and industrial wood.

The Prishtinë capital city area is associated with forestation from 1988-2007; less forestation is likely closer to the human settlements and more forest is likely away from them. Urban development (and agriculture development after the war) in central Kosovo could explain why there is less forestation. Forests in the north, east and southwest, and larger populated areas tend to be smaller, which shows that local people extracted wood for heating in more abundant and accessible forests as well as local institutions of forest management and protection could have been more passive to monitoring wood collection for firewood and logging and explain so the occurrences of more deforestation in these parts (i.e., north, east and southwest) of Kosovo during the first observed period compared to the other parts of the country.

Forests have suffered from the war activities of 1998-1999. The Kosovo-Albania, Kosovo-FYR of Macedonia and Kosovo-Serbia cross-border areas is expected to have experienced more changes of forest cover (deforestation) because of intensive refugee movements, mines and bombing. One of the highest refugee movements has been the area of Gjakovë, Prizren and Kukës in Albania; this is one of the most mined and bombed areas in the country. Locations of the mined and bombed areas have become known by local people, therefore, they stayed away from UXOM forest spots until they were cleared and safe for use. It is assumed firstly that deforestation dominates in the cross-border areas with Albania and the FYR of Macedonia during the first period, and forestation is expected to dominate in the second period. It is assumed secondly that mined and bombed forests were abandoned by inhabitants. These two assumptions help understand the complex patterns of the distance to nearest to UXOM patterns. Deforestation is likely closer to UXOM sites from 1988-2000 and they are concentrated in the north and southeast of the country. These areas are not heavily mined or contaminated by UXOM, so people use the forests extensively, as they rely on them for firewood. Positive relationship patterns are found in the southwest and northeast. The southwest area (Gjakovë) is one of the most contaminated areas with mines and Unexploded Object (UXO). Spatial patterns of positive GWR coefficients are associated with observed forestation in average (village), indicating that forests are potentially abandoned by people as forests could be still pernicious. On the other hand, spatial patterns of GWR negative coefficients are associated with observed deforestation because forests are still used by local inhabitants. From work experience in 2006 in Gjakovë (Gjakovë is within the Kosovo cross-border study region of this current study), the author observed that people who had experienced damage from war left almost everything (houses and land) and moved to safer places to start over again. In such cases, forests are not much under pressure for use because of rural de-population. This helps explain more forestation nearer to UXOM spots in Gjakovë, Prizren, Mitrovicë and Ferizaj from 2000-2007.

Spatial patterns of negative values of GWR coefficients of distance to nearest human settlements, elevation, to distance to nearest UXOM, distance to nearest highway are well-concentrated in the north and south. This indicates that forest cover has most likely changed in these regions. Wood extractions for firewood by villagers, logging and war have caused the changes of forest cover in north and south of Kosovo. Local institutions of forest management and environmental protection stimulate forest use in these regions more than protection illustrating that pressure to forest is evident and differ from north to center and south of Kosovo, which the author learned from the local patterns of determinants of political-institutional final selected model.

5.3.3 GLS MODELS RESULTS

The graphs of the residuals versus distance to nearest roads, distance to nearest as-phalted roads, distance to nearest human settlements, distance to nearest forest edge in 1988 and distance to nearest protected areas show the variance of these determinants increases when the determinant values increase, indicating the heterogeneity of the relationships between determinants and forest cover change. Determinants of dis-tance to nearest human settlements, distance to nearest roads, distance to nearest as-phalted roads, distance to nearest forest edge, elevation are selected for the analysis of GLS as they display heterogeneity in their relationships with the response variable in the final political-institutional and biophysical models.

The selected GLS models shown in Table 5.8 and Table 5.9 are the ones with the lowest AIC value. GLS model estimators are also the variance structure specified as the argument of weights in GLS, likelihood ratio, df, and p-values (Tables 5.8 and Table 5.9).

Table 5.8 Summary of GLS results, Albania

Model	GWR	GLS		Likelihood ratio	df	p-value	Determinant significance at p-value <.0001
1988-2000	AICc	AIC	Weights				
Biophysical	33320	33109	Elevation constant power structure variance	91.70	2	<.0001	Elevation, Pindus Mountain Forests, Cambisols
Demographic	33926	34498	Population exponential structure variance		1		
Political-institutional	33176	32574	Distance to nearest forest edge 1988 power structure variance	1970.84	1	<.0001	Distance to nearest: asphalted roads, roads, forest edge 1988
2000-2007							
Biophysical	31886	31926	Elevation constant power structure variance	79.00	2	<.0001	Elevation, Cambisols or Cambisols, Regosols
Demographic	32250	33200	Population exponential structure variance		1		
Political-institutional	31650	31774	Distance to nearest human settlement power structure variance	1487.96	1	<.0001	Landscape protected areas and Managed resource protected areas; distance to nearest: roads, asphalted roads, human settlements, city and commune center, forest edge 2000, protected areas

Note: Model selection estimator: Akaike's Information Criterion (AIC), variance structure, likelihood ratio, df, p-value. Levels of significance for p-value <0.05

Source: own calculation

Table 5.9 Summary of GLS results, Kosovo

Model	GWR	GLS		Likelihood ratio	df	p	Determinant significance at p <.0001
1988-2000	AICc	AIC	Weights				
Biophysical	12474	12393	Elevation constant power structure variance	23.85	2	<.0001	Elevation, Pindus mountain forests, Dinaric mountain forests, Luvisol
Demographic	12655	13003	Population exponential structure variance				
Political-institutional	12358	12397	Distance to nearest human settlement power structure	208.80	1	<.0001	Distance to nearest highway, Distance to nearest roads, distance to nearest protected areas

			variance				
2000-2007							
Biophysical	12395	12641	Elevation fixed structure variance function				Elevation, Pindus mountain forests; Rankers
Demographic	12440	12700	Population exponential structure variance				
Political-institutional	12317	12523	Distance to nearest human settlement power structure variance	70.75	1	<.0001	Distance to nearest city and commune center, distance to nearest protected areas

Note: Model selection estimator: Akaike's Information Criterion (AIC), variance structure, likelihood ratio, df, p-value. Levels of significance for p-value < 0.05.
Source: own calculation

GLS model with an elevation fixed variance structure (see Chapter 3) is the best weight in biophysical model 2000-2007 for Kosovo. The interpretation of elevation fixed variance structure is linearly related to the variance of elevation following Zuur et al. (2009). Interpretation for elevation constant power structure, population exponential structure, distance to nearest human settlement power variance structures are rather complex. Constant power and exponential variance structure tolerate for an increase or decrease in residual variation for forest cover change "along a continuous variance covariate" (Zuur et al., 2009) (covariate are elevation, population, distance to nearest human settlement of the biophysical, demographic and political-institutional model, respectively). Determinants that display the largest variance within the nested models are shown in bold. These are the significant determinants of heterogeneity that are obtained at p-value < 0.0001 and validated for the final political-institutional and biophysical models (see column 8 of Tables 5.8 and 5.9).

5.3.4 SPATIAL HETEROGENEITY OF RELATIONSHIPS, ALBANIA AND KOSOVO

GLS analysis helps uncover similarities and differences in the spatial heterogeneity of relationships in Albania and Kosovo regarding variance structure, statistically significant determinants and determinants with the largest variance. GLS has threefold finding as follows: the non-linear function of the variance structure for the relationships; the number of statistically significant determinants in the relationships, and determinants that have the largest variance (in the nested models). Distance to nearest road has the largest variance in the nested models in Albania and Kosovo from 1988-2000.

Distance to nearest forest edge has the largest variance in Albania, and distance to nearest city and commune center has the largest variance in the political-institutional model in Kosovo from 2000-2007. GLS weights are more or less the same for Albania and Kosovo models. However, they differ in variance structure e.g., GLS biophysical 1988-2000 models, political-institutional model in 1988-2000 models. Ecological zones show the largest variance in biophysical groups from 1988-2000 and soil types from 2000-2007 in Albania and Kosovo, though they are of different types of ecological zones, soil (Tables 5.8 and 5.9).

During the GLS analysis, there were observations with large residuals, which indicated that outliers could exist in the data; however, the aim of the GLS analysis was to expose the heterogeneity of the forest cover and determinant relationships and not to study the data outliers. In this regard, data outliers could be a fruitful area for a potential study in the future. Findings of the GLS analysis strengthened our assumption on GWR, that heterogeneity of forest cover change and determinant relationships existed, and spatial relationships of villages were nonlinear. The determinant of the distance to nearest human settlement of forest cover change (statistically significant below 0.05 of Monte Carlo test and high value of the variance of the GWR coefficient of above 0.70) was found to be also important in GLS analysis e.g., the variance structure of distance to nearest human settlement in the final political-institutional GLS model. Elevation obtained the highest value of variance of local coefficient obtained from GWR analysis in the best biophysical model determinants in Albania and Kosovo (Tables 5.8 and 5.9). This determinant had the weights of the variance structure in the best biophysical model of GLS analysis. The results of the decomposition of local variation of forest cover change and determinant relationships, of PCA and GLS indicated again the presence of the spatial heterogeneity of forest cover change and the determinant relationships in Albania and Kosovo (Tables 5.8 and 5.9 and appendixes A5.5: PCA results).

Relationships of village location and forest cover change

Model fit of GWR biophysical models show lower value with village location determinants than without them in biophysical models of Albania and Kosovo (Table 5.2, 5.4 and 5.6). The changes of forest cover increases for the villages that are more in east (i.e., larger X-coordinate) than in west from the first to the second period in Albania and Kosovo. Villages in the north of Albania (i.e., larger y-coordinate of a village) have larger changes of forest cover compared to villages in southern Albania in both periods. Differently, the changes of forest cover tend to reduce in the villages in the north of Kosovo from the first to the second period.

Location of village and therefore the condition of climate has higher influence to northern and eastern forests in Albania and Kosovo compare to forests in the west and south of Albania and Kosovo. These findings expose an interesting future study to investigate the relationships of climate conditions differences (and changes under the assumption of climate change) and forests in Albania and Kosovo.

5.3.5 DIFFERENCES BETWEEN ALBANIA AND KOSOVO AT COUNTRY LEVEL

The results of the forest cover change models showed a lower spatial autocorrelation in Kosovo than in Albania. Local variations of the determinants of forest cover change from 1988-2000 and 2000-2007 were higher and more dynamic in Albania than Kosovo, as revealed from the descriptive and analytical analysis. The patterns of the estimated local coefficients of the distance to nearest human settlements were concentrated in northern, southern and western Albania. In Kosovo, the patterns of the distance to nearest human settlement and forest cover change relationships were concentrated in the north and the south. The north of Albania and the north and south of Kosovo was likely associated with deforestation that occurred nearer settlements than in southern and western Albania and central Kosovo. Forests increased in the west of Albania during the first period, but decreased in the second, which could be related to the increased urban and agricultural activities in the second period in the west of Albania. More forestation was likely in southern Albania in the second period.

The estimated local coefficients of the distance to nearest human settlement showed that deforestation was greater nearer settlements during the first period. During the second period, forest increases were larger closer to human settlements and tended to decline in more remote areas and at higher elevations in Albania and Kosovo. This indicated that pressure on abundant and well-grown forests increased during the second period. Despite forest increased nearer settlements, the pressure existed on high elevations where more abundant, well-grown and likely primary forests exist. Furthermore, forest decreased observed from the satellite images indicates that forest resources in remote areas (i.e., where likely higher economic and ecological values forests grow) are very likely to shrink and are under continuous threat.

5.3.6 THE CROSS-BORDER STUDY REGION OF ALBANIA AND KOSOVO

Distance to nearest human settlements, distance to nearest roads and distance to nearest major roads are highly correlated (> 0.70). Variables that pass the Kruskal-Wallis test were used in the analysis (A5.S1). Therefore, I model once with one variable, drop the other correlated variable and calculate the values of model-fit of the model. This is repeated until a model is found with the lowest AICc value that is selected as the final model.

Ranker soil type is correlated with elevation and slope (0.71, 0.73) in Kosovo. Distance to nearest roads and distance to nearest the nearest human settlement has a value of correlation of 0.71. Spatial autocorrelation of deforestation and forestation dependent variables from 1988-2000 and 2000-2007 is less than (0.4) in the cross-border study site.

Political-institutional models are the final selected models that explain the forest cover changes in Albania from 1988 to 2000 and from 2000 to 2007. The biophysical and political-institutional models are the final selected models of forest cover changes in the first period, i.e., from 1988-2000 and political-institutional are the final model of forest cover changes in the second period, i.e., from 2000-2007 in Kosovo (Table 5.10). GWR models perform consistently better than OLS.

Table 5.10 Summary of GWR and OLS results of the cross-border study region

Model, Albania	AICc	AICc	Moran's I of the residuals	
1988-2000	OLS	GWR	OLS	GWR
Biophysical	2170.62	2098.83	0.38	0.10
Demographic	2180.49	2138.56	0.45	0.24
Political-institutional	2181.42	2074.65	0.43	0.09
2000-2007	OLS	GWR	OLS	GWR
Biophysical	2046.35	1992.39	0.35	0.11
Demographic	2076.53	2025.78	0.48	0.24
Political-institutional	2081.35	1971.98	0.48	0.04
Model, Kosovo	AICc	AICc	Moran's I of the residuals	
1988-2000	OLS	GWR	OLS	GWR

Biophysical	2864.58	2805.16	0.17	-0.05
Demographic	2892.14	2831.25	0.29	0.09
Political-institutional	2877.52	2802.80	0.21	-0.03
2000-2007	OLS	GWR	OLS	GWR
Biophysical	2926.79	2875.68	0.23	0.04
Demographic	2924.13	2868.39	0.25	0.18
Political-institutional	2924.71	2839.08	0.25	0.06

Note: Cross-border region Albania-Kosovo and model selection estimator: Corrected Akaike's Information Criterion (AICc), Moran 'I of residuals
Source: own calculation

The model-fit of GWR AICc shows that political-institutional and biophysical determinants are important for the cross-border study region of Albania and Kosovo. This is different from Albanian and Kosovan results at the country level. Monte Carlo test and the values of the variance of local coefficients are in the Table 5.11.

Table 5.11 GWR final model results of the cross-border study region

Model Albania	Determinant	1988-2000 Variance of local coefficient	Monte Carlo test p-value	2000-2007 Variance of local coefficient	Monte Carlo test p-value
Biophysical					
	Elevation	0.84	0.00	0.81	0.00
	Eutric Cambisol soil type	0.53	0.00	0.58	0.00
	Dinaric Mountains Mixed Forests			0.42	0.00
	Balkan Mixed Forests	0.42	0.16		
Demographic					
	Population census 1989	0.59	0.99		
	Population census 2001			0.47	0.96
Political-institutional					
	Distance to nearest asphalt road	0.66	0.00		
	Distance to nearest human settlement	0.78	0.10	0.71	0.01
	Distance to nearest city & commune center	0.83	0.05		
	Strict protected areas	0.44	0.05	0.50	0.33
	National parks	0.51	0.03		
	Distance to nearest protected area			0.75	0.00
	Years of establishment of communal forest administration			0.52	0.00
Model Kosovo	Determinant	1988-2000 Variance of local coefficient	Monte Carlo test p-value	2000-2007 Variance of local coefficient	Monte Carlo test p-value
Biophysical					
	Elevation	0.77	0.00	0.77	0.00
	Ranker soil type	0.46	0.00	0.55	0.00

	Dystric Cambisol soil type			0.58	0.21
	Eutric Cambisol soil type	0.46	0.01		
	Balkan Mixed Forests	0.98	0.00	0.93	0.00
Demographic					
	Population estimation 1991	0.29	0.77		
	Population projection 2004			0.31	0.12
Political-institutional					
	Distance to nearest road	0.57	0.01	0.53	0.01
	Distance to nearest human settlement	0.79	0.05	0.73	0.01
	Distance to nearest protected area	0.77	0.05		
	National parks			0.49	0.00
	Distance to nearest forest edge 2000			0.77	0.00

Note: Levels of significance for Monte Carlo test p-value < 0.05; high local variation is above the cut-off value of 0.5 for variance of local coefficient
Source: own calculation

Monte Carlo test results are higher in Kosovo than in Albania cross-border study region. Most of determinants (66 %) of biophysical, demographic and political-institutional models have statistically significant Monte Carlo test values (p-value < 0.0.5) from 1988-2000 and 75 % of determinants have Monte Carlo test values of p-value below 5 % from 2000-2007 in Albania. In case of Kosovo, 88 % percent of the determinants are statistically significant (p-value <0.0.5) from 1988-2000 and 78 % of determinants are statistically significant (p-value <0.0.5) from 2000-2007 (Table 5.11).

Distance to nearest human settlements and elevation is at the top of the hierarchy of determinants. Distance to nearest asphalt road, distance to nearest human settlement, and distance to nearest city and commune center have considerably high value of the variance of local coefficients above 0.60 from the selected political-institutional models of Albania. Distance to nearest human settlement and distance to nearest protected areas, distance to nearest forest edge 2000, Balkan Mixed forests and elevation have high values of the variance of local coefficient above 0.70 from the selected political-institutional and biophysical models, respectively, for Kosovo.

GWR for Albania and Kosovo is run to make a comparison of forest cover change at sub-region level between two countries and to check the robustness of GWR results that are obtained at country level. GWR results on local variations in the cross-border study region are robust. Political-institutional models are the final models for Albania, biophysical and political-institutional models are the final models for Kosovo from 1988 to 2000 and from 2000 to 2007. Final models that explain the forest cover changes in Albania are different from Kosovo cross-border study region which is a lesson learned of the cross-border study region analysis. Relationships between forests cover changes and biophysical and political-institutional model determinants are similarly important in the cross-border study region from 1988-2007; this is also a lesson learned from running the cross-border analysis of GWR. The GWR AICc model fit have lower values in Albania than Kosovo, Moran's I of residuals has lower values in Kosovo compared to Albania. The values of the variance of GWR coefficients of the cross-border study region analysis are comparable to those obtained from Albanian or Kosovan dataset analyses at country-level analysis. This is the third lesson learned of the cross-border analysis.

5.3.6.1 THE SPATIAL DISTRIBUTION OF THE LOCAL COEFFICIENTS IN THE CROSS-BORDER STUDY REGION OF ALBANIA AND KOSOVO

Spatial patterns of relationships of elevation, distance to nearest human settlement and forest cover change are summarized in Table 5.12. Spatial patterns of negative values of GWR coefficients of the distance to nearest human settlements and elevation are associated with observed deforestation and positive patterns with observed forestation in both periods in Albania (Fig. 5.8). Spatial patterns of positive values of GWR coefficients of distance to nearest human settlements are associated with observed forestation and negative values of GWR coefficients with deforestation in the first period and forestation in the second period. Spatial patterns of positive values of GWR of elevation are associated with observed forestation in both periods in average (per village) n Kosovo (Table 5.12).

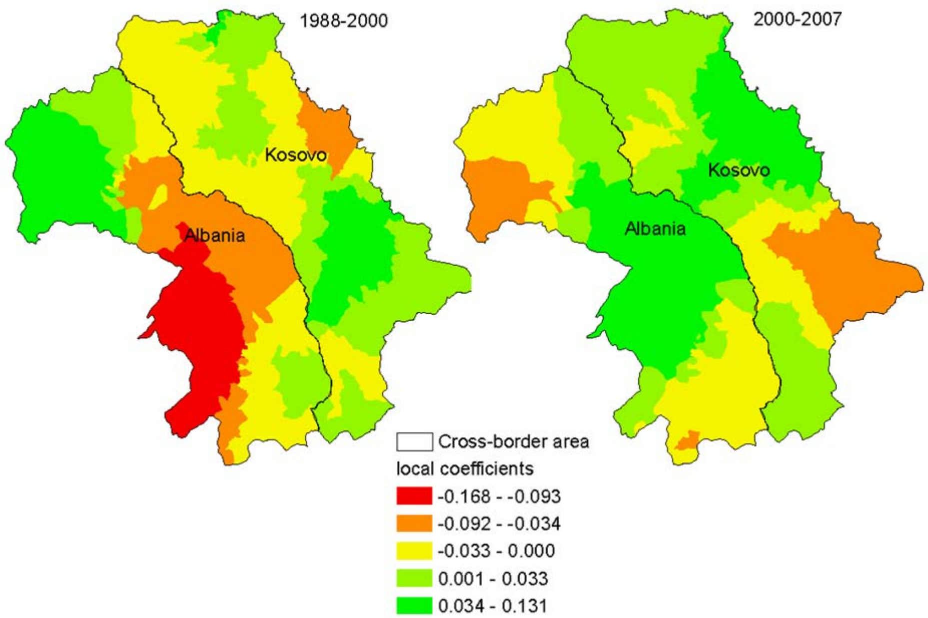
Table 5.12 Local patterns of distance to nearest human settlement and elevation and observed processes in average in the cross-border study region

	Deforestation		Forestation	
Patterns	1988-2000	2000-2007	1988-2000	2000-2007
Albanian distance to nearest human settlement	-	-	+	+
Albanian Elevation	-	-	+	+
Kosovan distance to nearest human settlement	-	+	+	+
Kosovan Elevation	+	+	+	+

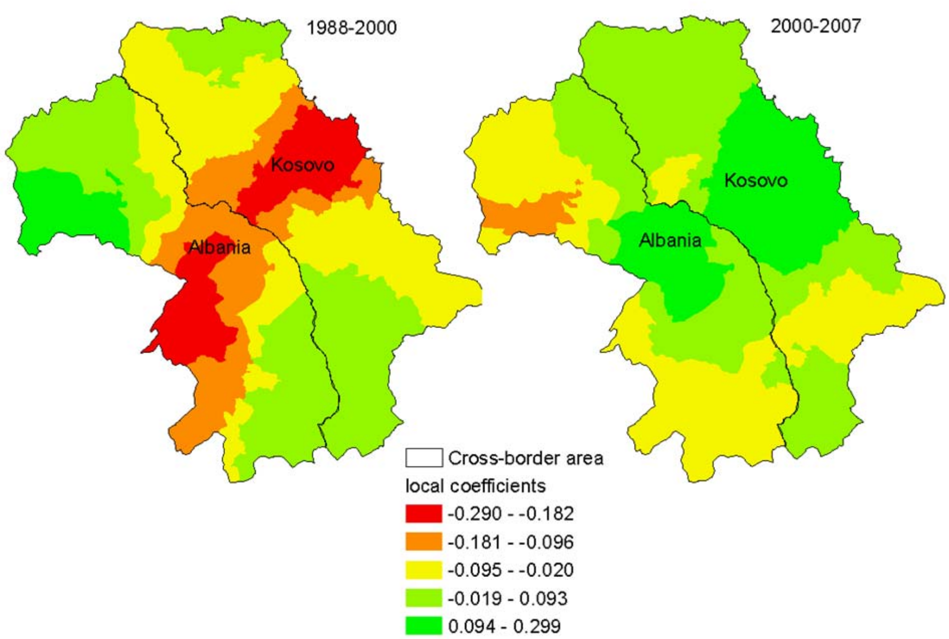
Source: own calculation

Figure 5.8 The spatial distribution of the local coefficients, the cross-border study region of Albania and Kosovo

A) Distance to nearest human settlements



B) Elevation



Note: Classification of local coefficients for all maps presented in this study is in natural breaks (Jenks).
Source: own calculation

In Fig. 5.8A and B, the changes of forest cover (most likely deforestation) are higher in villages located closer to human settlements and lower elevation in the central part of cross-border study region of Albania and Kosovo from 1988 to 2000. In contrary, the changes of forest cover (most likely forestation) are higher in villages located in higher elevation and far from human settlements in the central part of the cross-border Albania and Kosovo in the second period. For example, observed forestation happens in high elevation forests in Albania (946 m mean elevation) and Kosovo (1,008 m mean elevation). Therefore, the central part of the cross-border study region show similar rather than different patterns of elevation and the distance to nearest human settlement and forest cover change.

5.3.6.2 GLMs RESULTS

The Kruskal-Wallis non-parametric test is used before running the GLMs models. Determinants that show statistically significant values ($p < 0.05$) and pass the Kruskal-Wallis non-parametric test are selected for GLMs modeling. Distance to nearest human settlement and distance to nearest road from 1988-2000, distance to nearest roads, distance to nearest major road, distance to nearest asphalted road and distance to nearest protected area from 2000-2007 pass the test. Biophysical determinants that pass the Kruskal-Wallis test are Pindus Mountains Mixed Forests, Dinaric Mountains Mixed Forests, Humic Cambisols, and Eutric Cambisols from 1988-2000, and Pindus Mountains Mixed Forests, Haplic Phaeozems, Eutric Cambisols, elevation, and Balkan Mixed from 2000-2007 for Albania.

Distance to nearest UXOM, distance to nearest major road, distance to nearest protected area, distance to nearest forest edge and protected areas in percentage, proposed protected areas in percentage, Balkan Mixed Forests, elevation, Ranker, Dystric and Eutric Cambisols from 1988-2000 pass the test as well as Dystric Cambisols, Ranker and distance to nearest highway from 2000-2007 for Kosovo. Kruskall-Wallis test values for the Ranker soil type were 0.05 and 0.07 for distance to nearest major road from 1988-2000; however, the author use them to GLMs analysis because the GLMs models performed better with ranker and distance to nearest major road and their statistical significance in the model. Demographic determinants are excluded because they do not pass the Kruskal-Wallis test.

Deforestation and forestation from 1988-2000 and from 2000-2007 have the same model fit results. The biophysical model is the final and selected model that explains deforestation and forestation in both periods in Albania. Political-institutional models are the final model for Kosovo in the first period and also biophysical model in the second period (Table 5.13).

Table 5.13 GLMs results of the cross-border study region

Albania	AICc	AUC	D^2, %	Albania	AICc	AUC	D^2, %
Deforestation 1988-2000, model				Forestation 1988-2000, model			
Biophysical	237.85	0.67	1.93	Biophysical	237.85	0.67	1.93
Demographic				Demographic			
Political-institutional	250.13	0.65	1.48	Political-institutional	250.13	0.65	1.48
Deforestation 2000-2007, model				Forestation 2000-2007, model			
Biophysical	219.34	0.74	5.13	Biophysical	219.34	0.74	5.13
Demographic				Demographic			
Political-institutional	232.02	0.69	0.16	Political-institutional	232.02	0.69	0.16
Kosovo				Kosovo			
Deforestation 1988-2000, model				Forestation 1988-2000, model			
Biophysical	338.60	0.74	4.8	Biophysical	338.60	0.74	4.8
Demographic				Demographic			
Political-institutional	320.55	0.74	10	Political-institutional	320.55	0.74	10
Deforestation 2000-2007, model				Forestation 2000-2007, model			
Biophysical	332.16	0.61	1.45	Biophysical	332.16	0.61	1.45
Demographic				Demographic			
Political-institutional	334.95	0.58	1.56	Political-institutional	334.95	0.58	1.56

Note: Model selection estimator: Corrected Akaike's Information Criterion (AICc), Deviance Explained (D^2), Area under curve (AUC)
Source: own calculation

The biophysical and political-institutional models perform better from 2000-2007 in Albania (i.e., higher AUC values) than in Kosovo in the second period; the biophysical and political-institutional model performs better in Kosovo than in Albania (higher values of AUC).

The selected biophysical model for deforestation and forestation 1988-2000 in Albania compromised two soil types of Humic Cambisol and Eutric Cambisol and two ecological zones of Pindus Mountains Mixed Forests and Dinaric Mountains Mixed Forests. Deforestation occurs more in forests that grow in Humic Cambisol and Eutric Cambisol soil types and Pindus Mountains Mixed Forests ecological zones but forest increases in Dinaric Mountains Mixed Forests. Deforestation occurs in higher elevation, Balkan Mixed forests and forestation occurs in Haplic Phaeozems soil type, Eutric Cambisol soil type and Pindus Mountains Mixed Forests, in the second period in Albania sub-region (Table 5.14).

Table 5.14 GLMs final models of deforestation and forestation

Albania	Deforestation			
	1988-2000		2000-2007	
Biophysical	Coefficients	p-value	Coefficients	p-value
Elevation			0.0013	0.011
Balkan Mixed Forests			0.0027	0.539
Haplic Phaeozems soil type			-0.0082	0.363
Humic Cambisol soil type	0.0024	0.671		
Eutric Cambisol soil type	0.0019	0.651	-0.0079	0.118
Pindus Mountains Mixed Forests	0.0035	0.396	-0.0025	0.589
Dinaric Mountains Mixed Forests	-0.0152	0.005		
Biophysical	Forestation			
Elevation			-0.0013	0.011
Balkan Mixed Forests			-0.0027	0.539
Haplic Phaeozems soil type			0.0082	0.363
Humic Cambisol soil type	-0.002415	0.67183		
Eutric Cambisol soil type	-0.001977	0.65154	0.0079	0.118
Pindus Mountains Mixed Forests	-0.003526	0.39628	0.0025	0.589
Dinaric Mountains Mixed Forests	0.015263	0.00586		
Kosovo	Deforestation			
Biophysical				
Elevation				
Ranker soil type			0.009	0.031
Dystric Cambisols soil type			-0.000007	0.998
Eutric Cambisols soil type				
Balkan Mixed Forests				
Political-institutional				
Distance to nearest major road	0.0001	0.033		
Distance to nearest protected areas	-0.00009	0.0005		
Distance to nearest forest edge 1988	-0.006	0.003		
Protected areas	0.002	0.813		
Distance to nearest UXOM	-0.0001	0.104	0.00005	0.0395
Distance to nearest highway				
Biophysical	Forestation			
Elevation				
Ranker soil type			-0.009	0.031
Dystric Cambisols soil type			0.000007	0.998
Eutric Cambisol soil type				
Balkan Mixed Forests				
Political-institutional				
Distance to nearest major road	-0.0001	0.033		
Distance to nearest protected areas	0.00009	0.0005		
Distance to nearest forest edge 1988	0.006	0.003		
Protected areas	-0.002	0.813		
Distance to nearest UXOM	0.0001	0.104		

Distance to nearest highway	-0.00005	0.0395

Note. Level of significance for p-values is <0.05
Source: own calculation

The final political-institutional model for the first period in Kosovo shows that deforestation occurs in larger-distance from roads and forest increases in larger-distance from protected areas, and from UXOM sites. Forests within existing protected areas are likely not protected in Kosovo in the first period. The biophysical model compromises of ranker and Dystric Cambisols soil type. Deforestation happens more in forests that grown in ranker soil and forest increases in Dystric Cambisols soil type. The political-institutional model shows that forests that are in larger-distance from highway tend to decrease in the second period in Kosovo (Table 5.14).

5.3.6.3 SIMILARITIES AND DIFFERENCES IN THE CROSS-BORDER STUDY REGION

There were more extended local patterns of deforestation in Albania (GWR results) in both periods than in Kosovo. Forestation dominated in Kosovo. Forestation was farther from human settlements in northern Albania and southern Kosovo from 1988-2000. Less forestation took place in higher elevation areas in Albania and more in Kosovo in the second period.

Deforestation occurs in large-distance from roads and highways, high elevation in the study region of Kosovo and Albania from the GLMs results. Deforestation and forestation takes place in forests that grow in different types of soil and ecological zones. Forests grown in Balkan Mixed Forests and Ranker were used more in the second period than in the first period in Kosovo. Forests abundant in Eutric Cambisols and Pindus Mountain forests were used from 1988-2000, and forests grown in higher elevations and in Balkan Mixed Forests were under pressure from 2000-2007 in Albania.

Local patters obtained by GWR showed that protected forests were likely under pressure. More deforestation was present in the north of Albania, which is a protected area, and in the south. Less forestation was present in the protected area in the south of Kosovo. For example, less forestation was in the proposed national park in the north of Kosovo, indicating that forests of the proposed protected areas could be under pressure. The findings of GLMs showed that more deforestation took place closer – distance from existing protected areas and their surroundings but for Kosovo.

Synergy between GLMs and GWR

The relationships of forest cover change and the distance to nearest UXOM of Kosovo and elevation obtained from the GLMs are better understood by local patterns obtained from GWR. Forests closer to UXOM are likely used in Kosovo in the first period, according to GLMs results (table 5.15).

5.3.7 DISCUSSION OF RESULTS OF GWR AND GLMs ALBANIA-KOSOVO CROSS-BORDER AREA

There is a tendency towards more deforestation in remote forests and nearer protected areas in the study cross-border region. Abundant forests grown in appropriate environment gradients such as soil, ecological zones and elevation remained attractive to people to extract woods. Biophysical model determinants explained the forest cover change processes of deforestation and forestation in the region. Forests that grew naturally and were more abundant in the Dinaric, Pindus and Balkan ecological zones, as well as in Cambisols and at higher elevations, were used more for industrial wood and firewood. Remote forests were of high quality rather than woodland, indicating more industrial wood cutting could occur in the region compared to firewood. Deforestation in high forests and in surrounding of existing protected areas showed that institutions were unable to control and monitor forest harvesting activities in buffer areas of protected areas and in areas that were remarkable for high quality forests and biodiversity and were proclaimed as proposed protected areas during the second period. It also shows the passivity of villages to forest protection in surrounding existing protected areas and inside of those proposed as protected areas. Villagers and users are likely active forest users rather than a protector, which illustrates that forests are under pressure despite their status of protected forest.

Villages across the cross-border line shared the same attribute from 1988-2000, namely, forests decrease potentially because of pre-war and war activities that took place in this part of the Kosovo and Albania (due to conflict in 1998-1999). This is the explanation of the forests used near the mined and bombed areas (i.e., UXOM) in Kosovo during the first period from the GLMs. GWR showed that villagers tend to go to use forests nearer UXOM in the second period because most of land including forests were cleaned from mines (International Campaign to Ban Landmines, 2011), and thus forests were safer to use.

Forests were more potentially in use in middle to high elevations from 1988-2000, and relatively not far from human settlements in average (village). Forests in higher elevation and relatively farther from human settlements were saved during this period. Topography could have been an important factor determining the forest cover change processes from 1988-2000. High elevation forests were likely in use from 2000-2007 obtained from the GLMs, which showed that accessibility could have played a greater role in forest use based on the GWR results. Forests were plausibly utilized as soon as they become profitable (including illegal logging, forest overgrazing or similar activities); people also still relied heavily on forests for fuel-wood and forest grazing, and they did so as soon as they have the possibility.

5.4 HABITAT SUITABILITY MODELING RESULTS

The spatial autocorrelation of dependent variables at the model grain of 1 km for all three carnivore species occurrences data is insignificant because the value of Moran' I is of |0.007|. Results of Kruskal-Wallis test are in Appendix Supplementary text A5.S2.

Models of combined permanent presence and temporal presences models showed accuracy of AUC > 0.90 for the lynx, of bear > 0.70 and wolf models < 0.70 (Table 5.15).

Table 5.15 Habitat suitability final models of logistic regression for lynx, brown bear and wolf distributions

Permanent - temporal presences	Specie	Model or sub-model	radii (km)	AICc	AUC	D^2, (%)	CV	Akaike Wi
2000	Lynx	Landscape: forest cover, terrain index, elevation	1	65.43	0.93	46.32	0.80	0.16
	Lynx	Natural: Elevation, distance to nearest forest edge, forest cover, beech pure and mixed with coniferous forests, mixed broadleaved class	1	66.7	0.94	47.92	0.82	0.10
	Brown Bear	Landscape: forest cover, terrain in-	20	223.49	0.75	12.84	0.71	0.23

		dex, elevation						
	Wolf	Landscape: forest cover, terrain index, elevation	20	469.93	0.67	4.93	0.64	0.54
2007	Lynx	Landscape: forest cover, terrain index, elevation	1	66.57	0.93	45.12	0.80	0.15
	Lynx	Natural: Elevation, distance to nearest forest edge, forest cover, beech pure and mixed with coniferous forests, mixed broadleaved class	1	66.99	0.94	47.43	0.79	0.16
	Brown Bear	Landscape: forest cover, terrain index, elevation	20	223.15	0.75	12.98	0.71	0.19
	Wolf	Landscape: forest cover, terrain index, elevation	20	469.10	0.67	5.1	0.61	0.55

Note: Model selection estimator: AICc,= Corrected Akaike's Information Criterion, Akaike Wi= Akaike weight, D^2=Deviance Explained, CV=cross validation, AUC=area under curve
Source: own calculation

Akaike weights scores for the best approximating models are above 0.05 for permanent or temporal presences for three species, indicating that the pseudo-absence of random selection does not significantly affect the model results.

Lynx models

The landscape models are final ones for combined permanent and temporal occurrences in year 2000 and 2007. These models have the lowest values of AICc. These selected models use a radii of 1 km (range is the area of a circle (3.14) times the radius squared (1 km) resulting to an area of 3.14 km^2 for the lynx). These models predict that the lynx prefers denser forests in elevated landscape (equations 20, 21).

Equations for two final models of lynx are as follows:

$$\text{logit}\left(\text{PR } 2000\right) = -3.94 + 0.0033\ x\ elev. + 0.0332\ x\ forest\ \text{cov}.2000 - 0.1004\ x\ index\ terrain \quad (20)$$

$$\text{logit}\left(\text{PR } 2007\right) = -3.98 + 0.0034\ x\ elev. + 0.0314\ x\ forest\ \text{cov}.2007 - 0.0988\ x\ index\ terrain \quad (21)$$

The natural model is the second best models for the lynx in 2000 and 2007 (the AICc difference is of < 1). These models predict that lynx preferred denser forests in higher elevations, rich of beech forests type and less broadleaved mixed forests (Table A5.3).

Brown bear models

The final models for the combined permanent and temporal occurrences of brown bear are selected from the 'landscape' hypotheses for the years 2000 and 2007. These landscape models are the same for two time periods. They predict that brown bear prefers higher elevations, forested areas and more rugged landscape (equations 22 and 23) (Table 5.15).

$$\text{logit}\left(\text{PR}\ 2000\right) = -4.18 + 0.0015\ x\ elev. + 0.0032\ x\ forest\ \text{cov}.2000 + 0.1004\ x\ index\ terrain \quad (22)$$

$$\text{logit}\left(\text{PR}\ 2007\right) = -4.20 + 0.0015\ x\ elev. + 0.0043\ x\ forest\ \text{cov}.2007 + 0.0988\ x\ index\ terrain \quad (23)$$

The natural models of brown bear predict that brown bear selects suitable habitats consisting of beech forests and rocky areas (Table A5.3) at a radii of 20 km (Table 5.15). The high suitable habitats of final landscape models for bear are 32 % of total land area of Albania in 2000 and 2007 and 15 % (of 32 %) are within protected areas in 2000.

Wolf models

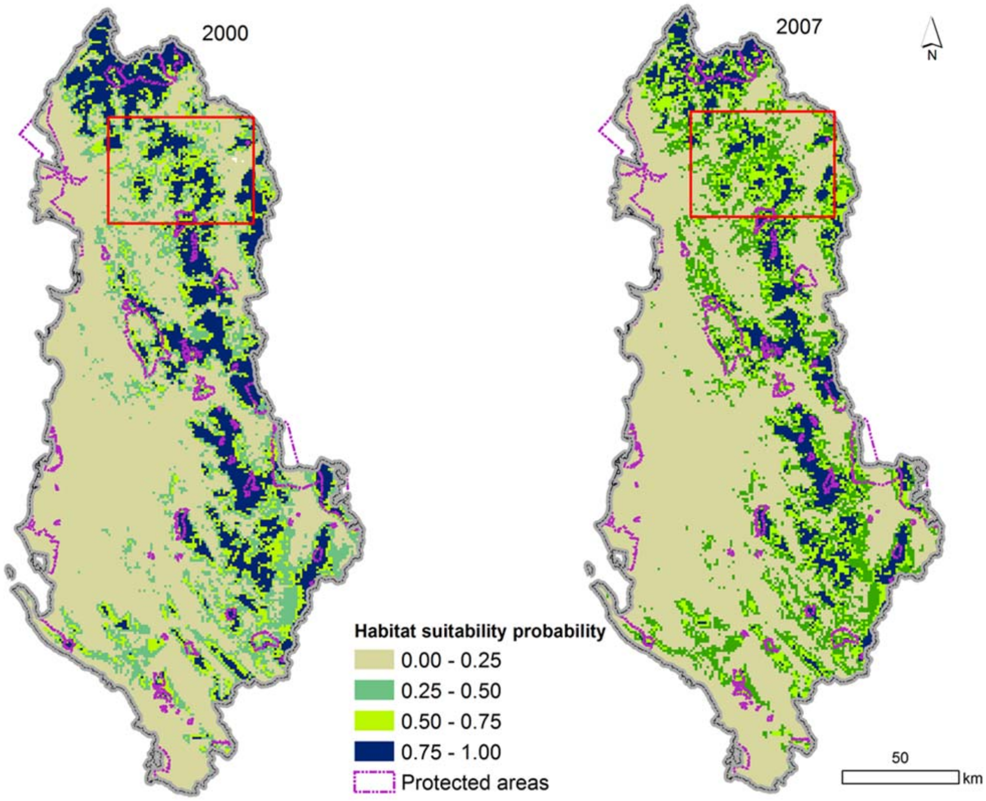
The final model for the permanent and temporal occurrences of wolf performs poorly (AUC < 0.7). Wolf occupies permanently in areas that are at higher elevation, more forested and rugged at radii of 20 km (Table 5.15).

5.4.1 HABITAT SUITABILITY MAPPING AND FRAGMENTATION OF SPECIE HABITATS

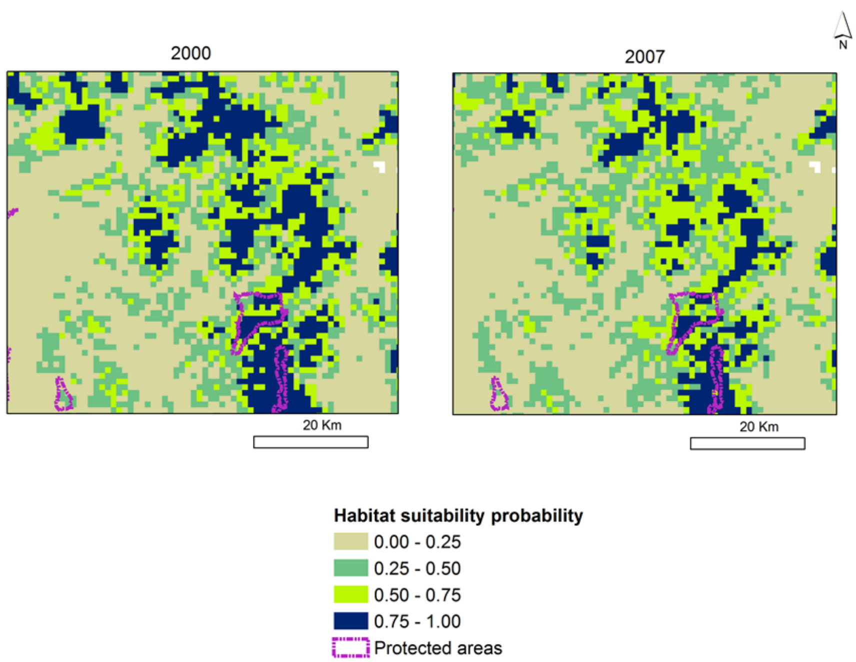
The selected landscape models of lynx and brown bear in 2000, 2007 are mapped out for the entire Albania to obtain the predicted probability of suitable habitats (*P*) by applying a cut-off predicted suitability score at $P >= 0.5$. Thus cut-off enables us to distinguish suitable habitats ($P > 0.50$) from lower quality habitat ($P < 0.50$) (Naves et al., 2003).

Figure 5.9 Predicted habitat suitability for lynx and brown bear

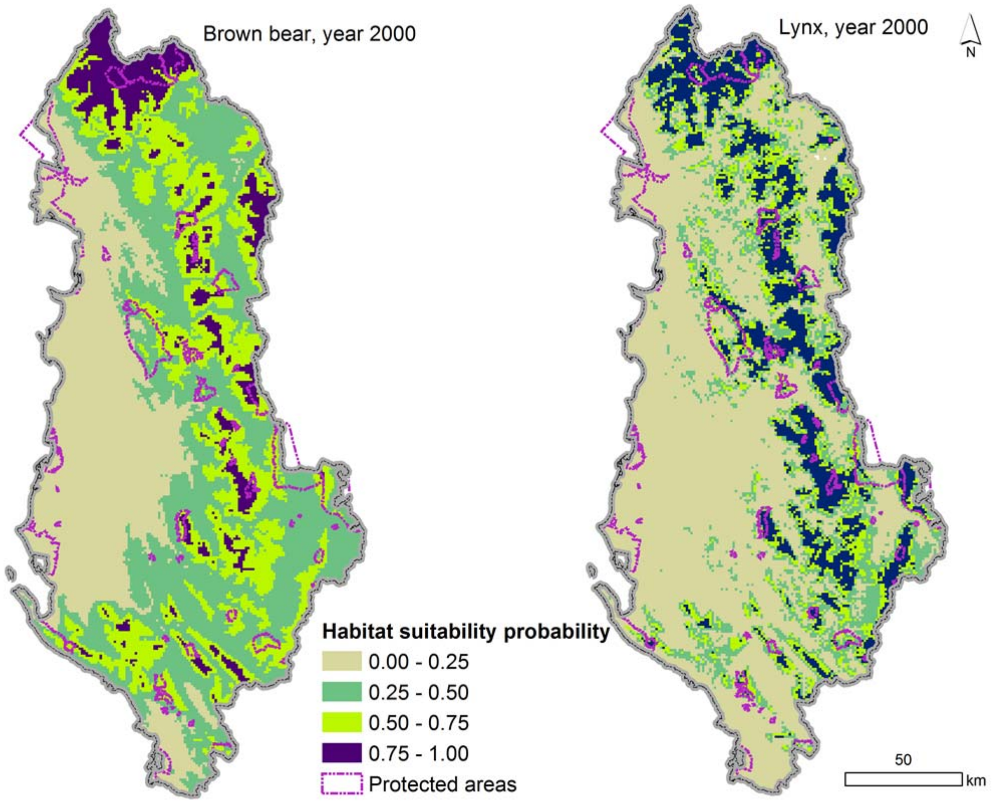
A) Lynx



B) Change of lynx habitat suitability between 2000 and 2007



C) Brown bear



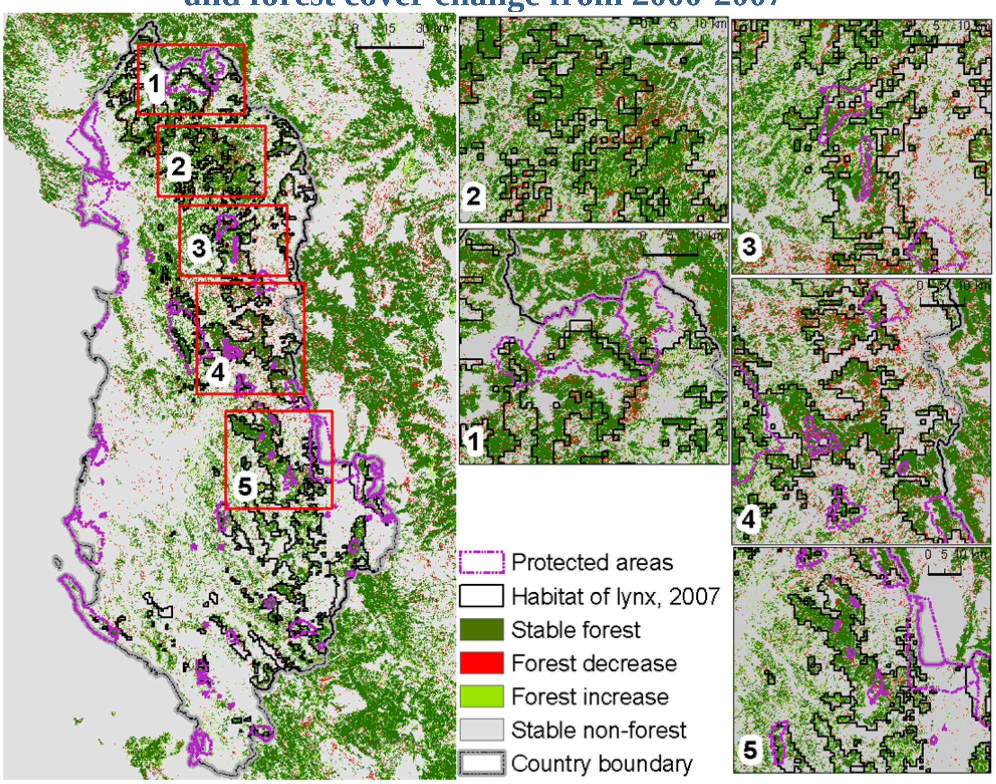
Note: Predicted habitat suitability for lynx are landscape model 2000 and 2007 (A), zoom-in for the red boxes of (A) is (B), predicted maps for brown bear are landscape model 2000 and 2007 in (C).
Source: own calculation

Suitable habitat tends to occur in forested areas and in high elevation, while low quality habitat is concentrated in low land and non-forested land. Suitable habitat patches are fragmented for the lynx and brown bear and divided by areas of lower quality habitat. Protected areas and elevated landscape outside of protected areas provide large tracts of suitable habitat for the lynx and brown bear (Figure 5.9A, C), indicating protected areas are in high probability of habitat suitability areas for lynx and bear, but they cover small areas of these identified habitats for both species. The high probability patches in northern and central, central and southeastern Albania also decreased in 2007. The high suitable habitats of final landscape models for lynx is 27 % of total land area of Albania in 2000 that decreased to 22 % in 2007 (Figure 5.9B).

Fragmentation of lynx habitat

The selected landscape model is composed of elevation, forest cover and terrain index. Elevation and terrain index do not change over time, forest cover does. The habitat of lynx in 2007 shrank mostly in, extreme north, the north-central (Figure 5.9B), where forest cover has reduced from 2000 to 2007. Figure 5.10 shows the loss of forest from 2000 to 2007 and the habitat suitability (*P* >=0.50) of the final land-scape model for lynx in 2007. Forest cover has a positive relationship with lynx occurrences and is statistically significant (p-value < 0.05) showing that lynx occurrences in forest loss areas has potentially decreased from 2000 to 2007 (Figure 5.9A), and therefore, the habitat of lynx has shrunken from 2000 to 2007 in Albania. Deforestation is observed within habitat area of lynx indicated by zoomed maps of 1, 2, 3, 4 and 5 of Fig.5.10. Northern and eastern Albania has experienced deforestation from 2000 to 2007 and is not protected. Small parts of habitat shown in maps 1, 3, 4 and 5 are protected in cross-border with Montenegro and the FYR of Macedonia. Habitat of lynx is inside and close to stable forest, thus, lynx relies very much on stable and non-disturbed forests. Small area of stable forests and habitat of lynx is protected in Albania (Figure 5.10).

Figure 5.10 Predicted suitable habitats for lynx 2007, protected areas and forest cover change from 2000-2007



Note: Forest data are received by Suess (2010) and aggregated at 1x1 km study unit, protected areas are provided by the Institute for Nature Conservation Albania.
Source: own calculation

The high probability of habitat is divided by lower probability of habitat in the north-central area, the southeast and south into smaller habitat areas, indicated by Figure 5.10. The habitat in the north-central (2 and 3) area is divided from the north (1) and southeast (4 and 5), and the habitat patches in the southeast are divided from those in the south. If the habitat patches get smaller, then the north and southeast habitats will likely no longer be connected with each other. The southeastern habitats are across the border with Macedonia, where the highest populations of lynx live, so there is a high interest in their protection to ensure the connection with habitats of the FYR of Macedonia. There is an evident division in the southeast. The habitats exist in the south (surrounding areas of 5), but these habitats are much smaller and more divided and closer to a low probability of the suitable habitat areas. The habitats of southern and extreme southern of Albania are well-divided from those southeastern, eastern and northern of Albania Figure 5.10.

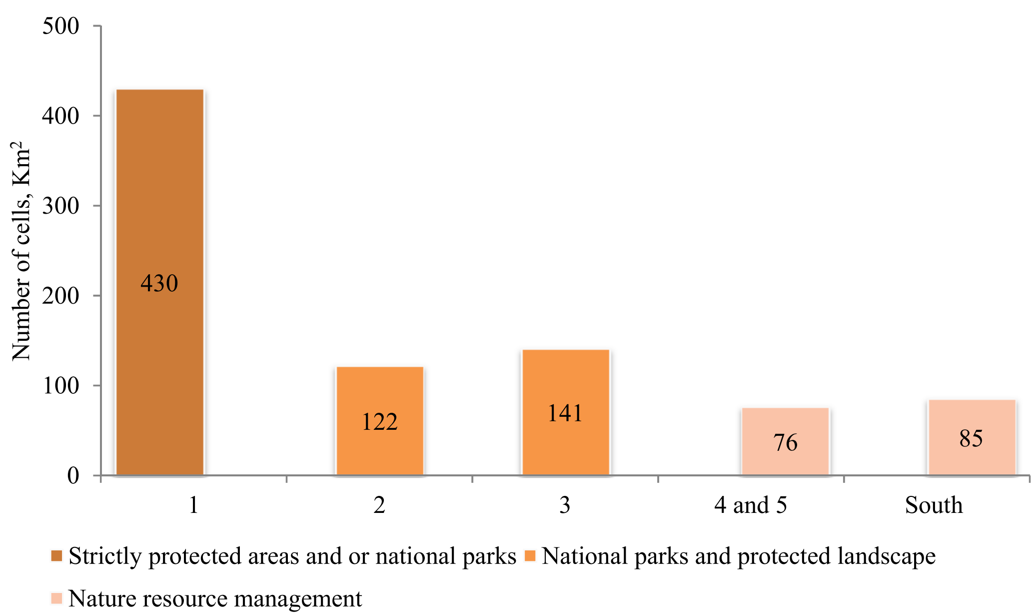
The size of suitable habitat patches matters very much because it ensures the connectivity between patches. If a patch becomes smaller in size, this patch will be further divided and the habitats will be divided into even smaller habitats until they disappear, or will no longer be suitable for the species. A very small patch cannot ensure enough space for species to searching for food, for refuge, breeding for the lynx and brown bear. Therefore, lynx and brown bear could not sustain themselves and therefore might disappear. The divisions of suitable habitat patches in the extreme north, north-central area and the southeast are likely very critical for lynx (and brown bear) to live in-situ in Albania.

5.4.2 CORE AREAS FOR BIODIVERSITY CONSERVATION IN ALBANIA

The permanent and temporal high probability of lynx habitat suitability in 2000 is intersected with protected areas to calculate the percentage of high suitable habitat within the existing protected areas. In total, 18 % of the high habitat suitability (grid) cells of lynx habitat suitability in are within protected areas. The number of cells of estimated habitats ($P > 0.50$) is calculated within the boundaries of protected areas: 1- national parks and nature resource management, 2- strictly protected areas and national parks 3- strictly protected areas, and 4- landscape protected areas and managed resource protected area. National parks and habitat resource management have 15 %, strictly protected areas and national parks have 12 %, strictly protected areas have 2.9 %, protected landscape and managed resource (low protection areas) have 3 % of lynx habitat suitability cells (1 cell has an area of 1 km^2).

Compared to total number of cells of Albania, approximately 4 % of lynx habitat suitability is in high protection areas (strictly protected areas and national parks) and 0.8 % is in strictly protected areas. These figures indicate that estimated habitats are well placed for lynx conservation. The area of the largest patches of the lynx habitat are compared to the carrying capacity of approximately 4-6 km^2 that a Eurasian lynx female needs (Fernández et al., 2006). Largest patches are in the extreme north in the cross-border with Montenegro (zoom-in box one of Figure 5.10), the east-central area (zoom-in box two of Figure 5.10), east in the cross-border area with Macedonia (zoom-in box four of Figure 5.10), the southeast, the south-central area and extreme southern patches on the border with Greece (Figure 5.10). The patch in the north has the largest size by (grid) cell number, and then it decreases in the south and southeast. The patch size (in grid cells number) is from 430 to 37 km^2 with a carrying capacity from 70 to 6 lynx females (Figure 5.11).

Figure 5.11 Size and carrying capacity of patches in protection



Note: Numbers 1, 2, 3, 4, and 5 refer to the zoom-boxes of Figure 5.10
Source: own calculation

The second-largest patches are in the central-eastern area and the eastern cross-border region with Macedonia. These patches are divided into smaller patches, not entirely protected and are not at the same level of protection. The southern (Fig. 5.11) and extreme southeastern patches are the smallest in size and the level of protection is lower (Appendix Figure A5.6). The scale of protection decreases from the strictly protected areas to protected landscape and managed resource. Based on the classification of protected areas from International Union for Nature Conservation (IUCN), strictly protected areas, national parks provide a high protection, nature resource management provide a medium scale protection, protected landscape and managed resource provide a low protection of suitable habitat of lynx and bear (see also Appendix Figure A5.6).

Delineating conservation areas for lynx and bear

Lynx and bear are the surrogate specie for wolf and other large carnivores in Albania. The spatially explicit analysis shows a large part of suitable habitat of lynx and bear is not protected and it is under a high threat of habitat fragmentation if forest loss and landscape degradation continues. Forest cover and landscape have a positive relationship and are statistically significant for the lynx, therefore the observed forest loss inside the habitat of lynx causes the loss of habitat (for lynx). Habitat of lynx has lost from 2000 to 2007 despite an overall increase of forest observed in Albania. Deforestation was observed in the north and north central of Albania (Figure 5.10) and forest loss has occurred inside strictly protected areas. The analysis of GWR explained that users access forest in the extreme north, north central of Albania, by utilizing these forests for fuel-wood and industrial wood putting pressure on forests (specifically, in northern Albania and the northern cross-border study region of Albania). The habitat suitability areas in northern and north-central of Albania reduced from 2000 to 2007, showing that forest loss has contributed to the habitat loss of lynx from 2000 to 2007. The findings of the current work show that forest use by people is not sustainably managed, because there is a loss of lynx habitat. The high probability of suitable habitats both inside and out of protected areas is jeopardized by forests and landscape degradation activities. Forest and environmental protection institutions should redesign and expand protected areas for lynx and bear in suitable habitat in central, east and cross-border with Macedonia, and in south and southeast. Otherwise, habitats of lynx and bear are likely at high risk of further fragmentation, if protected areas do not ensure adequate size and real forest biodiversity protection.

Forest cover changes, particularly, the loss of forests in high elevations and beech forests that define large carnivore existence, render suitable habitats smaller and divided. The division of habitats may lead to the extinction of lynx in Albania and decreasing its population in the Southeastern Europe. Political-institutional models were final models of GWR, which explained the forest increase and loss (disturbed forests) in Albania. The lynx and brown bear stay away from disturbed forests (e.g., logging), indicating that forests should be well-managed and well-protected by new (post-socialism) institutions of forest management and environmental protection in Albania to ensure biodiversity conservation as required by the United Nations Biodiversity Convention. Forest and environmental policies (designed and implemented by forest management and environmental protection) must be adequate by design and implementation (e.g., protected area planning, forests and biodiversity protection and conservation strategies, forest policies). This work shows that a considerable proportion of the protected areas are also identified as higher quality habitat for the lynx and brown bear indicating these areas are well-located for the conservation of lynx and brown bear. The priority of institutions should be the protection of forests and biodiversity protection, because a loss of forests implies the loss of native forests (e.g., beech forests), the reduction of forest resources, loss of habitat of lynx and bear and also the reduction of forest biodiversity service supply in Albania.

5.4.3 DISCUSSION OF HABITAT SUITABILITY ANALYSIS

The modeling of habitat suitability was based on previous work on large-scale carnivores, biological knowledge and specie monitoring works in the study area. Forest cover underwent massive changes from the socialism to post-socialism periods (Suess, 2010) affecting potentially the distribution of these carnivore species in Albania. Obtaining knowledge on distribution of large carnivores is an important step forward to design conservation plans in countries that experienced massive political and socioeconomic changes (Radeloff et al., 2013) as the case of the collapse of socialism in Albania. This study shows that protected areas should ensure enough space for these species, because habitat selection of a species in a human-altered landscape may occur at large spatial scales than expected because of the influence of anthropogenic fragmentation of the landscape (Fisher, 2010). There were different thoughts from domestic experts about three specie habitats (see CATS, 2011). Accordingly, it was believed that only the lynx habitat was fragmented. The present work showed that lynx and bear habitats were fragmented and habitat fragmentation could be an issue for wolf (lynx and bear were surrogate for wolf in this study). Lynx preferred higher elevations and denser forests, while brown bear and wolf higher elevations and more rugged areas. Our study revealed that all three carnivore species currently selected their habitats at different spatial scales highlighting the importance of forested landscape. The extent of the species habitat may be changed depending on the severity of the human activities and interspecific interaction may affect the distribution pattern of the species within this habitat extent in the landscape (Fisher, 2010).

Scale effects in different time periods

This study showed clearly the effects of scale on the habitat selection of lynx, bear and wolf in different time periods. Assessment of critical spatial scales for habitat selection is an important, albeit often overlooked, issue in studies of statistical habitat modeling (see Schadt et al., 2002). For example, one would expect that territorial species select areas at which their requirements are matched at the spatial scale of their home range (e.g. Schadt et al. 2002; Kanagaraj et al. 2011). Models based on permanent and temporal occurrences showed better performance for lynx and bear at a 3.1 and 1,256 km^2 neighborhood, whereas models of wolf better performed from 706.5 to 1,256 km^2 neighborhood. Models of landscape of lynx showed that lynx moved to search for suitable habitats within a territory of approximately 3 km^2. In addition to these estimations, the best two models with only real permanent presences (not temporal presences included in this case) and pseudo-absence data showed that lynx moved within a territory of range from 3 km^2 to 300 km^2 in 2007. The ‘natural’ hypothesis was the combination of ‘landscape’ and ‘refuge and food’ hypothesis, the decrease in forest cover and scarcity of food by human disturbance might be the reason for the increase in area of habitat selection by lynx from 2000 to 2007. This indicated that lynx could permanently occupy a larger space from approximately from 3 to 300 km^2 for food, refuge and breeding than indicated by previous studies. Truly, bear required a larger space from 706.5 km^2 to 1,256 km^2 to search for food, refuge and for suitable breeding habitats.

The size of patches and their locations was identified and compared with the carry capacity to maintain potentially large populations of female lynx in Albania. The largest habitat patches in protection were in the north, not in the cross-border region with Macedonia, where the existing largest population of lynx was observed (CATS, 2011). Protected areas in the cross-border area with Macedonia were very small and for that reason protected areas should be increased in size. The protected areas in the cross-border with the FYR of Macedonia had a carry capacity of 13-24 lynx females. Despite forest increased from 2000 until 2007 in these patches, they were not likely to be occupied permanently by lynx because of the existing fragmentation of patches.

Some habitat patches were identified in cross-border with Montenegro, Greece and Kosovo. A fruitful potential study could be the identification of the lynx habitat suitability in Albania and its neighborhood countries to look at the connectivity of patches for the entire lynx habitat.

These findings helped to understand that forests and landscape integrity defined the presences of large carnivores in Albania. The carrying capacity of protected areas and the connection of forest landscape patches remained crucial for species. It was identified high habitat suitability lynx and bear existing in the south, because forests and landscape could ensure suitable areas for specie to live there, but these habitats were fragmented even more than in the north requiring more restoration environmental measurements than in northern Albania. This study helped recommend on where to expand protected areas to strengthen the protection and conservation measurements of multiple species within protected and surrounding areas. This has implications for countries that need to expand, re-design protected areas for the species protection. The cross-border areas with the FYR of Macedonia are particularly important for species since they present a high probability of suitable habitats and the largest population was in this area, but was not well-protected. Therefore, the expansion of protected areas would allow more space for specie to move without disturbance to meet their requirements for food, refuge and breeding (the decision of the Convention on Biological Diversity (CBD) in 2010, for the increase of protection area to 17 % of terrestrial ecosystems, should be achieved by all governments by 2020). Albanian patches could ensure the connectivity of patches of suitable habitats from Montenegro to the FYR of Macedonia and further to Greece and this helped increase the importance of efforts of Albania to better protect lynx. The carrying capacity of protected areas should be increased in association with forest conservation, large carnivore population monitoring, and controlling of human activities such as lynx's prey hunting, poaching of large-carnivores.

6. Conclusions

This chapter begins with the contribution and the principal findings of the current work in the context of methodological approaches, previous work on land use change and forests in Albania, forest biodiversity, future studies and policy recommendations.

6.1 CONTRIBUTION OF THE CURRENT STUDY

This study examined forest cover change in two post-socialist countries of Southeastern Europe for two periods, from 1988 to 2000 and from 2000 to 2007. It was the first country-wide study for Albania and Kosovo that investigated the influence and the spatial variation of the determinants of forest cover change at the village level by applying GWR. The statistical modeling allowed both to draw comparisons across the two countries and over time. The results demonstrated the substantial differences in the patterns of determinants of forest cover change for distinct areas in both countries.

Three models of biophysical, political-institutional and demographic determinants, respectively, were estimated and the most parsimonious model was selected for the interpretation of the results. The variable selection in all models was based on the previous work on land use change, forestry in Albania and data availability. The decision criterion for the most parsimonious model was the corrected Akaike's Information Criterion. GWR was used to estimate patterns and processes and therefore to reveal the information at the local level for the relationships of forest cover change and its determinants. GWR allowed the calculation of the decomposition of local variation of the relationships, which defined the importance of the influence of local coefficients of determinants obtained by GWR to the response variable. GLS further allowed calculating the spatial relationships of observations and hence to investigate the variance structure function of relationships between determinants and forest cover change. The calculations of the variance of local coefficients and of the spatial relationship of observations are two steps that were frequently neglected in other studies.

The robustness of results was checked by using the cost distance variables and cross-border area dataset. The cross-border study region analysis helped also to identify patterns and processes at smaller (i.e., region scale) of the forest cover change. GWR application for forest cover change helped to calibrate the modeling of suitability habitat of lynx, brown bear and wolf. The focus was on the effects of forest cover and forest cover change variables on the distribution of three predators (i.e., lynx, brown bear and wolf). The methodological approach used in the current study could be replicated for the analysis of forests, grassland as well as other nature resources and species worldwide.

6.2 PRINCIPAL FINDINGS

The classification of forest cover from satellite images showed a decrease of forest cover in the first period and increase in the second period. Forests increased in Albania from 2000 to 2007 by 38,000 ha. Patterns of large deforested area were widespread in northern Albania and in northern and southwestern Kosovo in the first period and patterns of forest increase were concentrated in west and northeastern Albania, as well as in center and southern Kosovo. In the second period, the largest patterns of forest increase were detected in southern Albania and southwestern and northeastern Kosovo while forest decrease was concentrated in northeastern Albania and northern and center of Kosovo.

The political-institutional model was selected for the interpretation of the determinants of forest cover change in both countries and both periods. A hierarchy of determinants was set up based on the results of variance of GWR coefficients of determinants. The most influential determinants of forest cover change were, in descending order, the distance to nearest human settlement, road density, distance to nearest UXOM and accessibility to forest from the beginning of the period. The distance to nearest human settlements negatively affected forest cover, but this influence showed strong variations from north to south of the study area. Specifically, forests tended to decrease closer to human settlements and roads in the first period and forest cover increased closer to human settlements in the second period. Forests tended to decrease further away from human settlement and roads in the second period. Negative influence of the distance to human settlements dominated in northern Albania and in northern and southern Kosovo in the second period.

The principal finding of the current work is that the better accessibility of old-growth forests likely spurred a larger extraction of wood for firewood, export, construction, and for the production of charcoal. Forest cover was statistically significant and positively correlated with the predicted habitat of lynx, brown bear and wolf. The predicted habitat of lynx was fragmented and decreased by 5 % in Albania, which was attributed to the loss of forests that happened from 2000 to 2007 in areas that were occupied by lynx for refuge, food and breeding.

6.3 IMPLICATIONS OF THE FINDINGS

According to the previous work on land-use in Albania, deforestation was also connected to the fuel-wood extraction (see Müller and Sikor, 2006) and forest resource extraction was an important activity of villagers in the study conducted in Albania (Stahl, 2007) as well as illegal logging in forest villages (Stahl, 2012). As a result, I conclude that forest clearing in Albania was mainly driven by subsistence necessities around populated areas in the years after the collapse of socialism, while more commercial clearing patterns dominated in later stages of the post-socialist period, indicated by the changing influences of the determinants of accessibility (cf. Müller and Munroe, 2008).

The descriptive analysis of forest cover change showed a decrease of forests inside of protected areas, specifically, inside the strict protected areas in Albania and proposed national park of Kosovo as well as merely no change of forests in existing national parks in both countries. Deforestation tended to occur closer to protected areas i.e., in the surroundings of protected areas (from GWR results), where buffer zones of a protected areas could be normally allocated as well as inside the existing protected areas in Kosovo in the first period (from GLMs results). Similar results were found in case of Ukraine and Romania. For example, in Romania the high logging rates were likely trigged by rapid changes in institutions and ownership that resulted in forest decrease inside protected areas, which in turn consecutively caused an increasing fragmentation of forest cover in protected areas (Knorn et al., 2012).

The descriptive analysis showed a slight increase of forest cover in 364 commune forests. Forest cover change in the first period was negative (-3,013 ha) and positive in the second period (5,350 ha) within commune managed forests, which may point to an overall successful forestry reforms. It may also indicate that forest cover changes in Albania were driven by the state forest policy pathway that was identified by Lambin and Meyfroidt (2010).

GWR and descriptive analysis of forest data showed that forests mainly increased in lower elevation, closer to roads and human settlement from 2000 to 2007. The expansion of secondary forests in Albania likely led to improved provision of a climate regulation forest ecosystem services i.e., to the increases in carbon sequestration and carbon storage, specifically, in southern Albania and central Kosovo. The expansion of forests was seen as a good opportunity for carbon sequestration in Ukraine (Kuemmerle et al., 2011) and Romania (Olofsson et al., 2011). Furthermore, the expansion of secondary forests in Albania and Kosovo in the second period was likely spontaneous and natural regeneration of forests in Albanian commune forests. The spontaneous re-growth of the forests could happen on former abandoned agricultural lands and not accompanied by forest management interventions to improve the quality of forests. Natural regeneration through forest management interventions when encountered in commune forests in Albania can improve the quality of forests (Lambin and Meyfroidt, 2010).

On the other hand, the observed deforestation in northern Albania and the northern and southern Kosovo could threaten the provision of forest ecosystem services and jeopardized biodiversity and climate change policies.

6.4 OUTLOOK OF RESEARCH, FUTURE STUDIES AND POLICY RECOMMENDATION

The current work highlighted the need to carefully investigate the local variations before making a decision on the methods of analysis, because the spatial heterogeneity in relationships contributed to scale-dependency in the results. Such spatial nonstationarity in relationships was likely a common characteristic and impacted any study that made use of spatial data (Foody, 2004). The GWR applications were valuable in this respect because they (GWR application) visually revealed the spatial heterogeneity in the relationships. This is particular important for studies that investigated changes in land use patterns.

Future research may focus on: 1- studying local patterns in hotspots of rapid forest cover change more in depth with the help of primary data collections on other land use changes including agriculture land and on local socioeconomic characteristics, 2- the land use planning and protected area management with examinations that focus on socioeconomic and institutional drivers of land use change (without excluding bio-physical determinants), 3- obtaining longer-term forest cover change data with a higher temporal resolution to map the patterns and drivers of the forest transition 4- how habitats of endemic lynx changed over time and space since the socialism until today in four countries namely, Albania, the FYR of Macedonia, Kosovo and Montenegro, because the analysis of habitat suitability proved crucial for how forests were used in Albania, since the beginning of socialism time until today.

Information on processes and patterns of forest cover change provided by this research support policy and decision makers concerned with the management of forest and biodiversity resources. The results from the satellite images analysis showed a decrease of forest in the first period caused by the wood extraction for firewood and industrial wood close to roads and populated areas. In the second period, forest loss concentrated in higher elevation and remote areas and within the habitat suitability of sub-endemic specie of lynx. The loss of forest cover immediately after the collapse of socialism, inside of protected areas (caused by illegal activities) and their surroundings as well as the loss of habitat of lynx in the second period were caused by the wood extraction and weak monitoring of wood harvesting activities in forests accessed by users (from human settlements) contributed to the loss of forest cover.

Despite the forestation trend in the second period, deforestation was present. Local people and users utilize forests for firewood depending on the abundance and accessibility to forests and socioeconomic characteristics of villages (e.g., the firewood demand and the presence of poverty in the village). Adequate heating and living alternatives should be available to rural people by the government, rather than "*laisser-faire*" attitude that governmental institutions show towards forest use by villagers. Payment towards forest biodiversity protection may be introduced as finance scheme to villagers so that forest and biodiversity is well-protected. Protected area planning should consider in-depth socioeconomic analysis of villages and wood collection for firewood, within and outside of surrounding zones as well as the enforcement of forest and environmental protection law and well-monitoring of forest cutting activities. Moreover, the acknowledgement of forest resource, climate regulation and forest biodiversity services should be based on local people who encourage forest protection. Forest management and biodiversity policies are recommended to be better integrated to ensure real support to villagers that are active in protecting forests in their villages and surroundings and a proper governance of forests.

Summary

Forests are important resources for local livelihoods and the economy. Forests regulate climate by sequestrating and storing carbon and harbor significant biodiversity. Yet, forest integrity is threatened in a number of countries as a result of growing populations, increasing prices for forest products, and the expansion of agricultural land. Forest cover can also be significantly affected by changes in institutional and political framework conditions such as induced by the collapse of socialism in Eastern Europe and the war in Kosovo.

This study analyzed the determinants of changes in forest cover for two periods between 1988 and 2007 for Albania and Kosovo. Studying forest cover changes in Albania and Kosovo was interesting from several perspectives. First, both countries experienced major political, institutional, and economic disruptions. In the 1990s, Albania made a rapid transition to the free market, which led to considerable emigration movements, while Kosovo experienced political stagnation until the 1998-1999 Kosovo war. Second, recent advances of the availability of data of satellite imagery and improvements in analytical approaches and computational power allowed analyzing both countries from wall to wall and at high spatial resolution.

Forests made up approximately 27 % of the total land area in Albania, and 40 % of the land area in Kosovo in 2007. Forests were intensively used by local people in Albania and Kosovo for fuel, construction, and timber exports. Since the collapse of socialism, forests have experienced widespread degradation and clear cutting particularly in Albania, but also significant reforestation, mainly on former agricultural land that was abandoned as a result of the collapse of socialism and of the war in Kosovo. Moreover, initiatives for forest protection and the devolution of forest management and ownership rights from the central to local governments and villages may have spurred reforestation in Albania.

Biophysical, demographic and political-institutional determinants of forest cover change were selected based on extensive literature review on land use change, literature review on forests of Albania and the knowledge that the author obtained during the work experience in forestry in Albania and in Kosovo. Data on topography, population, soil types, ecological zones, protected areas, commune forests, road network, human settlement data were selected and aggregated at village level using GIS software. The method used in this thesis included Geographically Weighted Regression (GWR) that served to identify the local pattern and processes of forest cover change. The results from the GWR analysis were compared with those of the method of Ordinary Least Squares (OLS). Generalized Least Squares (GLS) allowed to investigate the non-linearity of village relationships and the Generalized Linear Models (GLMs) were used to explain deforestation and forestation in Albania and Kosovo cross-border study region as well as to predict the habitat suitability for lynx, brown bear and wolf in Albania. The variance of local coefficients between forest cover change and determinants (of the model) was calculated and Monte Carlo tests permitted identifying statistically significant determinants that displayed significant local variation in their relationship with forest cover change.

GWR models performed consistently better than OLS. Political and institutional determinants explained most of the changes of observed forest cover. Deforestation was higher closer to roads and populated areas in the first period, which was probably caused by a higher rate of wood extraction. Pressures on forest from subsistence extraction of wood decreased in the second period when deforestation was observed in larger distance from roads and populated areas. The determinant of distance to nearest human settlement showed high local variations in their relationships with forest cover change. A strong negative influence was particularly evident in the northern and northeastern regions in Albania and the northern and southern in Kosovo in the second period. Habitat suitability of lynx and bear were similar in 2000 and 2007, but considerably fragmented. By means of a landscape model, natural conditions determined the presence of lynx and bear. Results showed that the predicted habitat extension of lynx shrunk by 5 % between 2000 and 2007 due to the reduction of the forest cover.

The presented research was unique in that it analyzed the patterns and processes of the determinants of forest cover change relationships at fine spatial scales for two countries. This research, hence, contributed important country-evidence to the literature on the patterns and processes of the post-socialist forest cover change, and provided policy recommendations for forest, protected areas for both countries and for biodiversity management in Albania.

Zusammenfassung

Wälder sind eine wichtige Ressource für die Lebensbedingungen und die Wirtschaft in einer Region. Darüber hinaus regulieren sie durch Aufnahme und Speicherung von Kohlenstoff das Klima und beherbergen eine große Artenvielfalt. Jedoch ist in vielen Ländern die Unversehrtheit der Wälder bedroht. Gründe hierfür sind zum Beispiel Bevölkerungswachstum, ein Preisanstieg für Forsterzeugnisse und die Ausweitung von landwirtschaftlich genutzten Flächen. Das Ausmaß der Waldbedeckung kann außerdem in hohem Maße von institutionellen und politischen Rahmenbedingungen beeinflusst werden, wie etwa dem Ende des Sozialismus in Osteuropa oder dem Kosovokrieg.

In dieser Studie werden Determinanten für die Veränderung der Waldbedeckung in Albanien und dem Kosovo für zwei Zeiträume zwischen 1988 und 2007 untersucht. Eine Untersuchung der Veränderung der Waldbedeckung in Albanien und dem Kosovo ist unter verschiedensten Gesichtspunkten interessant. Zum einen kam es in beiden Staaten zu politischen, institutionellen und wirtschaftlichen Umbrüchen. - Albanien wandelte sich in den 1990er Jahren rasant in eine freie Marktwirtschaft um, was einschneidende Auswanderungswellen zur Folge hatte, während sich der Kosovo, bis zum Ausbruch des Kosovokriegs in den Jahren 1998-1999, in einer Phase politischen Stillstands befand. Zum anderen erlauben der Fortschritt in der Verfügbarkeit von Satellitenbilddaten sowie die Verbesserung von analytischen Herangehensweisen und rechnerischer Leistungskraft eine flächendeckende Untersuchung beider Länder mit hoher räumlicher Auflösung.

In Albanien machten Wälder im Jahr 2007 ca. 27 % der Gesamtfläche aus, im Kosovo waren es 40 %. In beiden Ländern werden Wälder und Forstprodukte von den Einheimischen vorrangig als Brennstoff, für den Bau und für Holzexporte genutzt. Seit Ende des Sozialismus kam es vor allem in Albanien zu einem Rückgang im Waldbestand. Andererseits lässt sich aber - wie es schon frühere Studien zu den Wäldern Albaniens gezeigt haben - auch eine signifikante Wiederbewaldung beobachten, vor allem dort, wo zuvor landwirtschaftlich genutztes Land als Folge des Zusammenbruchs des Sozialismus und des Kosovo-Kriegs aufgegeben wurde. Zudem scheinen Waldschutzinitiativen und die Dezentralisierung des Forstmanagements und der

Eigentumsrechte von der nationalen auf die kommunale Verwaltungsebene, sowie die Initiative der Dorfgemeinschaften die Wiederbewaldung in Albanien begünstigt zu haben.
Nach intensiver Literaturrecherche zu Veränderungen der Bodennutzung und zu früheren Untersuchungen zu Wäldern in Albanien, sowie basierend auf dem Wissen, das sich die Autorin während ihrer Arbeitspraxis im Forstwesen in Albanien und im Kosovo angeeignet hat, wurden biophysikalische, demographische und politisch-institutionelle Determinanten für die Veränderung der Waldbedeckung ausgewählt. Daten (auf Dorfebene) zu Topographie, Bevölkerung, Bodentypen, Klimazonen, Schutzgebieten, Kommunalwäldern, Infrastruktur und Besiedlung wurden ausgewählt und mit Hilfe von GIS-Software aggregiert.
Zu den in dieser Arbeit verwendeten Methoden zählt die *Geographically Weighted Regression* (GWR), die zur Feststellung regionaler Muster und Prozesse in der Veränderung der Waldbedeckung genutzt wurde. Die Ergebnisse der GWR-Analyse wurden dann mit den Ergebnissen der *Ordinary Least Squares* (OLS) Methode verglichen. Die *Generalized Least Squares* (GLS) Methode ermöglichte es, die nichtlinearen Dorfbeziehungen zu untersuchen; die *Generalized Linear Models* (GLMs) Methode wurde verwendet, um Ent- und Wiederbewaldung in Albanien und in der grenzübergreifenden Region des Kosovo zu erklären. GLMs wurde auch angewandt, um die Eignung des Walds in Albanien als Lebensraum für den Luchs, den Braunbären und den Wolf zu prognostizieren. Die Varianz der lokalen Koeffizienten zwischen der Veränderung der Waldbedeckung und den Determinanten (des Models) wurde berechnet. Mithilfe des Monte-Carlo-Tests konnten die statistisch signifikanten Determinanten, die eine erhebliche lokale Abweichung im Verhältnis zur Veränderung der Waldbedeckung darstellten, bestimmt werden.
Die Ergebnisse zeigten sehr deutlich, dass die GWR-Modelle besser geeignet waren als die OLS-Modelle. Die politisch-institutionellen Determinanten erklärten den größten Teil der Veränderung in der Waldbedeckung. Die Entwaldungsrate erwies sich im ersten Untersuchungszeitraum in der Nähe von Straßen und besiedelten Gebieten als deutlich höher, was wahrscheinlich das Resultat einer höheren Holzentnahmerate ist. Die Belastung auf den Wald durch existenzsichernde Holzgewinnung war im zweiten Untersuchungszeitraum, für den eine Entwaldung in größerer Entfernung von Straßen und Siedlungen zu beobachten war, geringer. Die Determinante *Entfernung zu menschlicher Besiedelung* zeigte im Zusammenhang mit der Veränderung der Waldbedeckung starke lokale Unterschiede auf. Besonders negativen Einfluss dieser Determinante auf die Waldbedeckung ließ sich vor allem in den nördlichen und nordöstlichen Gebieten Albaniens und den nördlichen und südlichen Regionen des Kosovo im zweiten Untersuchungszeitraum feststellen.

Die Eignung als Lebensraum für den Luchs und Bären war in den Jahren 2000 und 2007 vergleichbar; wobei sich die Habitate als sehr fragmentiert zeigten. Mittels des in der Studie entwickelten Landschaftsmodells konnten die Faktoren, die die reale Verbreitung von Luchs und Bär determinieren, identifiziertet werden. Den Ergebnissen folgend, verringerte sich der retrospektiv prognostizierte Lebensraum des Luchs von 2000 bis 2007 um 5%, was sich durch die festgestellte Reduktion des Waldanteils innerhalb geeigneter Habitate begründen lässt. Diese Studie ist in ihrer Art bisher einmalig, da sie die Relationen von Mustern, Prozessen und Determinanten von Veränderungen in der Waldbedeckung für zwei Länder auf sehr genauer Skalenebene analysiert. Ein weiteres Alleinstellungsmerkmal dieser Studie ist die Untersuchung der Geeignetheit der Wälder in Albanien als Lebensräume für ausgewählte Spezies. Diese Studie leistet somit einen wichtigen Beitrag zur Literatur, insbesondere im Hinblick auf Ergebnisse zu Mustern und Prozesse der postsozialistischen Veränderungen der Waldbedeckung in den betrachteten Ländern. Weiter lassen sich von ihr Empfehlungen für politische Maßnahmen für Wälder, Schutzgebiete in beiden Ländern und für das Biodiversitätsmanagement in Albanien ableiten.

References

Adger W.N. (2006) Resilience, Vulnerability, and Adaptation - A Cross-Cutting Theme of the Human Dimensions of Global Environmental Change Program. Global Environmental Change 16:268-281.

Agrawal A., Chhatre A. (2006) Explaining success on the Commons: Community Forest Governance in the Indian Himalaya. World Development 34:149-166.

Agrawal A., Chhatre A., Hardin R. (2008) Changing Governance of the World's Forests. Science 320:1460-1462. DOI: 10.1126/science.1155369.

Agrotec.SpA.Consortium. (2004) Albanian National Forest Inventory (ANFI): Analysis of the spatio-temporal and semantic aspects of land cover/use dynamics Agrotec SpA Consortium, Rome.

Allen M., Frame D., Frieler K., Hare W., Huntingford C., Jones C., Knutti R., Lowe J., Meinshausen M., Meinshausen N., Raper S. (2009) The exit strategy. Nature Publishing Group:56-58.

Anselin L. (1988) Spatial Econometrics: Methods and Models Kluwer Academic Publishers, Dordrecht.

Anselin L. (1995) Local Indicators of Spatial Association: LISA. Geographical Analysis 27:93-115.

Arx M.v., Breitenmoser-Wuersten C., Zimmermann F., Breitenmoser U. (2004) Balkan population. In: Status and conservation of the Eurasian lynx (Lynx Lynx) in Europe in 2001. KORA Bericht 19: 239-245. KORA, Muri b. Bern.

Asner G.P., Knapp D.E., Broadbent E.N., Oliveira P.J.C., Keller M., Silva J.N. (2005) Selective Logging in the Brazilian Amazon. Science 310:480-482.

Bae J.S., Joo R.W., Kim Y.S. (2012) Forest transition in South Korea: reality, path and drivers. Land Use Policy 29:198-207.

Balkan Lynx Strategy Group. (2008) Balkan Lynx Strategy Group. Strategy for the Conservation of the Balkan Lynx in Macedonia and Albania. Peshtani, MK, 3-4 June 2008.

Bego F. (2000) On the status and distribution of the large carnivores (Mammalia: Carnivora) in Albania http://www.catsg.org/balkanlynx/07_library/7_2_publications/Pdfs/Bego_2000_Status_and_distribution_of_large_carnivores_in_Albania.pdf.

Bego F. (2001) Existing knowledge on the status and distribution of the lynx in Albania in The Balkan Lynx Population - History, recent Knowledge on its Status and Conservation Needs. Breitenmoser-Würsten, Ch. and Breitenmoser, U. (Eds.). KORA Bericht 7: 18. KORA, Muri B. Bern.

Berger J. (1997) Population Constraints Associated with the Use of Black Rhinos as an Umbrella Species for Desert Herbivores. Conservation Biology 11:69-78. DOI: 10.1046/j.1523-1739.1997.95481.x.

Bickford S.A., Laffan S.W. (2006) Multi-extent analysis of the relationship between pteridophyte species richness and climate. Global Ecology and Biogeography 15:588-601. DOI: 10.1111/j.1466-8238.2006.00250.x.

Bojovič D. (1978) Der autochtone luchs in Jugoslawien - Verbreitung, Bestand und Tendenz. in Luchsgruppe. Der Luchs: Erhaltung and Wiedereinbürgerung in Europa. Symposium der 'Luchsgruppe' am 14/15 Juli 1978 in Spiegelau, Bayerischer Wald.

Breitenmoser-Würsten C., Breitenmoser U. (2001) Kora Bericht Nr.7 "The Balkan Lynx Population - History, recent knowledge on its status and conservation needs".

Breitenmoser U., Arx M.v., Bego F., Ivanov G., Keçi E., Melovski D., Schwaderer G., Stojanov A., Spangenberg A., Trajçe A., Linnell J.D.C. (2008) Strategic planning for the conservation of the Balkan lynx. Proceedings of the III Congress of Ecologists of the Republic of Macedonia with International Participation, 06-09.10.2007, Struga Special issues of Macedonian Ecological Society 8.

Breitenmoser U., Arx M.v., Schwader G. (2005) Workshop on the conservation of the Balkan Lynx.

Burnham K.P., Anderson D.R. (1998) Model selection and inference. A practical information-theoretic approach, Springer-Verlag, New York, USA.

Burnham K.P., Anderson D.R. (2002) Model selection and Multi-Model Inference. A practical information-theoretic approach, Springer-Verlag, New York, USA.

Burnham K.P., Anderson D.R. (2004) Multimodel Inference. Sociological Methods & Research 33:261-304. DOI: 10.1177/0049124104268644.

Calogero C., Benjamin D., Stampini M., Zezza A. (2006) A Country on the Move: International Migration in Post-Communist Albania. International Migration Review 40:767-785.

Caro T.M., O'Doherty G. (1999) On the Use of Surrogate Species in Conservation Biology. Conservation Biology 13:805-814.

CATS. (2011) Balkan Lynx Compedium. http://www.catsg.org/balkanlynx/20_blx-compendium/home/index_en.htm.

Charlton M., Fotheringham S.A., Brunsdon C. (2003) GWR 3 Software for Geographically Weighted Regression.

Chefaoui R.M., Lobo J.M. (2008) Assessing the effects of pseudo-absences on predictive distribution model performance. Ecological modelling 210:478-486.

Chomitz K.M. (2007) At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests The World Bank, Washington, D.C.

Chowdhury R.R. (2006) Driving forces of tropical deforestation: The role of remote sensing and spatial models. Singapore Journal of Tropical Geography 27:82-101.

Cihlar J. (2000) Land cover mapping of large areas from satellites: status and research priorities. International Journal of Remote Sensing 21:1093-1114.

Costanza R., d'Arge R., Groot R.d., Farber S., Grasso M., Hannon B., Limburg K., Shahid Naeem, V.O'Neill R., Paruelo J., Raskin R.G., Sutton P., Belt M.v.d. (1997) The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Council of Europe, Ministry of Environment Forests and Water Adminsitration. (2006) Second Emerald Project in Albania-Final report.

Cungu A., Swinnen J.F.M. (1999) Albania's Radical Agrarian Reform. Economic Development and Cultural Change 47:605-620.

DeFries R., Asner G.P., Foley J. (2006) A Glimpse Out the Window: Landscapes, Livelihoods, and the Environment. Environment 48:22-36.

Deininger K., Minten B. (2002) Determinants of Deforestation and the Economics of Protection: An Application to Mexico. American Journal of Agricultural Economics 84:943-960.

Diaz S., Fargione J., Chapin F.S., Tilman D. (2006) Biodiversity Loss Threatens Human Well-Being. PLoS Biology 4:e277.

Epprecht M. (2003) Poverty mapping and market access in Vietnam. Final workshop. International Conference Center, Hanoi, IFPRI.

Epprecht M., Minot N., Dewina R., Messerli P., Heinimann A. (2008) The geography of poverty and inequality in the Lao PDR, Swiss National Center of Competence in Research (NCCR) North-South, University of Bern, and International Food Policy Research Institute (IFPRI), Bern:Geographica Bernensia.

ESRI. (2009) Environmental Systems Research Institute. The World. http://www.esri.com

ESRI. (2011) ArcGIS 9.2 Online Help. http://webhelp.esri.com/arcgisdesktop/9.2.

European Forest Institute. (2009) Long Term Forest Resources Assessment Database, LTFRA. http://www.efi.int

Evans T.P., VanWey L.K., Moran E.F. (Eds.). (2005) Human-environment research, spatially explicit data analysis, and geographic information systems in Moran E.F. and Ostrom E. Seeing the Forest and the Trees: Human-Environment Interactions in Forest Ecosystems, MIT Press, Cambridge, MA. pp. 442.

Falcucci A., Ciucci P., Maiorano L., Gentile L., Boitani L. (2009) Assessing habitat quality for conservation using an integrated occurrence-mortality model. Journal of Applied Ecology 46:600-609. DOI: doi: 10.1111/j.1365-2664.2009.01634.x.

FAO. (2000) Forest Global Resources Assessment. www.fao.org/docrep/004/Y1997E/y1997e0w.htm

FAO. (2005) Global Forest Resources Assessment Update 2005. Terms and Definitions. Forestry Department Working Paper 83/E.

FAO. (2010a) Forest Global Resources Assessment

FAO. (2010b) Global forest resources assessment 2010. Country report Albania.

FAO, Dida M. (2003) State of forest tree genetic resources in Albania.

Farley K.A. (2007) Grasslands to Tree Plantations: Forest Transition in the Andes of Ecuador. Annals of the Association of American Geographers 97:755-771. DOI: doi:10.1111/j.1467-8306.2007.00581.x.

Fernández N., Miguel D., Francisco P. (2006) Landscape evaluation in conservation: molecular sampling and habitat modeling for the Iberian Lynx. Ecological Applications 2006:1037-1049.

Fernández N., Miguel D., Francisco P., David M. (2003) Identifying breeding habitat for the Iberian Lynx: Inferences from a fine-scale spatial analysis. Ecological Applications 13:1310-1324.

Fischer J., Lindenmayer D.B. (2007) Landscape modification and habitat fragmentation: a synthesis. Global Ecology and Biogeography 16:265-280. DOI: 10.1111/j.1466-8238.2007.00287.x.

Fisher J.T. (2010) Cross-scale habitat selection by terrestrial and marine mammals. PhD thesis. University of Victoria.

Foley J.A., DeFries R., Asner G.P., Barford C., Bonan G., Carpenter S.R., Chapin F.S., Coe M.T., Daily G.C., Gibbs H.K., Helkowski J.H., Holloway T., Howard E.A., Kucharik C.J., Monfreda C., Patz J.A., Prentice I.C., Ramankutty N., Snyder P.K. (2005) Global Consequences of Land Use. Science 309:570-574.

Foody G.M. (2004) Spatial nonstationarity and scale-dependency in the relationship between species richness and environmental determinants for the sub-Saharan endemic avifauna. Global Ecology and Biogeography 13:315-320. DOI: 10.1111/j.1466-822X.2004.00097.x.

Fotheringham S.A., Brundson C., Charlton M. (1998) Geographically Weighted Regression: A Natural Evolution of the Expansion Method for Spatial Data Analysis. Environment and Planning A 30:1905-1927.

Fotheringham S.A., Brunsdon C. (2004) Some thoughts on inference in the analysis of spatial data. International Journal of Geographical Information Science 18:447-458.

Fotheringham S.A., Brunsdon C., Charlton M. (2000) Quantitative Geography Sage Publications Ltd., London.

Fotheringham S.A., Brunsdon C., Charlton M. (2002) Geographically Weighted Regression: The analysis of spatially varying relationships. John Wiley & Sons, LTD

Gaston K.J. (2005) Biodiversity and extinction: species and people. Progress in Physical Geography 29:239-247. DOI: 10.1191/0309133305pp445pr.

Geist H.J., Lambin E.F. (2002) Proximate causes and underlying driving forces of tropical deforestation. BioScience 52:143-150.

GLP. (2005) Global Land Project, Science Plan and ImplementationStrategy IGBP Report No. 53/IHDP Report No. 19. Stockholm. 64pp.

Grainger A. (2010) The bigger picture - tropical forest change in context, concept and practice in H. Nagendra and J. Southworth (eds.), Reforesting Landscapes: Linking Pattern and Process, Landscape Series 10. Springer Science + Business Media B.V.2010 10:15-43.

Gutman G., Janetos A.C., Justice C.O., Moran E.F., Mustard J.F., Rindfuss R.R., Skole D., Turner Ii B.L., Cochrane M.A. (2004) Land Change Science: Observing, Monitoring and Understanding Trajectories of Change on the Earth's Surface Springer, Berlin.

Haines-Young R. (2009) Land use and biodiversity relationships. Land Use Policy 26:S178-S186. DOI: 10.1016/j.landusepol.2009.08.009.

Henebry G.M. (2009) Carbon in idle croplands. Nature 457:1089-1090.

Hooper D.U., Chapin F.S., Ewel J.J., Hector A., Inchausti P., Lavorel S., Lawton J.H., Lodge D.M., Loreau M., Naeem S., Schmid B., Setala H., Symstad A.J., Vandermeer J., Wardle D.A. (2005) Effects of biodiversity on ecosystem functioning: A consensus of current knowledge. Ecological Monographs 75:3-35. DOI: 10.1890/04-0922.

Hosmer D.W., Lemeshow S. (2000) Applied Logistic Regression John Wiley and Sons (ed.), New York, USA, 373pp.

Huang C., Davis L., Townshend J. (2002) An assessment of support vector machines for land cover classification International Journal of Remote Sensing 23:725-749.

International Campaign to Ban Landmines. (2000a) Albania: Landmine Monitor Report 2000. www.icbl.org/lm/2000/albania.

International Campaign to Ban Landmines. (2000b) Kosovo: Landmine Monitor Report 2000. www.icbl.org/lm/2000/kosovo.html.

International Campaign to Ban Landmines. (2011) Mine Action http://www.the-monitor.org/index.php/cp/display/region_profiles/theme/1099.

IPCC. (2001) Climate Change 2001: Working Group I: The Scientific Basis.

IPCC. (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report.

Irwin E.G., Geoghegan J. (2001) Theory, data, methods: developing spatially explicit economic models of land use change. Agriculture, Ecosystems & Environment 85:7-23.

Jansen L., Carrai G., Morandini L., Cerutti P., Spisni A. (2006) Analysis of the spatio-temporal and semantic aspects of land-cover/use change dynamics 1991 - 2001 in Albania at national and district levels. Environmental Monitoring and Assessment 119:107-136.

Janz A., Linden S.v.d., Waske B., Hostert P. (2007) Images SVM - A user-oriented tool for advanced classification of hyperspectral data using Support Vector Machines

Jetz W., Rahbek C., Lichstein J.W. (2005) Local and global approaches to spatial data analysis in ecology. Global Ecology and Biogeography 14:97-98. DOI: 10.1111/j.1466-822X.2004.00129.x.

Kamar A., Partridge M.D., Olfert M.R. (2007) Can Geographically Weighted Regressions Improve Regional Analysis and Policy Making? International Regional Science Review 30:300-329.

Kanagaraj R., Wiegand T., Kramer-Schadt S., Anwar M., Goyal S.P. (2011) Assessing habitat suitability for tiger in the fragmented Terai Arc Landscape of India and Nepal. Ecography:no-no. DOI: 10.1111/j.1600-0587.2010.06482.x.

Kareiva P., Watts S., McDonald R., Boucher T. (2007) Domesticated Nature: Shaping Landscapes and Ecosystems for Human Welfare. Science 316:1866-1869. DOI: 10.1126/science.1140170.

King R.L. (2005) Albania as a laboratory for the study of migration and development. Journal of Southern Europe and the Balkans 7:133-155.

Kmeta J. (1986) Elements of Econometrics. Macmillan Publishin Company, New York.

Knorn J., Kuemmerle T., Radeloff V.C., Szabo A., Mindrescu M., Keeton W.S., Abrudan I., Griffiths P., Gancz V., Hostert P. (2012) Forest restitution and protected area effectiveness in post-socialist Romania. Biological Conservation 146:204-212. DOI: 10.1016/j.biocon.2011.12.020.

Knorn J., Rabe A., Radeloff V., Kuemmerle T., Kozak J., Hostert P. (2009) Land cover mapping of large areas using chain classification of neighboring Landsat satellite images Remote Sensing of Environment 113:957-964.

Koomen E., Stillwell J. (2006) Modelling Land - Use Change.

Kramer-Schadt S., Revilla E., Wiegand T. (2005) Lynx reintroductions in fragmented landscapes of Germany: Projects with a future or misunderstood wildlife conservation? Biological Conservation 125:169-182.

Kramer-Schadt S., Revilla E., Wiegand T., Breitenmoser U. (2004) Fragmented landscapes, road moratlity and patch connectivity: modelling influences on the dispersal of Eurasian lynx. Journal of Applied Ecology 41.

Kuemmerle T., Chaskovskyy O., Knorn J., Radeloff V.C., Kruhlov I., Keeton W.S., Hostert P. (2009a) Forest cover change and illegal logging in the Ukrainian Carpathians in the transition period from 1988 to 2007 Remote Sensing of Environment RSE-07342:14.

Kuemmerle T., Hostert P., Radeloff V., van der Linden S., Perzanowski K., Kruhlov I. (2008) Cross-border Comparison of Post-socialist Farmland Abandonment in the Carpathians. Ecosystems 11:614-628.

Kuemmerle T., J. Kozak, V.C Radeloff, Hostert P. (2009b) Differences in forest disturbance among land ownership types in Poland during and after socialism. Journal of Land Use Science 4:73-83. DOI: DOI: 10.1080/17474230802645857.

Kuemmerle T., Olofsson P., Chaskovskyy O., Baumann M., Ostapowicz K., Woodcock C.E., Houghton R.A., Hostert P., Keeton W.S., Radeloff V.C. (2011) Post-Soviet farmland abandonment, forest recovery, and carbon sequestration in western Ukraine. Global Change Biology 17:1335-1349. DOI: 10.1111/j.1365-2486.2010.02333.x.

Kupfer J.A., Farris C.A. (2007) Incorporating spatial non-stationarity of regression coefficients into predictive vegetation models. Landscape Ecology 22:837-852. DOI: 10.1007/s10980-006-9058-2.

Lambin E.F., Baulies X., Bockstael N., Fischer G., Krug T., Leemans R., Moran E.F., Rindfuss R.R., Sato Y., Skole D., Turner Ii B.L., Vogel C. (1999) Land-Use and Land-Cover Change (LUCC) Implementation Strategy IHDP Publication Programme, Bonn.

Lambin E.F., Geist H. (2006) Land -Use and Land-Cover Change: Local Processes and Global Impacts Springer Verlag, Berlin.

Lambin E.F., Meyfroidt P. (2010) Land use transitions: Socio-ecological feedback versus socio-economic change. Land Use Policy:108-118.

Large carnivores on the Balkan. (2004) Status and trends for large carnivores in Europe: Large carnivores on the Balkan report for the UNEP-WCMC project "Biodiversity Trends and Threats in Europe".

Laze K., Kola H. (2004) CDD Transparency in Albanian Communal Forest Project in "SEDA NGO Albanian Community Driven Development School":37 - 63; 151 - 152.

Lepers E., Lambin E.F., Janetos A.C., Defries R., Achard F., Ramankutty N., Scholes R.J. (2005) A Synthesis of Information on Rapid Land-cover Change for the Period 1981 - 2000. BioScience 55:115-124.

Lerman Z., Csaki C., Feder G. (2004) Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries Lexington Books, Lanham, Maryland.

Lindenmayer D., Fischer J. (2006) Habitat fragmentation and landscape change: an ecological and conservation synthesis. ISBN:1-59726-021-5.

Loiselle B.A., Graham C.H., Goerck J.M., Ribeiro M.C. (2010) Assessing the impact of deforestation and climate change on the range size and environmental niche of bird species in the Atlantic forests, Brazil. Journal of Biogeography 37:1288-1301. DOI: 10.1111/j.1365-2699.2010.02285.x.

Long H., Tang G., Li X., Heilig G.K. (2007) Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. Journal of Environmental Management 83:351-364. DOI: 10.1016/j.jenvman.2006.04.003.

Machlis G.E., Hanson T. (2008) Warfare Ecology. BioScience 58:729-736.

Mather A.S. (1992) The forest transition. Area:367-379.

Mather A.S. (2007) Recent Asian Forest Transitions in Relation to Forest-Transition Theory. International Forestry Review 9:491-502. DOI: 10.1505/ifor.9.1.491.

Mather A.S., Fairbairn J., Needle C.L. (1999) The course and drivers of the forest transition: The case of France. Journal of Rural Studies:65-90.

Mather A.S., Needle C.L. (1998) The forest transition: a theoretical basis Area:117-124.

May R., Dijk J.v., Wabakken P., Swenson J.E., John D.C.L., Zimmermann B., Odden J., Pedersen H.C., Andersen R., Landa A. (2008) Habitat differentation within the large-carnivore community of Norway's multiple-use landscapes. Journal of Applied Ecology 45:1382-1391. DOI: doi: 10.1111/j.1365-2664.2008.01527.x.

McCullagh P., Nelder J.A. (1989) Generalized Linear Models. Chapman and Hall, London, England, 511 pp.

McGarigal K., Cushman S., Stafford S. (2000) Multivariate statistics for wildlife and ecology research

Mertens B., Forni E., Lambin E.F. (2001) Prediction of the impact of logging activities on forest cover: A case-study in the East province of Cameroon. Journal of Environmental Management 62:21-36.

Meta M. (1993) Forests and forest policy in Albania. Journal of Forestry 91:27-28.

Meyfroidt P., Lambin E.F. (2010) Forest transition in Vietnam and Bhutan: Causes and Environmental Impacts in H. Nagendra and J. Southworth (eds.), Reforesting Landscapes: Linking Pattern and Process, Landscape Series 10. Springer Science + Business Media B.V.2010 10 315-339.

Millenium Assessment. (2005a) Ecosystems and Human Well-being: Synthesis Island Press, Washington, DC.

Millenium Assessment. (2005b) Forest and woodland systems, Ecosystems and Human Well-being: Current State and Trends World Resources Institute, Washington, DC.

Ministry of Agriculture Forestry and Rural development of Kosovo. (2007) Të dhënat statistikore bujqësore (Albanian).

Ministry of Economy Trade and Energy of Albania. (2007) Strategjia ndërsektoriale për zhvillimin rajonal 65.

Ministry of Environment Forests and Water Adminsitration. (2006) National Environmental Strategy

Moran E.F., Ostrom E. (Eds.). (2005) Seeing the Forest and the Trees: Human-Environment Interactions in Forest Ecosystems, MIT Press, Cambridge, MA. pp. 442.

Moran P.A.P. (1948) The interpretation of statistical maps. Journal of the Royal Statistical Society. Series B. (Methodological) 10:243-251.

Müller D. (2003) Land-use Change in the Central Highlands of Vietnam: A spatial econometric model combining satellite imagery and village survey data, Georg-August University Göttingen, Göttingen. pp. 195.

Müller D. (2012) Postsocialist land-use change in Eastern Europe: Case studies in Albania and Romania. Unpublished habilitation., Humboldt-Universität zu Berlin.

Müller D., Munroe D.K. (2008) Changing rural landscapes in Albania: Agricultural abandonment and forest clearing in the postsocialist transition. Annals of the Association of American Geographers 98(4): 855-876. DOI: http://dx.doi.org/10.1080/00045600802262323.

Müller D., Sikor T. (2006) Effects of postsocialist reforms on land cover and land use in South-Eastern Albania. Applied Geography 26:175-191.

Müller D., Zeller M. (2002) Land Use Dynamics in the Central Highlands of Vietnam: A spatial model combining village survey data and satellite imagery interpretation. Agricultural Economics 27:333-354.

Nagendra H., Southworth J. (2010) Reforesting Landscapes: Linking Pattern and Process. Landscape Series 10. Springer Science + Business Media B.V.2010 10.

Naidoo R., Ricketts T.H. (2006) Mapping the economic costs and benefits of conservation Plos Biology 4:2153-2164.

Naves J., Wiegand T., Eloy Revilla, Delibes M. (2003) Endangered species constrained by natural and human factors: the case of Brown Bears in Northern Spain. Conservation biology 17:1276-1289.

Nelson G.C. (2002) Introduction to the special issue on spatial analysis for agricultural economists. Agricultural Economics 27:197-200.

Nelson G.C., Hellerstein D. (1997) Do Roads Cause Deforestation? Using Satellite Images in Econometric Analysis of Land Use. American Journal of Agricultural Economics 79:80-88.

Nelson G.C., Pinto A.D., Harris V., Stone S. (2004) Land Use and Road Improvements: A Spatial Perspective. International Regional Science Review 27:297-325.

Nielsen S.E., Stenhouse G.B., Boyce M.S. (2006) A habitat-based framework for grizzy bear conservation in Alberta. Biological conservation 130:217-229.

Ogden K. (2000) Coping strategies developed as a result of social structure and conflict: Kosovo in the 1990s. Disasters:117-132.

Ogneva-Himmelberger Y., Pearsall H., Rakshit R. (2009) Concrete evidence&geographically weightes regression: A regional analysis of wealth and the ;and cover in Massachusetts Applied Geography

Olofsson P., Kuemmerle T., Griffiths P., Knorn J., Baccini A., Gancz V., Blujdea V., Houghton R.A., Abrudan I.V., Woodcock C.E. (2011) Carbon implications of forest restitution in post-socialist Romania. Environmental Research Letters 6:045202.

Osborne P.E., Foody G.M., Suàrez-Seoane S. (2007) Non-stationarity and local approaches to modelling the distributions of wildlife. Diversity and Distributions 313-323.

Palang H., Printsmann A., Gyuró É.K., Urbanc M., Skowronek E., Woloszyn W. (2006) The Forgotten Rural Landscapes of Central and Eastern Europe. Landscape Ecology 21:347-357.

Panagos P., Van Liedekerke M., Jones A., Montanarella L. (2012) European Soil Data Centre: Response to European policy support and public data requirements. Land Use Policy 29:329-338. DOI: http://dx.doi.org/10.1016/j.landusepol.2011.07.003.

Pearce D.W., R.Cline W., Achanta A., Fankhauser S., Pachauri R., Tol R., Vellinga P. (1996) The social costs of climate change: greenhouse damage and the benefits of control. Climatic Change 1995: Economic and Social Dimensions of Climate Change, Cambridge University Press, Cambridge, 183-224.

Pimm S.L., Raven P. (2000) Biodiversity: Extinction by numbers. Nature 403:843-845.

Prishchepov A.V., Radeloff V.C., Baumann M., Kuemmerle T., Müller D. (2012) Effects of institutional changes on land use: agricultural land abandonment during the transition from state-command to market-driven economies in post-Soviet Eastern Europe. Environmental Research Letters 7:024021.

Radeloff V.C., Beaudry F., Brooks T.M., Butsic V., Dubinin M., Kuemmerle T., Pidgeon A.M. (2013) Hot moments for biodiversity conservation. Conservation Letters 6:58-65. DOI: 10.1111/j.1755-263X.2012.00290.x.

Redo D.J., Grau H.R., Aide T.M., Clark M.L. (2012) Asymmetric forest transition driven by the interaction of socioeconomic development and environmental heterogeneity in Central America. Proceedings of the National Academy of Sciences. DOI: 10.1073/pnas.1201664109.

Ricketts T.H., Dinerstein E., Olson D.M., Loucks C. (1999) Who's where in North America. BioScience 49.

Rietveld P., Wagtendonk A.J. (2004) The location of new residential areas and the preservation of open space; experiences in the Netherlands. Environment and Planning A:2047-2063.

Rounsevell M.D.A., Reginster I., Araujo M.B., Carter T.R., Dendoncker N., Ewert F., House J.I., Kankaanpaa S., Leemans R., Metzger M.J. (2006) A coherent set of future land use change scenarios for Europe: Scenario-Based Studies of Future Land Use in Europe. Agriculture, Ecosystems & Environment 114:57-68.

Rozelle S., Swinnen J.F.M. (2004) Success and Failure of Reform: Insights from the Transition of Agriculture. Journal of Economic Literature 42:404-456.

Rudel T.K. (1998) Is There a Forest Transition? Deforestation, Reforestation, and Development. Rural Sociology 63:533-552.

Rudel T.K. (2002) Paths of Destruction and Regeneration: Globalization and Forests in the Tropics. Rural Sociology 67:622-636.

Rudel T.K. (2010) Three paths to forest expansion: a comparative historical analysis in H. Nagendra and J. Southworth (eds.), Reforesting Landscapes: Linking Pattern and Process, Landscape Series 10. Springer Science+Business Media B.V.2010 10:45-57.

Rudel T.K., Bates D., Machinguiashi R. (2002) A Tropical Forest Transition? Agricultural Change, Out-migration, and Secondary Forests in the Ecuadorian Amazon. Annals of the Association of American Geographers 92:87-102.

Rudel T.K., Coomes O.T., Moran E., Achard F., Angelsen A., Xu J., Lambin E. (2005) Forest transitions: towards a global understanding of land use change. Global Environmental Change Part A 15:23-31.

Sala O.E., Chapin F.S., III, Armesto J.J., Berlow E., Bloomfield J., Dirzo R., Huber-Sanwald E., Huenneke L.F., Jackson R.B., Kinzig A., Leemans R., Lodge D.M., Mooney H.A., Oesterheld M., iacute, Poff N.L., Sykes M.T., Walker B.H., Walker M., Wall D.H. (2000) Global Biodiversity Scenarios for the Year 2100. Science 287:1770-1774.

Schadt S., Revilla E., Wiegand T., Knauer F., Kaczensky P., Breitenmoser U., Bufka L., Červený J., Kouber P., Huber T., Staniša C., Trepl L. (2002) Assessing the suitability of central European landscapes for the reintroduction of Eurasian lynx. Journal of Applied Ecology 39:189-203.

Serneels S., Lambin E.F. (2001) Impact of land-use changes on the wildebeest migration in the northern part of the Serengeti-Mara ecosystem. Journal of Biogeography 28:391-407.

Sheppard S.R.J. (2005) Landscape visualisation and climate chnage: the potential for influencing perceptions and behaviour. Environmental scence and policy

Stahl J. (2007) The Political Ecology of Postsocialist Land Use Change: Case studies from three villages in Southeastern Albania, Doctoral dissertation, Humboldt-Universität zu Berlin, Berlin.

Stahl J. (2012) Rent from the Land: A Political Ecology of Postsocialist Rural Transformation Anthem Press.

Statistical Office of Kosovo. (2007a) Disa fakte mbi mjedisin.

Statistical Office of Kosovo. (2007b) Series 1: General Statistics: Kosovo in figures 2007.

Statistical Office of Kosovo. (2008) Series 2: Agriculture and Environmental Statistics: Agricultural Household Survey 2006. www.ks-gov.net/esk.

Suess S. (2010) Forest cover change of post-socialist landscapes in Albania and Kosovo: A remote sensing and statistical approach. Diplomarbeit. Universität Humboldt zu Berlin. Germany.

Taff G.N., Müller D., Kuemmerle T., Ozdeneral E., Walsh S.J. (2010) Reforestation in central and eastern Europe after the breakdown of socialism in H. Nagendra and J. Southworth (eds.), Reforesting Landscapes: Linking Pattern and Process, Landscape Series 10. Springer Science + Business Media B.V.2010 10:121-147.

World Bank. (2002) Rural Strategy Albania – Underpinning Growth and Sustainable Development.

World Bank. (2004) Albania - Forestry Project, Washington D.C. - The Worldbank. http://documents.worldbank.org/curated/en/2004/11/5508254/albania-forestry-project

World Bank. (2007a) Integrating Environment into Agriculture and Forestry Progress and Prospects in Eastern Europe and Central Asia. Country review Albania.

World Bank. (2007b) Kosovo Poverty Assessment: Accelerating Inclusive Growth to reduce Widespread Poverty.

World Bank. (2011) The World Bank. Albania Natural Resources Development Project. http://www.worldbank.org.al.

Thuiller W., Lavorel S., Araujo M.B., Sykes M.T., Prentice I.C. (2005) Climate change threats to plant diversity in Europe. Proceedings of the National Academy of Sciences 102:8245-8250.

Turner II B.L., Lambin E.F., Reenberg A. (2007) The emergence of land change science for global environmental change and sustainability. Proceedings of the National Academy of Sciences 104:20666-20671. DOI: 10.1073/pnas.0704119104.

Turner II B.L., Meyer W.B. (1994) Global Land-Use and Land-Cover Change: An Overview, in: W. B. Meyer and B. L. T. II (Eds.), Changes in Land Use and Land Cover: A Global Perspective, Cambridge University Press, Cambridge. pp. 3-10.

UNEP. (2001) Depleted uranium in Kosovo: Postconflict Environmental Assessment

United Nations Development Program of Kosovo. (2004) Human Resource Development Report Kosova 2004. The Rise of the Citizen: Challenges and Choices.

Veldkamp A. (2004) Editorial: Modelling land use change and environmental impact. Journal of Environmental Management 72:1-3.

Verburg P.H., de Nijs T.C.M., Ritsema van Eck J., Visser H., de Jong K. (2004a) A method to analyse neighbourhood characteristics of land use patterns. Computers, Environment and Urban Systems 28:667-690. DOI: 10.1016/j.compenvurbsys.2003.07.001.

Verburg P.H., Schot P.P., Dijst M.J., Veldkamp A. (2004b) Land use change modelling: current practice and research priorities. GeoJournal 61:309-324.

Vitousek P.M., Mooney H.A., Lubchenco J., Melillo J.M. (1997) Human domination of Earth's ecosystems. Science 277:494-499. DOI: 10.1126/science.277.5325.494.

Wiegand T., Knauer F., Kaczensky P., Naves J. (2004) Expansion of brown bear (Ursus arctos) into the eastern Alps: a spatially explicit population model. Biodiversity and Conservation 13:79-114.

Wiegand T., Naves J., Garbulsky M.F., Fernández N. (2008) Animal habitat quality and ecosystem functioning: exploring seasonal patterns using NDVI. Ecological Applications 78:87-103.

Wiegand T., Naves J., Stephan T., Fernández A. (1998) Assessing the risk of extinction for the Brown Bear (Ursus Arctos) in the Cordillera Cantabrica, Spain. Ecological Applications 64:539-570.

Xu J., Yang Y., Fox J., Yang X. (2007) Forest transition, its causes and environmental consequences: empirical evidence from Yunnan of Southwest China. Tropical Ecology:137-150.

Yu D.-L. (2006) Spatially varying development mechanisms in the Greater Beijing Area: a geographically weighted regression investigation.

Zuur A.F., Ieno E.N., Walker N.J., Anatoly A. S., Smith G.M. (2009) Mixed effects models and extensions in ecology with R. Springer

Appendix

A3: GWR R programming codes

```
#Source: GWR in R programming, package “spgwr”: Geographically weighted
#regression”, by Roger Bivand and Danlin Yu, version 0.6-2 June 26, 2009”.
Website: http://cran.r-project.org
#Author: kuenda laze
#Email: laze@iamo.de
#date: 2009-2010
***********************************************************************
require(spgwr) # package for GWR
require(lattice) # package for maps, graphics
require(spdep) # package to calculate Moran’I
setwd("C:\\Documents and Settings\\Laze\\My Documents\\R\\gwr") # define
the working #directory
source("permutation_test_second_version.r")
#source("permutation_test.r")

# step 1. Get GWR model fit AICc values
albania<-readShapePoly("Albania", IDvar="CODE", proj4string=CRS("+proj=utm
+zone=34 +datum=WGS84")) # read the shape file using CODE of villages as
ID.
plot(albania) # map of Albania

# Get AICc to compare models number, neighbors is 30 or 1% in case of Alba-
nia.
# AFCCH00HA is forest cover change 1988-2000 dependent variable
# ALBPOP2001 is population in 2001.
albaniam5.adpt<-gwr(AFCCH00HA~ALBPOP2001,data=albania, adapt = 0.0098,
coords= cbind(albania$X, albania$Y), longlat=FALSE), hatmatrix=TRUE,
se.fit=TRUE)
albaniam5.adpt# get summary of GWR coefficient estimates.
summary(albaniam5.adpt$SDF$localR2)# get local R2 values
summary(albaniam5.adpt$SDF$ ALBPOP2001)# get local coefficients of rela-
tionships of
# population and forest cover change 1988-2000
spplot(albaniam5.adpt$SDF, " ALBPOP2001")# get a map of patterns the rela-
tionship
summary(albaniam5.adpt$SDF) # summary of results
spplot(albaniam5.adpt$SDF, "response_resids") # summary of residuals re-
sults
# Get Moran’I of residuals
# Moran’I of residuals calculated “Queen”, continuity equal 1
albania.nb<-poly2nb(albania, queen=TRUE)
albania.lw <- nb2listw(albania.nb, style="W") # create weights
moranresult<-gwr.morantest(albaniam5.adpt, albania.lw)
plot(albania.lw, coords=cbind(albania$X, albania$Y)) # mapping results
summary(albania.nb, coords=cbind(albania$X, albania$Y))
summary(albania.lw) # summary of weights
summary(albania.nb) # summary of neighborhoods
```

```
# step 2. Get OLS model fit and Moran'I values
albaniam5<-lm(AFCCH00HA~ALBPOP2001,data=albania)
summary(albaniam5) # summary of OLS results
AIC(albaniam5.adpt) # get AIC values
lm.morantest(lm(AFCCH00HA~ALBPOP2001, data=albania), albania.lw) # weights
are the same as in GWR # get Moran'I of global residuals
# if OLS AICc is required apply
AICc <- function(lm(AFCCH00HA~ALBPOP2001, data = albania))
{
if(!(inherits(lm(AFCCH00HA~ALBPOP2001, data = albania), "lm")))
{
stop("only implemented for lm and glm...")
}
rank <- object$rank
npar <- rank -1
df.resid <- lm(AFCCH00HA~ALBPOP2001, data = albania)$df.residual
n <- rank + df.resid
aicc <- AIC(lm(AFCCH00HA~ALBPOP2001, data = albania)) +
(2*npar*(npar+1)/(n-npar-1))
return(aicc)
}
g <- lm(…)
AICc(g)

# step 3: Monte Carlo test
g.result <- gwr.permutation_test2(data= albania, formula =
AFCCH00HA~ALBPOP2001, adapt=0.0098, hatmatrix=TRUE, n.perm = 99)
print(g.result) # full code attached next pages

# step 4. Mapping of relationship patterns e.g., local coefficients from R
into ArcGIS
# save table of results asking to maintain column and row names and "CODE"
of villages, file saved e.g., in desktop. "CODE" used to join with shape
files in ArcGIS.
table<-write.table(albaniam5.adpt$SDF,"C:\\Documents and Set-
tings\\Laze\\Desktop\\table.dbf", sep="\t", col.names=T,row.names=T)
```

```
#####################################################
# permutation test for GWR
#
# the permutation test
# following C. Brunsdon, S. Fontheringham & M. Charlton (1988), The Statis-
tician
# Geographically weighted regression - modelling non-stationarity, 47,
Part3, pp.431-443
# test is descriped on p. 436
#
# author: sven.lautenbach@ufz.de
#
# date: 04.06.2010
#
#####################################################

if (! require(spgwr) )
{
  install.packages("spgwr")
  require(spgwr)
}

# assumes that the data object in spgwr is a SpatialPointDataframe or Spa-
tialPolygonDataFrame
# if it is a normal dataframe, the method will break at present
# is going to be updated
gwr.permutation_test2 <- function(formula, data, coords, adapt=0.06, n.perm
= 999,...)
{

  if (n.perm < 0)
  {
    print(paste("gwr.permutation_test. Value for n.perm smaller than zero.
Got", n.perm, "- reseting to 9999"))
    n.perm = 999
  }

  gwr.ref <- gwr(formula = formula, data=data, coords = coords,
adapt=adapt, ...)
  SDF <- gwr.ref$SDF


  data.class <- class(data)
  #browser()

  n <- nrow(coordinates(SDF))
  theXnames <-  as.character(formula)
  theXnames <- unlist(strsplit(theXnames, "+", fixed = TRUE) )
  theXnames <- gsub("(^ +)|( +$)", "", theXnames)   # trim string
  res <- data.frame(predictor = theXnames, p.value = rep(NA,
length(theXnames)) )
  vjs <- matrix(data=NA, nrow=length(theXnames), ncol=n.perm+1)
  vijs.col <- 0
  # loop over the fieldnames
  for (aX in theXnames)   # aX relates to j in Brunsdon et al.
  {

    vijs.col <- vijs.col +1
    count <- 1
    print(paste("processing", aX))
    # get the original vi values
```

```
    betas <- attr(SDF, "data")[,1]   # SDF refers to the Spatial Data Frame
with the betas, prediction SE etc. pp.
    beta.m <- mean(betas)
    beta.diff <- (betas - beta.m)^2
    vj.ref <- sum(beta.diff) / n
    vjs[vijs.col, count] <- vj.ref
    count <- count +1
    for (k in 1:n.perm)
    {
       # permutate the coordinates

      #browser()
      if(data.class ==  "SpatialPointsDataFrame")
       { # todo: use the other properties of Spatial classes as well like
prj
          perm.coords <- coordinates(data)[sample(1:n),]
          perm.data <- SpatialPointsData-
Frame(coords=coordinates(perm.coords), data =attr(data, "data"), match.ID =
FALSE )
          perm.coords <- NULL
       }
       if(data.class ==  "SpatialPolygonsDataFrame")
       { # todo: use the other properties of Spatial classes as well like
prj

          perm.polygon <- SpatialPolygons(attr(data, "poly-
gon"))#[sample(1:n)])
          perm.data <- SpatialPolygonsData-
Frame(Sr=SpatialPolygons(attr(data, "polygon")), data=attr(data, "da-
ta")[sample(1:n),], match.ID = FALSE )
          perm.coords <- NULL
       }
       else #if(data.class ==  "data.frame")
       { # todo: use the other properties of Spatial classes as well like
prj

          #perm.coords <- coords[sample(1:n),]
          #perm.coords <-
as.data.frame(eval(gwr.obj$this.call$coords))[sample(1:n),]
          #names(perm.coords) <- coord.names
          #perm.data <-  data
          # create a SpatialPointsDataFrame from the matrix and use that
          perm.data <- SpatialPointsDataFrame(coords=coords, data
=data[sample(1:n),], match.ID = FALSE )
          perm.coords <- NULL
       }
       #browser()

       # refit model
       new.gwr <- gwr(formula = formula, data=perm.data, adapt=adapt, ...)

       # get vj value and store it in vector
       betas <- attr(new.gwr$SDF, "data")[aX][,1]
       beta.m <- mean(betas)
       beta.diff <- (betas - beta.m)^2
       vjs[vijs.col,count] <- sum(beta.diff) / n
       count <- count +1
    }
    # compute rank R of unpermutated vi in the vj vector
    #browser()
    theRanks <- rank(vjs[vijs.col,])
```

```
    theR <- theRanks[1] # since the reference values has been inserted
first!
    # calculate p value for the randomization hypothesis (R/n.perm)
    p.val <- 1 - theR / ( n.perm + 1)
    # the H0 is that beta_i,j does not vary with i for variable j
    res[which(res$predictor==aX),]$p.value <-  p.val


  }
  #browser()
  boxplot(t(vjs), names=theXnames, log="y", main="MC test for spatial vari-
ation \nof regression coefficients")
  points(x=1:length(theXnames), y=vjs[,1], cex=2, pch=16, col="grey")
  #abline(h=vj.ref)
  return(res)
```

Table A4.1: Dataset of Albania at village level

Variables	Unit	MEAN	STD	MIN	MAX
Forest cover change 1988-2000	hectare	-5.6	69.38	-901.11	467.78
Forest cover change 2000-2007	hectare	18.12	56.1	-562.48	397.35
Population density 1989	number of inhabitants per km2	416.52	2011.47	0.63	38782.56
Population density 2001	number of inhabitants per km2	451.78	2314.02	0.19	35428.47
Village area	km2	9.28	9.12	0.42	195.87
Elevation mean	50 meter steps	10.41	8.64	0.02	40.50
Pindus Mountain Forests	percentage	41.38	48.56	0.00	100.00
Cambisols	percentage	26.19	40.78	0.00	100.00
Regosols	percentage	28.90	43.01	0.00	100.00
Forest cover 1988	percentage	20.68	20.46	0.00	90.59
Forest cover 2000	percentage	20.84	19.44	0.00	90.46
Roads density	100 km per km2	92.04	71.46	0.00	507.50
Asphalted road density	101 km per km2	23.29	34.03	0.00	264.50
Protected areas	percentage	3.44	15.35	0.00	100.00
Years since the establishment of communal forest administration		0.50	1.40	0.00	5.00
Accessibility to forests since the beginning of first period	30 minutes	0.94	0.92	0.09	10.62
Accessibility to forests since the beginning of second period	30 minutes	0.94	0.91	0.09	11.15
Population 2001	number of inhabitants	1137.9	3867.7	2.00	98792.00
Population 1989	number of inhabitants	1166	3492.4	15.00	82719.00
Eutric regosols	percentage	28.8	43.01	0.00	100.00
Calcaric regosols	percentage	0.09	1.88	0.00	80.29
Eutric cambisols	percentage	17.74	35.88	0.00	100.00
Cambic aerosols	percentage	0.99	8.62	0.00	100.00
Elevation mean	meters	520.2	432.05	0.74	2024.76
Balkan Mixed Forests	percentage	2.36	15.17	0.00	100.00
Dinaric Mountain Forests	percentage	3.44	18.22	0.00	100.00
Years of establishment of communal forest administration	percentage	11.91	32.4	0.00	100.00
Strict nature reserve	percentage	0.29	4.19	0.00	100.00
National parks	percentage	2	12.39	0.00	100.00
Natural monuments	percentage	0.18	3.2	0.00	99.65
Habitat/species management area	percentage	0.98	7.7	0.00	100.00
Protected landscape/seascape area	percentage	2.69	15.29	0.00	100.00
Managed resource protection area	percentage	0.54	5.94	0.00	100.00
Distance to nearest roads	meter	612.64	544.12	69.65	5214.46
Distance to nearest major roads	meter	1400.2	1326.9	92.14	9969.53
Distance to nearest asphalted road	meter	2371.4	2262.1	119.67	16357.20
Distance to nearest human settlements	meter	1070.8	539.52	318.12	5714.65
Distance to nearest city and commune center	meter	3442.3	1494.8	369.52	10995.20
Distance to nearest forest edge 1988	meter	220.79	254.6	3.37	3602.54
Distance to nearest forest edge 2000	meter	185.76	201.95	3.80	2074.16

Source: own calculation

Table A4.2: Dataset of Kosovo at village level

Variables	Unit	Mean	STD	Min	Max
Forest cover change 1988-2000	hectare	-0.42	36.03	-358.77	218.41
Forest cover change 2000-2007	hectare	9.12	32.51	-176.91	323.27
Population estimation 1991	number of inhabitants	1471.26	6400.38	0.00	155499.00
Population projection 2004	number of inhabitants	1621.41	7489.05	0.00	188776.00
Luvisols	percentage	3.17	15.93	0.00	100.00
Rankers	percentage	8.01	25.62	0.00	100.00
Cambisols	percentage	54.43	46.30	0.00	100.00
Dystric Planosols	percentage	1.81	12.06	0.00	100.00
Elevation mean	meters	703.49	276.04	308.09	2234.79
Pindus Mountain Forests	percentage	1.60	11.82	0.00	100.00
Balkan Mixed Forests	percentage	97.28	14.31	0.00	100.00
Dinaric Mountain Forests	percentage	1.11	8.14	0.00	100.00
National parks	percentage	1.12	7.86	0.00	99.00
Proposed national parks	percentage	2.29	13.53	0.00	100.00
Protected landscape/seascape area	percentage	0.02	0.50	0.00	13.00
Distance to nearest roads	meter	556.05	496.79	54.73	7461.87
Distance to nearest major roads	meter	2899.8	2448.95	90.44	16833.2
Distance to nearest highway	meter	5013.71	4242.58	223.1	30095.8
Distance to nearest UXOM	meter	7942.44	6811.32	183.81	45737.3
Distance to nearest city and commune center	meter	7636.47	3375.58	742.08	21782
Distance to nearest human settlements	meter	1011.4	444.8	271.36	5146.68
Distance to nearest forest edge 1988	meter	141.22	181.25	2.163	1927.26
Distance to nearest forest edge 2000	meter	114.24	122.72	2.46	1138.42

Source: own calculation

Table A4.3: Dataset of the cross-border study region of Albania-Kosovo, at village level
Source: own calculation

Variables, Albania	Unit	MEAN	STD	MIN	MAX
Forest cover change 1988-2000	hectare	3.54	92.07	-410.92	467.78
Forest cover change 2000-2007	hectare	14.78	69.28	-242.62	303.45
Population 2001	number of inhabit-ants	581.90	1317.92	16.00	16421.00
Population 1989	number of inhabit-ants	784.87	1157.21	0.00	13511.00
Eutric regosols	percentage	8.09	23.85	0.00	100.00
Eutric cambisols	percentage	33.86	44.35	0.00	100.00
Elevation mean	meters	814.59	387.35	217.02	1781.22
Balkan Mixed Forests	percentage	26.78	44.28	0.00	100.00
Dinaric forests	percentage	26.23	43.98	0.00	100.00
Strict nature reserve	percentage	1.26	9.78	0.00	94.64
National parks	percentage	2.72	14.63	0.00	99.84
Protected areas	percentage	4.01	17.80	0.00	99.95
Distance to nearest roads	meter	802.89	793.21	78.32	4973.35
Distance to nearest major roads	meter	1512.65	1311.39	108.68	6987.55
Distance to nearest asphalted road	meter	3118.07	3036.57	143.04	16357.20
Distance to nearest human settlements	meter	1247.08	760.31	318.12	5714.65
Distance to nearest city and commune center	meter	3773.99	1600.14	568.01	8187.82
Distance to nearest protected areas	meter	12180.78	6461.49	0.02	27252.3
Distance to nearest forest edge 1988	meter	112.12	92.34	7.16	559.86
Distance to nearest forest edge 2000	meter	96.15	70.23	6.50	399.08
Variables, Kosovo					
Forest cover change 1988-2000	hectare	5.86	37.83	-223.29	218.41
Forest cover change 2000-2007	hectare	15.74	39.9	-104.62	323.28
Population estimation 1991	number of inhabit-ants	1609.79	6518.9	0.00	92303.00
Population projection 2004	number of inhabit-ants	1743.02	7645.54	0.00	116579.00
Ranker	percentage	27.72	42.13	0.00	100.00
Eutric cambisols	percentage	0.2	2.26	0.00	36.71
Dystric cambisols	percentage	50.58	46.85	0.00	100.00
Elevation mean	meters	688.144	422.19	308.09	2234.79
Balkan Mixed Forests	percentage	91.22	26.06	0.00	100.00
National parks	percentage	2.14	10.64	0.00	83.00
Proposed national parks	percentage	3.82	16.92	0.00	100.00
Distance to nearest roads	meter	578.43	754.74	54.73	7461.87
Distance to nearest major roads	meter	3344.22	2628.19	90.44	16833.20
Distance to nearest highway	meter	5541.44	4932.4	327.03	30095.80
Distance to nearest human settlements	meter	1101.69	594.28	431.59	5146.68
Distance to nearest city and commune center	meter	8589.8	3225.28	807.12	16923.80
Distance to nearest UXOM	meter	3572.81	2188.68	349.72	12886.70
Distance to nearest protected areas	meter	10108.34	6130.62	0.00	25217.80
Distance to nearest forest edge 1988	meter	115.3	106.12	8.25	760.43
Distance to nearest forest edge 2000	meter	91.43	58.82	7.40	432.37

Table A4.4: Algorithms in ArcGIS

Variable	ArcGIS commands	Units
Mean elevation	Zonal statistics, mean	meter
Distance to nearest roads	Spatial analyst, Straight line, Euclidean mean distance from village boundaries to the closest road line	meter
Distance to nearest protected areas	Spatial analyst, straight line, Euclidean mean distance from village boundaries to the closest protected area boundary	meter
Distance to nearest town and commune center	Spatial analyst, straight line, Euclidean mean distance from village boundaries to the closest commune, town point	meter
Distance to nearest human settlements	Spatial analyst, straight line, Euclidean mean distance from village boundaries to the closest human settlement point	meter
Distance to nearest UX-OM	Spatial analyst, straight line, Euclidean mean distance from village boundaries to the closest UXOM point	meter
Village area	Calculate geometry of the village area in kilometer squares units	km^2
Population density	Field calculator, number of inhabitants divided by village area	Number of inhabitants in km^2
Road density	Intersect roads with village boundaries, calculate geometry of the road line in km unit, summarize lines lengths within a village by village CODE, and join with village shape file, road length divided by village area.	km/ km^2
Soil type	as above.	percentage
Accessibility of forest at the beginning of the period	Weighted steep slopes to flat areas. Spatial analyst: cost distance functions.	minutes
Forest cover change	Zonal statistics, sum up the number of forest pixels, multiple with forest cell size in square and divided by 104	hectare
Neighborhood variables	Spatial statistics, neighborhood circle or annual in various radii.	kilometers, percentage

Source: (ESRI, 2011)

Table A4.5: Habitat suitability modeling variables

Model explanatory variable	Units	Models
Land cover 1991, 2001		
Beech pure and mixed with coniferous forests	percentage per km^2	Food, Natural
Mixed broadleaved class	percentage per km^2	Food, Natural
Coniferous forests	percentage per km^2	Food, Natural
Cultivated land	percentage per km^2	Human
Mediterranean macchia	percentage per km^2	
Bare rocks and soil	percentage per km^2	Refuge, Refuge and food, Natural
Urban and industrial areas	percentage per km^2	
Aquatic vegetation	percentage per km^2	Landscape, Natural
Artificial and natural perennial waters	percentage per km^2	Landscape, Refuge, Refuge and food, Natural
Oak forests	percentage per km^2	Food, Refuge and food, Natural
Forest cover		
Forest cover connectivity	kilometer r	Refuge, Food, Refuge and food, Natural
Forest & woodland cover 1988, 2000, 2007	percentage per km^2	Landscape, Refuge and food, Natu-ral,
Forest cover change 1988-2000, 2000-2007*	kilometer	Refuge, Food, Refuge and food, Natural
Natural environment		
Elevation	meter per km^2	Landscape, Natural
Terrain ruggedness index	unitless	Landscape, Natural
Distance to nearest forest edge 1988, 2000, 2007	meters per km^2	Refuge, Refuge and food, Natural
Distance to nearest *Lutra Lutra* pres-ence	meters per km^2	Food, Refuge and food, Natural
Anthropogenic variables		
Distance to nearest asphalted road	meters per km^2	Human
Distance to nearest well-kept road	meters per km^2	Human
Distance to nearest seasonal road	meters per km^2	Human
Distance to nearest dwelling road	meters per km^2	Human
Distance to nearest village	meters per km^2	Human
Village density 1989, 2001	number of villages km^2	Human
Population diffusion 1989, 2001	unitless	Human

Source: own calculation

A5: Results

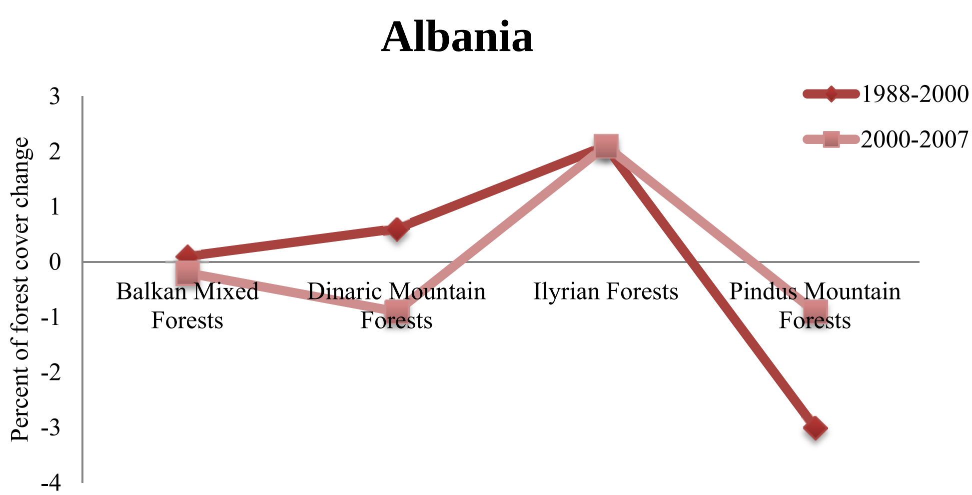
Note: Forest data were taken from (Suess, 2010), ecological zones were from Environmental Legislation Planning Albania (ELPA), soil types were from the European soil database, protected areas from the Institute for Nature Conservation Albania and from the Kosovo Agency for Environmental Protection, villages boundaries were from Edmond Leka, names of communes and years of establishment of communal forests were from the publication of SEDA NGO Albanian Community Driven Development School (Laze and Kola, 2004).

Table A5.1 Forest cover change by Albanian communal forests

Forest cover change	Year 1996	Year 1997	Year 1998	Year 1999	Year 2000
1988-2000	3.57	-0.2	-2.11	4.37	-31.08
2000-2007	1.38	0.14	0.08	6.38	-0.06

Table note: The administration of communal forests were established in 14 villages in 1996, in 4 villages in 1997, 18 villages in 1998, in 185 villages in 1999 and 143 villages in year 2000. They were approximately 12% of total number of villages and municipalities that took part in the forest reform from 1996 to 2000. Forest cover change of communal forests was divided by the total (sum) of forest cover change to get the percentage of forest cover change in communal forest. Forests increased from the first period to the second period in communes of years 1997, 1998, 1999 and 2000. Forests decreased by 2.19% in communes of year 1996 from the first to the second period.
Source: own calculation

Figure A5.2 Percentage of forest cover change by ecological zone



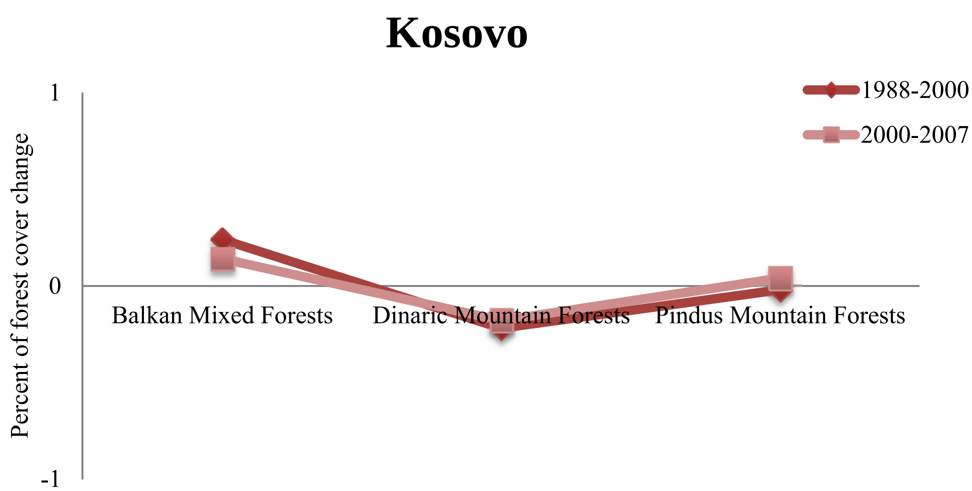


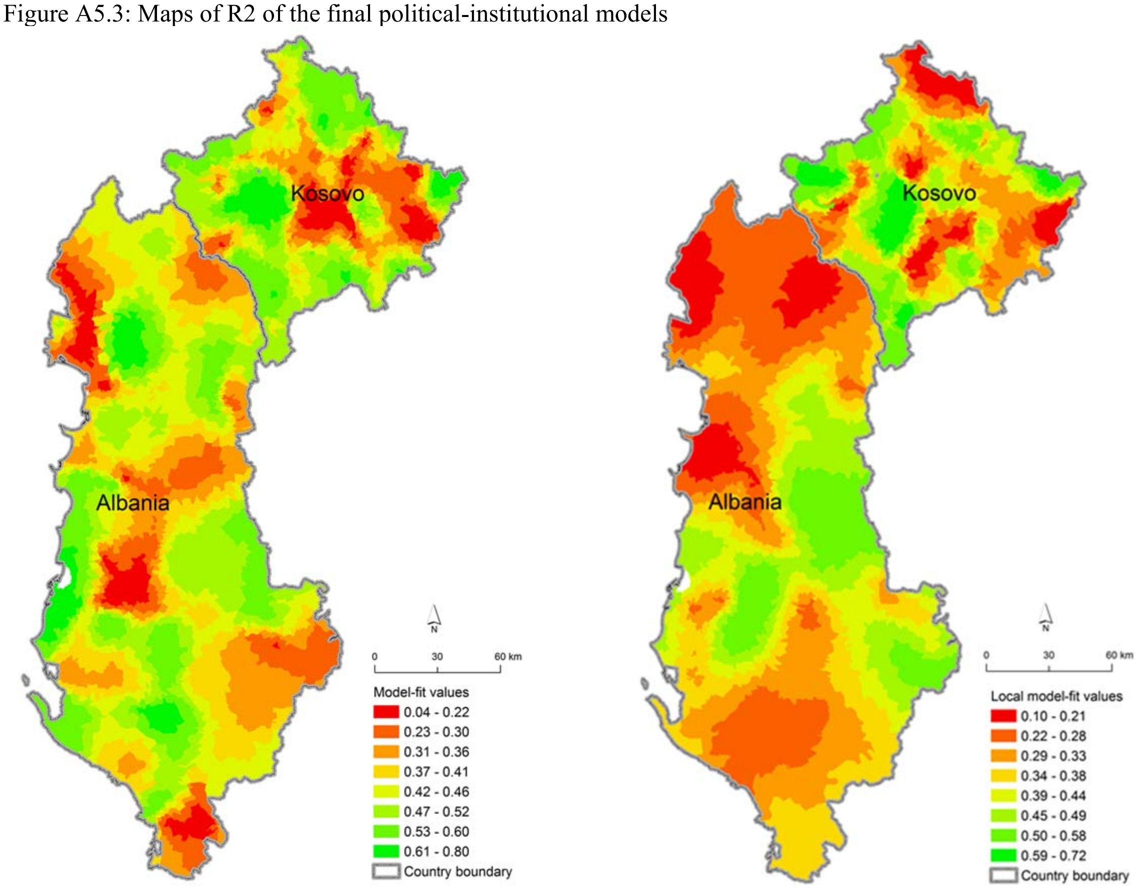
Table note: Most forestation is concentrated in Illyrian Forests and the largest share of deforestation in the Pindus Mountain Forests. There are comparable few changes of forest cover in Dinaric Mountain Forests, Balkan Mixed Forests in Albania and Kosovo.
Source: own calculation

Table A5.4: GWR second biophysical model result

Model	AICc	Moran's I of the residuals
1988-2000	GWR	GWR
Biophysical	33323.27	0.184

Source: own calculation

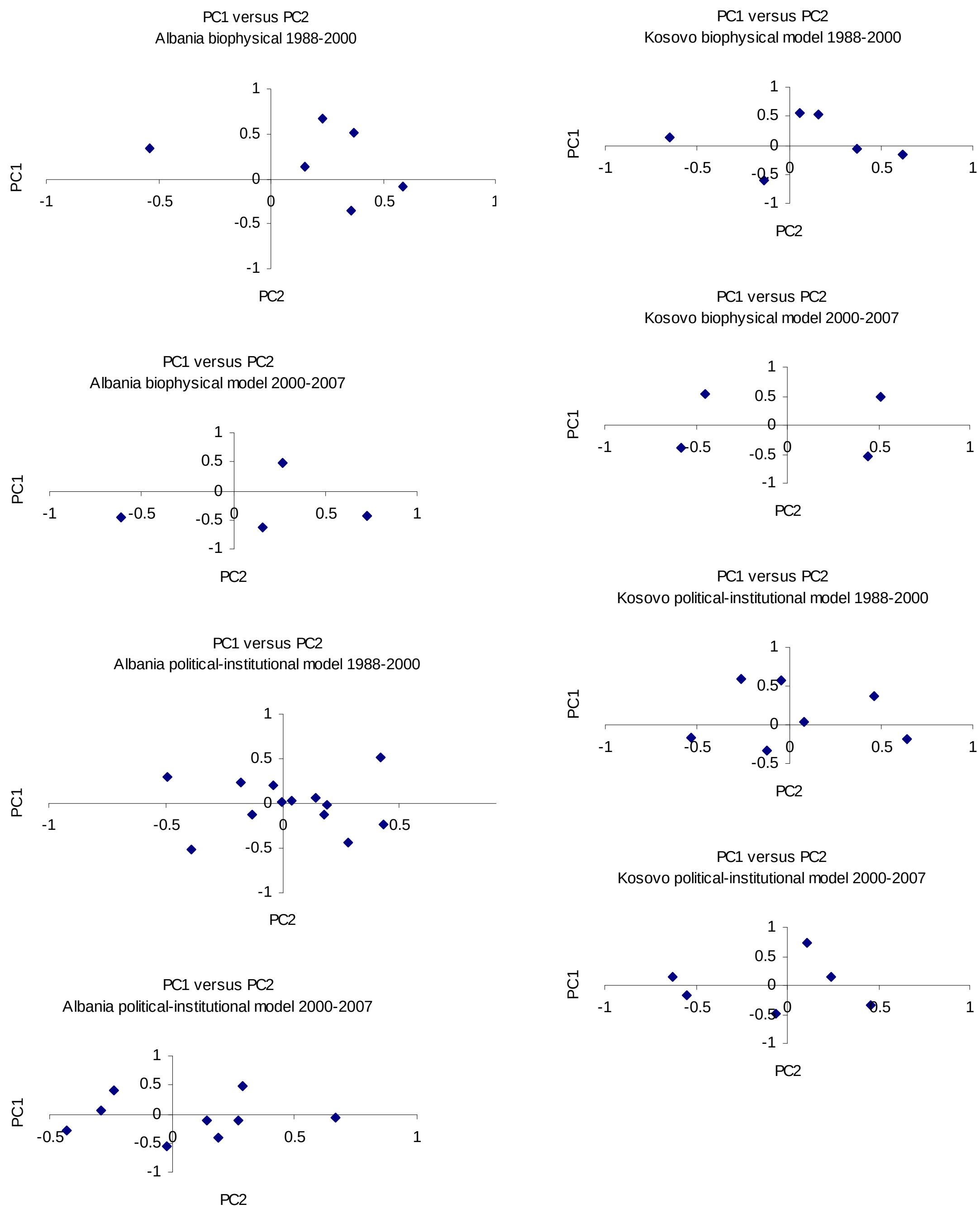
Figure A5.3: Maps of R2 of the final political-institutional models



Note: This figure shows the values of model fit for the final models of political-institutional models of Albania and Kosovo from 1988-2000 (left) and from 2000-2007 (right). The model fit reasonably well in remote areas in the largest parts of northern, eastern and southern Albania and in northern, western and southern part of Kosovo during the first period. In the second period, the model fits well in northern-eastern part of Albania and western and southern part of Kosovo.

Source: own calculation

Figure A5.5: Results of principal component analysis for Albania and Kosovo



Note: The number of principal components is equal to the number of determinants. The principal component (PC1) "explains the maximum amount of variation" (McGarigal et al., 2000) in models for Albania and Kosovo. Plots of principal components are used to check the linearity assumption for the data of Albania and Kosovo, which means that "principal components analysis assumes that variables change linearly along underlying gradients and that linear relationships exist among variables such that the variables can be combined in a linear fashion to create principal component" (McGarigal et al., 2000) , which is not true for the data of Albania and Kosovo because of nonlinearity of the principal components shown in the graphs of this figure.

Supplementary text: A5.S1 Kruskall-Wallis test results of the cross-border study region of Albania and Kosovo

Variables of deforestation and forestation that passes the Kruskal Wallis test for Albania and Kosovo are: 1) Albanian Distance to nearest protected area, Distance to nearest human settlement, Distance to nearest road, Distance to nearest major road, Distance to nearest main road, Eutric Cambisol, Haplic Phaeozem, Pindus Mountains Forests, Dinaric Mixed Forests, Balkan Mixed Forests, elevation, Humic Cambisols, 2) Kosovan Distance to nearest UXOM, Distance to nearest forest edge, Distance to nearest protected area, protected areas, ranker soil type, Humic Cambisols, Eutric Cambisol, proposed protected areas, elevation, Distance to nearest highway, Dystric Cambisol, Dystric Planosol.

Supplementary text: A5.S2. Kruskall-Wallis test results of the habitat suitability modeling

The variables that passes the Kruskal-Wallis test are as follows: the percentage of Fagus S., of broadleaved mixed forests, of forest cover, distance to forest edge, and index terrain in a 1km radius, Fagus S in a neighborhood radius of 3-10 km, index terrain radius of 10-15 km, shrub neighborhood of 3-5 km, bare rocks neighborhood radius of 3-15 km, and forest connectivity radii 1 and 4 are all statistically significant for lynx presences in 2000. Variables of bare rocks neighborhood and index terrain neighborhood have a significant correlation (> 0.70).

Table A5.2: Exploratory variables signs, coefficient values and p-values for lynx final and second best models

Model	Explanatory variable	2000			2007		
		sign	coefficients	P<0.05	sign	coefficients	P<0.05
Landscape	Elevation	+	0.0033	0.00	+	0.0034	0.00
	Forest cover	+	0.0332	0.00	+	0.0314	0.00
	Terrain index	-	0.0216	0.58	-	0.0238	0.55
Natural	Elevation	+	0.0036	0.00	+	0.0037	0.00
	Forest cover	+	0.0431	0.00	+	0.0390	0.00
	Distance to nearest forest edge	+	0.0009	0.21	+	0.0007	0.29
	Beech forests connectivity	+	0.0116	0.61	+	0.0227	0.42
	Broadleaved mixed forests connectivity	-	0.0167	0.16	-	0.0144	0.21

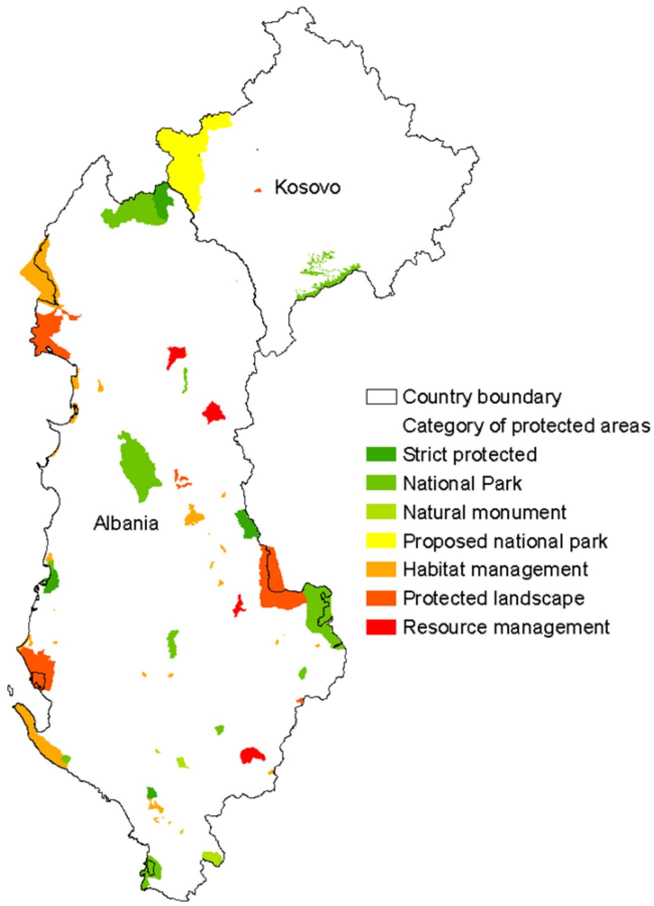
Source: own calculation

Table A5.3: Exploratory variables signs, coefficient values and p-values for bear landscape final and second best natural models

Model	Explanatory variable	2000 sign	2000 coeffi-cients	2000 P-value	2007 sign	2007 coeffi-cients	2007 P-value
Land-scape	Elevation	+	0.0015	0.00	+	0.0015	0.00
	Forest cover	+	0.0032	0.56	+	0.0043	0.41
	Terrain index	+	0.1004	0.00	+	0.0988	0.00
Natural model	Elevation	+	0.0014	0.00	+	0.0014	0.00
	Broadleaved mixed forests in percentage	-	0.0024	0.67	-	0.0015	0.79
	Forest connectivity	+	2.5350	0.19	+	2.609	0.07
	Distance to nearest forest edge	-	0.0004	0.41	-	0.0008	0.33
	Rocky and bare areas in percentage	+	0.0091	0.14	+	0.0094	0.13
	Beech forests connectivity	+	0.3939	0.27	+	0.0002	0.32
	Rocky and bare areas con-nectivity	+	0.9192	0.28	+	1.442	0.06
	Oak forests connectivity	-	0.4274	0.39	-	3.258	0.82
	Land use change neighbor-hood	+	0.4733	0.06			
	Broadleaved mixed forests connectivity				+	0.066	0.71

Source: own calculation

Figure A5.6 Protected area network in Albania and Kosovo



Note: strictly protected is the first category of protected areas according to International Union for Nature Conservation (IUCN), national parks are the second category, natural monuments are the third category, nature resource management is the fourth category, protected landscape is the fifth category and managed resource is the six category. Strictly protected areas, national parks, natural monuments and nature resource management ensure higher protection; compared to protected landscape and managed resource. Source of information is the Institute for Nature Conservation Albania and Institute for Environmental Protection Kosovo.

Kuenda Laze
Ish-F. Aviacionit, G. 8, Ap.21
Tirana, Albanien
edalaze@gmail.com
laze@iamo.de

ERKLÄRUNG

Hiermit erkläre ich, dass mit dieser wissenschaftlichen Arbeit noch keine vergeblichen Promotionsversuche unternommen wurden.

Des Weiteren erkläre ich, dass keine Strafverfahren gegen mich anhängig sind.

Halle (Saale), den 22 November 2012

Kuenda Laze

KUENDA LAZE

Edalaze@gmail.com

EDUCATION

Leibniz Institute of Agriculture Development in Transition Economies, Martin-Luther Universität Halle-Wittenberg, Germany
Dr. agr. in English (defense of this doctoral thesis was on 18 November 2013) **2008-2012**
Dissertation: "Identifying and understanding the patterns and processes of forest cover change in Albania and Kosovo"
Tirana University, Albania
University diploma in Business Administration (part-time) **1993-2000**
Wageningen University, The Netherlands
Master of Sciences of Environmental Sciences in English **1998-2000**
Thesis: "Integrated Assessment of Ecological and Socio-Economical Effects of Dam Building in the Drini River, Albania"
Tirana University, Albania
University diploma in Physics **1988-1992**

INTERNATIONAL COURSES

International Ocean Institute-Canada, Canada **2013**
Certificate on "Ocean Governance: Policy, Law and Management"
SSPA Sweden AB
Certificate on "Sustainable Coastal Development – COAST – 2006 A **2006**
EASY-ECO Training Program for Young Researchers on Evaluation of Sustainability, REC, Hungary
Certificate on "Evaluation of Sustainability" European Conferences and Training Courses **2006**
Maastricht School of Management of the Netherlands and Isabela State University, Philippines
Certificate on "Sustainable development: Good Governmental Governance and Social Responsibility" **2005**
University of Twente and Maastricht School of Management, the Netherlands
Certificate on "Energy Management and Cleaner Production in Small and Medium Scale Industries" **2000**
Academia Istropolitana, Slovakia
Postgraduate Certificate on Environmental Planning and Management **1996-1997**
Working paper: "Analysis of Wastewater treatment plant project in Vlore, Albania"

AWARDS

Grant holder, International Ocean Institute-Canada	May 2013 – July 2013
Doctoral scholarship holder, Leibniz Institute of Agriculture Development in Transition Economies, Germany	February 2008 – September 2012
Grant holder, Swedish International Development Program, Sweden	October 2006 – November 2006
Grant holder, EASY-ECO 2005-2007	January 2006 – February 2006
Grant holder, Maastricht School of Management	July 2005 – July 2005
Fellowship holder, Netherlands Fellowship Program, the Netherlands	October 2000 – November 2000
Master Fellowship holder, Netherlands Fellowship Program, the Netherlands,	September 1998 – January 2000
Scholarship holder, Academia Istropolitana Slovakia	September 1996 – June 1997

INTERNET SITES

Research gate: www.researchgate.net/profile/Kuenda_Laze/publications
Doctoral research institution: www.iamo.de

RESEARCH VISITS

Leibniz Institute of Agriculture Development in Central and Eastern Europe, Germany, 2/2008 – 6/2012

PUBLICATIONS AND PAPERS

Laze, K. 2013. Identifying and understanding the patterns and processes of forest cover change in Albania and Kosovo. European Scientific Journal Special edition. In press

Laze, K., T. Wiegand, and R. Kanagaraj. 2013. Habitat selection within the large-carnivore community changes in space and time in the multiple-use landscapes of Albania. PLOS One. In review

Laze, K. 2013. Identifying and understanding the forest cover change patterns and processes in Albania and Kosovo. Doctoral thesis (accepted). Martin-Luther Universität Halle-Wittenberg, Germany

Laze, K. and A. Gordon. 2014. Incorporating natural and human factors in habitat modelling and spatial prioritisation for the Lynx lynx martinoi. PloS One (to submit)

Laze, K. 2014. Differences in forest use of high-stem forests and coppice forests from 1953 to 1990: case study of Albania and the Former Yugoslavia (European Scientific Journal) (to submit)

Laze, K. 2014. Insights on the use of high-stem forests and coppice forests in communes after the collapse of socialism in Albania (European Scientific Journal) (to submit)

Laze, K (2000). "Integrated Assessment of Ecological and Socio-Economical Effects of Dam Building in the Drini River, Albania." Master Thesis (unpublished). Wageningen University. The Netherlands

CONFERENCE PROCEEDINGS

Laze, K. 2014. Has forest transition of high and low forests ever occurred in Albania: insights on high and low forest use from 1953 to 2007. (abstract accepted) ForestSAT2014, 4-7 November 2014, Riva del Garda, Italy

Laze, K., T. Wiegand, and R. Kanagaraj. 2013. Habitat selection within the large-carnivore community changes in space and time in the multiple-use landscapes of Albania (abstract accepted). ForestSAT2014, 4-7 November 2014, Riva del Garda, Italy

Laze K. (2013). Identifying and understanding the patterns and processes of forest cover change in Albania and Kosovo. 1st International Scientific Forum, ISF 2013, 12-14 December 2013, Tirana, Albania. European Scientific Institute. ISBN: 978-608-4642-16-9 (Vol. 2) http://isforum.us/index.php/proceedings

Laze, K., S. Lautenbach, and D. Müller. 2010. Identifying and understanding the forest cover change patterns and processes in Albania (Poster). ISEE 2010, 22-25 August 2010, Oldenburg, Germany

Laze, K. and D. Müller. 2009. Patterns, processes, and future developments of land use in Albania and Kosovo (Poster). MACE Conference 2009, January 14-15 2009, Berlin, Germany

SKILLS

Spatial analysis (regression), Ecological modeling, GIS, R Programming, Zonation, Microsoft Office

PROFESSIONAL WORK EXPERIENCE

Faculty of Civil Engineering, Albania
Lecturer – "Ecology" **2007-2008**
Developed seminars and administrated working papers of students

Albania Leadership Program, Albania
Development programmes' coordinator and trainer (part-time) **2007-2008**
Assisted the development program preparation and training conduction

Strengthening Albanian's National Response to HIV/AIDS, TBC, among Vulnerable Groups Project, Albania
Consultant **2007**
Monitored and evaluated the project of TBC and budget management

Support in the Formulation, Revision and Implementation of MDG-based Municipal Development Plans in selected municipalities' Project, UNDP, Kosovo
Project Manager **2006**
Managed tasks, finance, parties, supervised project staff and organized two MDG workshops, stakeholder analysis

Ministry of Interior, Albania
Decentralization expert **2004-2005**
Provided expertise on decentralization policy implementation to parties and project coordination

Agriculture Services Project, Albania
Head of working group **2004**
Conducted a follow-up environmental assessment, prepared training modules and environmental booklet and plan, supervised staff and report writing

Poverty and social impact assessment of irrigation and rehabilitation project
Key Consultant **2004**
Conducted survey and data collection

Poverty and social impact assessment of irrigation and rehabilitation project
Research assistant **2004**
Conducted survey and data collection
Organization and logistics management, conducted interviews, supervision of staff and translation

European Commission, DG Regio, Belgium
Trainee **2002**
Introduced to EU, reviewed Interreg project Italy-Albania and Greece – Albania and translation

Albania Forestry Project, Albania
Environmental expert **2000-2004**
Conducted Environmental Impact Assessment Reports (EIA) for 13 Forest Management Plans, Conducted two EIA reports for forest roads, prepared and conducted environmental training, established environmental – forestry database, supervised preparation of two guidelines of EIA of forest management plans and forest roads and evaluated 13 biodiversity assessment report

LANGUAGES

Albanian – native
English – speak, read and write fluently
French - Alliance Française de Tirana, Diplôme de la Langue Française
German - TELC Zertifikat Deutsch-Test B1, Deutschland
Italian - speak and read fluently, write intermediate competencies