ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

UTILIZING CORINE LAND COVER DATA IN DIVERSE SPATIAL DECISION MAKING AND MANAGEMENT PROCESSES

Ph.D. THESIS

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Department of Landscape Architecture

Landscape Architecture Programme

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Date of Defense : 01 October 2018

To my parents, spouse and our sons...

FOREWORD

This thesis is the product of a research interest on exploring the tools and methods developed within the field of landscape research as an alternative to classical architectural and urban design methods, in providing sustainable solutions to spatial problems of our existence. In achieving that, my experience has not been easy, majorly due to my professional background being educated as an architect. But this thesis has been finalized with the support and guidance of many people to whom I owe at least an acknowledgment.

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July 2018 Artan HYSA (researcher)

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ABBREVIATIONS

AHP	: Analytical Hierarchy Processing
ASIG	: State Authority for Geospatial Information
BZ	: Buffer Zone
CA	: Cellular Automata
CAPI	: Computer-Assisted Photointerpretation
CLC	: CORINE Land Cover
CLCC	: CORINE Land Cover Change
CORINE	: Co-ORdinated INformation on the Environment
CPR	: Common Pool Resource
CV	: Coefficient of Variation
DG AGRI	: General Directory of the EU for Agriculture
DLA	: Digital Landscape Architecture
DRM	: Disaster Risk Management
DRMFS	: Disaster Risk Management and Fire Safety
EC	: European Commission
EEA	: European Environmental Agency
EIONET	: European Environment Information and Observation Network
ELC	: European Landscape Convention
ESRI	: Environmental Systems Research Institute
EU	: European Union
EUROSTAT	: European Statistical Office
FAO	: Food and Agriculture Organization
FRA	: Forest Resources Assessment
FRI	: Fire Risk Index
FS	: Fire Safety
FSE	: Fire Safety and Evacuation
GEOSS	: Global Earth Observation System of Systems
GIS	: Geographic Information Systems
GLC	: Global Land Cover
GMES	: Global Monitoring for Environment and Security

GSSET : Graduate School of Science, Engineering and Technology
HELM : Harmonized European Land Monitoring
HRLs : European High-Resolution Layers
ICZM : Integrated Coastal Zone Management
IT : Information Technology
ITU : Istanbul Technical University
JRC : Joint Research Center
LC : Land Cover
LCCS : Land Cover Classification System
LCF : Land Cover Flows
LEE : Edge to Edge link
LFA : Landscape Fragmentation Assessment
LU : Land Use
LUCAS : Land Use and Cover Area frame Survey
LULC : Land Use and Land Cover
MG : Matrix Green toolbox
MMU : Minimum Mapping Unit
MOLAND : Monitoring Land Use/Cover Dynamics
PBL : Project Based Learning
PDA : Patch Distance Analysis
POR : Problem Oriented Research
QA : Quality Assurance
QC : Quality Control
RDS : Relative Standard Deviation
SCT : Sustainable Coastal Tourism
SCOPUS : The largest abstract and citation database of peer-reviewed literature produced by the Elsevier Co.
TAR : Territorial and Administrative Reform
TCD : Transversal Continuum Degree
TCNLM : Transversally Connected Natural Landscapes Mosaic
UA : Urban Atlas
UN : United Nations
WIPI : Wildfire Ignition Probability Index
WSCI : Wildfire Spread Capacity Index

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UTILIZING CORINE LAND COVER DATA IN DIVERSE SPATIAL DECISION MAKING AND MANAGEMENT PROCESSES

SUMMARY

This research work originates from a basic interest in scrutinizing the unexplored symbiotic relationship between the advancements in information technologies and real life complex problems. Generally, the later boosts an intellectual energy in search for solutions to specific everyday life problems, leading to significant innovation in technology. These advancements mainly overpass the expectations of the problem solving goals of the initial phase, marking further progress in technology. Meanwhile, this progression, the utilization of which may provide solutions to several other unexplored real life problems, defines new areas of research to be discovered.

The advancements in information technologies have shown the ability to assist human intellect first in understanding and later in handling the complexity of issues in spatial planning and management. The high storage capacities of the machine make possible archiving of big data covering a gradient of spatial scales simultaneously. Furthermore, the high computation abilities of the computer enable multivariable and multiscale analytical processes approaching closer to a holistic handling of everyday life problems.

Holistic solutions can be developed only upon all-inclusive understanding of the problem. Within the scope of decision making objectives of territorial planning and management, the properties of the landscape become very crucial. Landscape here is used following the definition in European Landscape Convention (ELC), “as an area whose character is the result of the action and interaction of natural and/or human factors” (EC, 2000, p.2). Similarly, according to Hartshorne (1939), landscape is described as “an outward manifestation of most of the factors at work in the area”. One of the main methods of monitoring the properties of the landscape in a territory is land cover assessment.

In this context, this work focuses on exploring the potentials in utilizing the land cover monitoring technologies in various spatial decision making and management processes. Following a Problem Oriented Research (POR) method, it defines and makes cases of various situations of decision making circumstances that can benefit from CORINE land cover (CLC) data. CLC data is the product of the land cover monitoring program initiated by European Union in 1985. It is providing periodically (every 6 years) monitored data of land cover in a pan-European scale as an open source. The thesis presents a set of real-life diverse cases being studied and sharing a single common. CLC utilization acts as the common material and method for all cases presented in this thesis. The main analytical phases of each study have been worked in ArcGIS 10.2.2 software. Besides, ArcGIS extension toolboxes like MatrixGreen or ModelBuilder have been used in a specific study. Each case is prepared in the format of an article manuscript being published in internationally recognized scientific journals.

First, CLC data are utilized as a mean to measure the landscape fragmentation among broad-leaved forested surfaces (Chapter 2). Landscape fragmentation assessment is a crucial analysis in a territory prior to developing natural conservation management agendas in Europe. The study is theoretically set on the patch-corridor-matrix concept as developed by Forman and Gordon, where patches consist of broad-leaved surfaces as derived from CLC data and corridors as generated by MatrixGreen (MG) toolbox. The territory of Albania is selected as the study area for this article. The results of the study have shown that the combined utilization of CLC data and MG toolbox provide ground to enable rapid landscape fragmentation assessment at landscape scale. This work has been presented in the conference of Digital Landscape Architecture-2017 in Bernburg, Germany. Entitled as *"Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data"* it is published as an article in the Journal of Digital Landscape Architecture (JoDLA).

The study in chapter 3 presents a method of utilizing CLC data as an environmentally friendly decision making mediator during Territorial Administrative Reform (TAR, on local administrative divisions). The case study and the main focus of this research is the current Albanian TAR (2014). First, CLC data is utilized to measure the landscape fragmentation caused by the new local administrative borders within the recent TAR which results to have not considered the environmental factors of the territory. Furthermore, CLC data is utilized as a criterion for readjusting the local administrative borders of the capital city, Tirana. As a result, the research has shown that CLC data can be a successful input during the local boundaries definition phase of TAR process, minimizing landscape fragmentation caused by the local administrative boundary line. Entitled as *"Land cover data as environmentally sensitive decision-making mediator in territorial and administrative reform",* this paper is published in the journal Cogent Environmental Science (Taylor & Francis).

Next, chapter 4 makes a case of CLC data utilization in disaster risk assessment and fire safety management (DRMFS). It starts with a literature review to identify main factors either causing ignition or motivating the spread of a wildfire event. Consequently, a multi-criteria indexing framework is proposed both for ignition probability and spread capacity. The study makes a case of broad-leaved forested surfaces in the northern Albanian territory as derived from CLC data of 2006. The workflow consists of three stages; multi-criteria inventory for each location (data collection), analyzing and interpreting the gathered data via Analytical Hierarchy Processing (AHP) and clustering them via Jenks natural break method (data interpretation), and finally, indexing every location within the forested surface by their wildfire ignition probability (WIPI) and wildfire spread capacity (WSCI). Later a validation procedure is developed by comparing the results from 2006 CLC data with CLC data of 2012. The results show successful prediction abilities of the model in assessing the wildfire risk. The method developed within this study results successfully in delivering a rapid, not-expensive and reliable wildfire risk assessment model useful for DRMFS agendas. Entitled *"A GIS based method for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spreading capacity"* is currently published in the journal of Modelling Earth Systems and Environment (Springer).

Finally, in chapter 5 and chapter 6, CLC data utilization is explored within the scope of coastal zone studies. CLC spatial data are used as the raw material of an analytical workflow aiming to analyze the structure of the coastal landscapes and to reveal the transversal continuum of natural landscapes within the coastal zone. The novel approach makes a shift from the classical longitudinal analysis of the coastal lands towards the transversal one. Chapter 5 presents the method applied to the Turkish Mediterranean coast, leading to significant findings of the natural landscapes along the Turkish Mediterranean coast.

First, the method introduces two new attributes for each coastal landscape patch; the band and the transversal continuum depth (TCD) values. The band level is the value of the physical connectivity order of each patch in relation with the coastline. Whereas, TCD value refers to the maximum band level a specific landscape patch is providing transversal connectivity for. Moreover, the method is successful in mapping the transversally connected natural landscape mosaics (TCNLMs) in the coastal zone. As a result, there are identified landscape patches which are endangered for being singular connectors within a certain identified TCNLM. Similarly, there are identified artificial landscape patches on the coastline that if restored can provide a transversal continuum for potential TCNLMs. The presented method may assist different analysis within the Integrated Coastal Zone Management (ICZM) initiative and Sustainable Coastal Tourism. The results of this study are served for use by different public administration and governmental bodies such as responsible ministries or local administration. The study presented in Chapter 5 is entitled *"Revealing the transversal continuum of natural landscapes in coastal zones - Case of the Turkish Mediterranean coast"* and is published in Ocean and Coastal Management journal (Elsevier).

The detailed explanation of the method developed in ModelBuilder (ArcGIS) is presented in Chapter 6. Developed as a toolbox, the model is already tested in and resulted to be successfully applicable for another coastal zone having a coastline and land cover data. Furthermore, the model has the potential to be utilized in other contexts like watersheds, by introducing the watercourse line or the perimeter line of the lake by replacing the coastline. The method presented in chapter5 and chapter 6 is projected to be further developed towards a multi-scale transversal analysis of water-centered landscapes. Entitled as *"A GIS-based method for revealing the transversal continuum of natural landscapes in the coastal zone"* this work is published as an article in MethodsX journal (Elsevier).

Besides the core chapters presenting the published articles, the thesis includes an Introduction (Chapter 1) and a Conclusions & Recommendations (Chapter 7) chapter. Chapter 1, presents a brief introduction to the topic focusing on the CLC data emergence in the discourse of sustainability and the age of information technology. It delivers the motivation, objectives, research questions, and the hypothesis behind this research activity.

Each article presented here draws significant results and puts forward certain topics as further improvements and future steps. But, common conclusions and comparative discussions are provided in the final chapter of this thesis. In the Conclusions and Recommendations chapter, certain drawbacks and limitations of the research process are discussed, targeting further improvements as future steps of this research. Moreover, a comparative discussion is made by comparing the cases included in this thesis trying to figure out the most appropriate case in which CLC data could be utilized for. As the final conclusion, the collection of works comprising this thesis shows the successful utility of CLC data in diverse spatial decision making and management processes.

CEŞİTLİ MEKANSAL KARAR ALIM VE YÖNETİM SÜREÇLERİNDE CORINE ARAZİ ÖRTÜSÜ VERİSİNDEN YARARLANILMASI

ÖZET

Bu araştırma, bilgi teknolojilerindeki ilerlemeler ile gerçek hayataki karmaşık problemler arasındaki keşfedilmemiş simbiyotik ilişkiyi incelemeye yönelik temel bir ilgiden kaynaklanmıştır. Genel olarak, bu durum belirli günlük yaşam sorunlarına çözüm arayışı içerisindeyken teknolojide önemli yeniliklere yol açan entelektüel bir enerjiyi tetiklemektedir. Bu ilerlemeler, ilk aşamadaki problem çözme beklentilerinin ötesine geçerek teknolojide ileri seviyeye sahip gelişmelere işaret edebilmektedir. Söz konusu gelişmeler, günlük hayatta dair irdelenmemiş problemlere çözüm getirebilme kapasitelerine sahip olmaları sayesinde araştırılacak yeni alanlar tanımlamaktadırlar.

Bilişim teknolojilerindeki ilerlemeler, öncelikle mekânsal planlama ve yönetimdeki sorunların karmaşıklığını anlamada, sonrasında ise bu sorunları ele alma konusunda insan aklına yardımcı olmaktadırlar. Bilgisayarın yüksek depolama kapasitesi, eşzamanlı bir şekilde mekansal ölçeklerin gradyanını kaplayan büyük verilerin arşivlenmesine imkan vermektedir. Ek olarak, bilgisayarın yüksek hesaplama yeteneği, günlük yaşam sorunlarının bütüncül şekilde ele alınmasına imkan veren çok değişkenli ve çok ölçekli analitik süreçleri mümkün kılmaktadır.

Bütünsel çözümlerin geliştirilebilmesi ancak sorunun kapsayıcı bir yaklaşımla ele alınmasıyla mümkündür. Bölgesel planlama ve yönetimine dair karar verme hedefleri açısından, peyzaj özellikleri çok önemli bir hale gelmektedir. Burada kullanılan peyzaj terimi, Avrupa Peyzaj Sözleşmesinde (ELC) yer alan tanıma göre “karakteri doğal ve / veya insan faktörlerinin etkisi ve etkileşimi sonucu oluşan bir alan” şeklindedir. Benzer biçimde Hartshorne (1939) 'a göre ise peyzaj, “bir alanda işlemekte olan faktörlerin çoğunun dışa doğru tezahürü şeklinde tanımlanmaktadır”. Bir arazideki peyzajın özelliklerinin izlenmesinin ana yöntemlerinden biri ise arazi örtüsü değerlendirmesidir.

Bu bağlamda, bu çalışma çeşitli mekansal karar verme ve yönetim süreçlerinde, arazi örtüsü izleme teknolojilerinden yararlanma potansiyellerini araştırmaya odaklanmaktadır. Sorun Odaklı Araştırma (POR) yöntemini takiben, bu çalışma CORINE arazi örtüsü (CLC) verisinden yararlanabilecek olan çeşitli karar verme durumlarını tanımlamakta ve araştırmaktadır. CLC verileri, Avrupa Birliği tarafından 1985 yılında başlatılan arazi örtüsü gözlemlenmesi programının ürünüdür. CLC, Avrupa ölçeğinde arazi örtüsü gözlemlenmesinin periyodik (6 yılda bir) olarak gerçekleştirildiği, herkese erişimi açık olan bir veritabanıdır. Tez çalışması, tek bir ortak paydaşa sahip olan gerçek hayata dair bir dizi farklı vakayı sunmaktadır. CLC kullanımı, bu tezde sunulan tüm vakalar için ortak materyal ve yöntem olarak kullanılmıştır. Her çalışmanın temel analitik aşamaları ArcGIS 10.2.2 yazılımında işlenip üretilmiştir. Bunun yanısıra, Matrix Green veya ModelBuilder gibi ArcGIS uzantısı olan araç kutuları da spesifik bazı çalışmalarda kullanılmıştır. Bu tez içerisinde yer alan herbir araştırma çalışması, uluslararası bilimsel dergilerde yayımlanmış olan makale formatında hazırlanmıştır.

Öncelikle, CLC verileri geniş yapraklı ormanlık yüzeyler arasındaki peyzaj parçalanmasını ölçmek için bir araç olarak kullanılmıştır (Bölüm 2). Peyzaj parçalanmasının değerlendirilmesi, Avrupa'da doğal koruma yönetimine dair gündemlerin geliştirilmesinden önce bir bölgede yapılmasına gerek duyulan oldukça önemli bir analizdir. Çalışma, teorik olarak, Forman ve Gordon tarafından geliştirilen yama-koridor-matris kavramı üzerine kurulmuştur. Burada, yamalar, CLC verisinden elde edilen geniş yapraklı yüzeylerden oluşmaktadır. Koridorlar ise, MatrixGreen (MG) araç kutusu tarafından üretilen bağlantı cizgilerinden belirlenmektedir. Bu makalenin çalışma alanı olarak Arnavutluk Cumhuriyeti alanı seçilmiştir. Çalışmanın sonuçları, CLC verileri ile MG araç kutusunun birlikte kullanımının peyzaj ölçeğinde hızlı peyzaj parçalanması değerlendirmesini mümkün kılan bir zemin sağladığını göstermiştir. Bu çalışma, Dijital Peyzaj Mimarlığı-2017 konferansında (Bernburg, Almanya) sunulmuş olup sonrasında *"MatrixGreen Araç Kutusu ve CORINE Arazi Örtüsü Verilerini Kulanarak Peyzaj Parçalanma Değerlendirmesi" (Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data)* başlıklı bir makale olarak Journal of Digital Landscape Architecture (JoDLA) dergisi'nde yayımlanmıştır.

Bölüm 3'teki çalışma, Alansal İdari Reform (TAR, yerel idari bölümler) sırasında çevre dostu karar verme aracı olarak CLC verilerinin kullanılması için bir yöntem sunmaktadır. Vaka çalışması ve bu araştırmanın ana odak noktası en son Arnavutluk alansal idari reformudur (2014) . İlk önce, CLC verileri söz konusu olan alansal idari reformun bir sonucu olan yeni yerel idari sınırların neden olduğu peyzaj parçalanmasını ölçmek için kullanılmıştır. Bunu yaparken, alandaki çevresel faktörlerin TAR sürecinde dikkate alınmadığı sonucuna varılmış durumdadır. Bunun ötesinde, CLC verileri, başkent Tiran'ın yerel idari sınırlarını yeniden düzenlemek için bir kriter olarak kullanılmaktadır. Sonuç olarak, araştırma, CLC verilerinin, yerel idari sınır çizgisinin neden olduğu peyzaj parçalanmasını en aza indirerek, TAR sürecinin yerel sınırları tanımlama aşamasında başarılı bir girdi olabileceğini göstermiştir. Bu yazı, *"Alansal ve İdari Reformda Çevreye Duyarlı Karar Verme Aracısı Olarak Arazi Örtüsü Verilerinin Kullanımı" (Land cover data as environmentally sensitive decision-making mediator in territorial and administrative reform)* başlıklı bir makale olarak Cogent Environmental Science (Taylor & Francis) dergisinde yayımlanmış durumdadır.

Bölüm 4, afet risk değerlendirmesi ve yangın güvenliğinin yönetiminde (DRMFS) CLC verilerinin kullanımını irdelemektedir. Bu çalışma, tutuşma ve orman yangını olayının yayılmasına neden olan ana faktörleri tanımlamak için literatür taraması ile başlamaktadır. Sonuç olarak, çalışmada hem tutuşma olasılığı hem de yayılma kapasitesi için çok kriterli bir indeksleme çerçevesi önerilmiştir. Çalışma alanı olarak ise 2006 yılının CLC verisinden elde edilen kuzey Arnavutluk topraklarında geniş yapraklı orman yüzeylerinin durumu ortaya konmaktadır. İş akışı üç aşamadan oluşmaktadır; her bir konum için çok kriterli envanter (veri toplama), toplanan verilerin Analitik Hiyerarşi İşleme (AHP) ile analiz edilerek yorumlanması ve bunların Jenks natural break metoduyla (veri yorumlama) kümelemesi ve sonunda, ormanlık yüzeydeki tüm temsilci noktaların yangın tutuşma olasılığının (WIPI) ile yangın yayılma kapasitesinin (WSCI) değerlendirilmesi şeklindedir. Sonrasında, 2006 CLC verilerinden elde edilen sonuçların 2012'nin CLC verileriyle karşılaştırılmasıyla bir doğrulama prosedürü geliştirilmiştir. Çalışmanın sonuçları, geliştirilen modelin orman yangın riskini değerlendirmede tahmin kabiliyetinin yüksek olduğunu göstermektedir. Bu çalışmada geliştirilen yöntem, afet risk değerlendirmesi ve yangın güvenliği yönetimine (DRMFS) dair gündemlerde kullanılabilen hızlı, ucuz ve güvenilirliği yüksek olan bir orman yangını risk değerlendirme modelini bizlere sunmaktadır. Bu çalışma, *"Geniş Yapraklı Orman Yüzeylerinin Orman Yangını Tutuşma Olasılığı ve Orman Yangını Yayılma Kapasitesi üzerinde, GIS Tabanlı bir İndeksleme Metodu" (A GIS based method for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spreading capacity)* başlıklı bir makale şeklinde yayına kabul edilmiş olup Modelling Earth Systems and Environment dergisinde (Springer) yayımlanmaktadır.

Bölüm 5 ve bölüm 6'da, kıyı bölgesi çalışmaları kapsamında CLC veri kullanımı araştırılmış durumdadır. CLC verileri, kıyı peyzajı yapısını analiz etmeyi ve kıyı bölgesindeki doğal peyzajların enine sürekliliğini ortaya çıkarmayı hedefleyen analitik bir iş akışının hammaddesi olarak kullanılmaktadır. Yeni yaklaşım, kıyı alanlarının klasik boylamsal analizinden farklı olarak, kıyı bölgesini enine doğru bir yöneliş ile ele almaktadır. Bölüm 5, Türkiye'nin Akdeniz kıyılarında uygulanan ve bu kıyı bölgesindeki doğal peyzaj katmanları hakkında önemli bulgular ortaya koyan bir yöntemi sunmaktadır.

İlk olarak, bu yöntem peyzaj yamalarının her biri için iki yeni değer atfetmektedir; bant numarası ve enine süreklilik derinliği (TCD). Bant seviyesi, her bir yamanın sahil şeridine fiziksel bağlantı sırasını ifade eden değerdir. Bununla birlikte, TCD değeri, belirli bir yamanın enine süreklilik sağladığı en yüksek bant seviyesine karşılık gelmektedir. Ayrıca, yöntem kıyı bölgesinde enine bağlantılı doğal peyzaj mozaiklerini (TCNLM) haritalamada başarılı olmuştur. Sonuç olarak, belirli bir TCNLM içinde tekil bağlaç niteliği taşımakta olup varlığı tehlike altında bulunan peyzaj yamaları belirlenebilmektedir. Benzer şekilde, kıyı şeridinde, restorasyonu yapıldığı taktirde potansiyel TCNLM'ler için enine devamlılık sağlayabilecek yapay peyzaj yamaları da belirlenebilmektedir. Sunulan yöntem Entegre Kıyı Bölgesi Yönetimi (ICZM) girişimi ve Sürdürülebilir Kıyı Turizmi kapsamında farklı analizlere yardımcı olabilecek durumdadır. Bu çalışmanın sonuçları, sorumlu bakanlıklar veya yerel yönetim birimleri gibi farklı kamu yönetimi ve hükümet organları tarafından kullanılmak üzere sunulmaktadır. Bölüm 5'te sunulan çalışma, *"Kıyı Bölgelerinde Doğal Peyzajların Enine Sürekliliğinin Ortaya Çıkarılması- Türkiye Akdeniz Kıyı Bölgesi Örneği" (Revealing the transversal continuum of natural landscapes in coastal zones - Case of the Turkish Mediterranean coast)* başlıklı makale olarak Ocean and Coastal Management (Elsevier) dergisinde yayımlanmaktadır.

Bir önceki bölümde sunulan çalışmanın ModelBuilder (ArcGIS) programında geliştirilen yönteminin ayrıntılı bir açıklaması, Bölüm 6'da yer almaktadır. Bir araç kutusu olarak geliştirilen model, halihazırda denenmiş olup kıyı şeridi ve arazi örtüsü verisine sahip başka kıyı bölgelerinde başarılı bir şekilde uygulanabilir durumdadır. Ayrıca, model, kıyı şeridi yerine nehir hattını veya gölün çevre çizgisini tanıtarak havzalar gibi farklı alanlarda da kullanılma potansiyeline sahiptir. Bölüm 5 ve Bölüm 6'da, sunulmakta olan yöntemin, su merkezli peyzajların çok ölçekli enine analizine yönelik geliştirilebileceği tahmin edilmektedir. Bu çalışma, *"Kıyı Bölgesinde Doğal Peyzajların Enine Sürekliliğini Göstermek için CBS'ye Dayalı Bir Yöntem" (A GIS-based method for revealing the transversal continuum of natural landscapes in the coastal zone)* başlıklı bir makale olarak MethodsX (Elsevier) dergisinde yayımlanmaktadır.

Yayımlanan makaleleri sunan ana bölümlerin yanı sıra, tez bir adet Giriş (Bölüm 1) ve bir adet Sonuç ve Öneriler (Bölüm 7) bölümünü içermektedir. Bölüm 1, sürdürülebilirlik söylemi ve bilgi teknolojisi çağı birlikteliğinde CLC verilerinin ortaya çıkmasına odaklanan kısa bir giriş niteliğindedir. Bu bölüm, araştırma faaliyetinin ardındaki motivasyonu, hedefleri, araştırma soruları ve hipotezi bizlere sunmaktadır.

Bu tezde sunulan her makale kendi içinde önemli sonuçlar ortaya çıkarmakta ve bazı konuları ileri düzey iyileştirmeler ve gelecekteki adımlar için öne çıkarmaktadır. Tezin son bölümünde ise ortak bir sonuç ve karşılaştırmalı tartışma bölümü sunulmaktadır. Sonuç ve Öneriler bölümünde, araştırma sürecinin sınırlamaları tartışılmış olup bunları gidermek için geleceğe yönelik birtakım hedefler belirlenmiştir. Ayrıca, bu tezde yer almakta olan olguların, CLC verilerinin kullanılabileceği en uygun durumu belirlemek adına karşılaştırmalı bir tartışması yapılmıştır. Sonuç olarak, tezde yer alan çalışmaların toplamı, CLC verilerinin farklı mekansal karar verme ve yönetim süreçlerinde başarılı ve yararlı bir şekilde kullanılabileceğini bizlere göstermektedir.

1. INTRODUCTION

This thesis presents the product of the scientific research process during the doctoral studies by the author at the Graduate School of Science, Engineering and Technology (GSSET) at Istanbul Technical University (ITU). It is organized in compliance with the rules and regulations of preparing a doctoral thesis out of published scientific papers (FBE, 2018). There are five articles included as the main chapters of this dissertation. The complete research activity presented here is driven by Problem Oriented Research (POR) method. Each article is focusing on a specific real-life problem in spatial planning and management. Even though each paper makes a particular case of supporting decision making processes of a diverse and wide spectrum, all of them share one common. CORINE Land Cover (CLC) is utilized as the main raw data of diverse analytical workflows in support of a variety of decision making processes of spatial planning and management. ArcGIS 10.2.2 software package is the main analytical interface utilized in all studies presented in this thesis.

As it is stated in each study, the proposals presented within this thesis do not claim for providing the most successful methodical approach and results. Instead, each study presented here should be accepted as a modest tendency to explore and highlight novel methods of utilizing CLC data in different cases of spatial management discourse.

Instead of searching for a holistic solution[1], the research work presented in this thesis should be considered as a humble laboratory work aiming to develop novel approaches towards well-known spatial management problems by utilizing CLC data as a mean. Each study included here is defining new research paths, which should be explored and improved further as explained in the further steps and future works section.

[1] Which is impossible to be realized within a thesis research. Because, the complexity of real life problems of spatial management require a transdisciplinary approach, including into the research process a variety of stakeholders and specialists.

1.1 Purpose and Goals of the Thesis

The main purpose of this research work is to explore new ways of utilizing open source data such as CLC in decision making processes of territorial planning and management at landscape scale. Fundamentally, CLC data is developed and generated for the purpose of monitoring the landscape dynamics in the European continent in a periodical time basis (every 6 years). Whereas, this thesis presents a variety of cases where CLC data are utilized as the raw material for analytical workflows assisting diverse decision making processes of spatial management.

Another objective of this work is to present research activity motivated by Problem Oriented Research (POR) principles as a crucial methodology for sustainable development (Kueffer et al, 2012). POR has resulted much more successful than theory-oriented research (Lawrence, 1992), as a promising pedagogical method of better preparing future professionals. Problem/ Project Based Learning (PBL) is advocated to equip engineers beyond the technical skills with the ability to identify non-technical aspects of problems, in a context where systems are increasingly larger and their boundaries are not easily identifiable, and where societal rather than technical issues are more influential (Lehmann et al, 2008).

A further purpose of this work is to perform a successful doctoral research work, the results of which can be scientifically validated by being published in blind peer reviewed and internationally indexed scientific journals. As specified in the official regulation by GSSET on the preparation of the doctoral thesis out of published scientific articles, this is a valuable opportunity not only for the author, but also for the institution by contributing to its institutional presence in the international scientific arena (FBE, 2018).

1.2 Common Motivation and Theoretical Basis

Even though the thesis is composed of separate research articles having their specific goals and objectives, they have a common motivation and share one major theoretical background. The motivation relies on the question of how to utilize information technology means in decision making processes through a problem oriented research method. Furthermore, all articles focus on the utilization of a specific land use and land cover (LULC) data set such as CLC as a mean in different processes of sustainable spatial decision making and management processes.

1.2.1 Sustainability in the information age

The awareness about the anthropogenic impact on earth systems is not new. Documented, it dates 400 B.C, when Plato recognizes deforestation as a phenomenon leading to soil erosion and drying of springs (Mooney and Ehrlich, 1997). The adverse consequences of modernist spatial design and planning to natural lands have been loudly denounced starting from the early decades of 20th century. Meanwhile, the passionate criticism settled down by a consciousness on the complexity of spatial planning and management problems. This background has motivated the emergence of sustainability discourse in spatial management.

This research work is motivated by the question on how to expand the utilization of the advancements in technology in crucial decision making and management processes of society in the information age. The computational capabilities of the machine in dealing with big data and complexities of every day problems have far exceeded those of humans. Yet, it is far away from the sensible decision making skills of the human mind. The proper collaboration of both may generate objective holistic solutions to multifaceted real-life problems for achieving sustainability goals.

The successful utilization of different technological development in solving real-life problems of labyrinthine layers of complexity is presented by several authors. For example, Bill Tomlinson in his book "*Greening through IT: Information Technology for Environmental Sustainability*" investigates how the tools and techniques of information technology (IT) can help society tackle environmental problems at large scales and of multifaceted complexities. Tomlinson presents many efforts toward sustainability supported by IT, giving specific examples of research projects and describes theoretical, technological, and social aspects of a growing interdisciplinary approach to sustainability (Tomlinson, 2012).

In spatial planning and management discourse, land usage sustainability is a very crucial topic. In the report of 2015 on the state and outlook of the environment in Europe by European Environment Agency (EEA), the imbalance between unprecedented demands on land and the finite availability of it is highlighted as an unsustainable condition (EEA, 2015). Searching for ways to minimize the "land consumption" is already targeted as a vital objective in policymaking and management agendas at national and local levels. For instance, in the 7th Environment Action Programme of the European Union (EU), the accomplishment of "no net land take" by the year 2050 is targeted as a critical goal (Steenmans, 2016). Landscape transformation trends are very crucial at this stage. Consequently, within this objective, land cover monitoring is set as a significant method of assessing landscape dynamics in a territory.

1.2.2 Land cover monitoring in the sustainability discourse

Landscapes are facing continuous alterations due to the expansionof urbanized areas, transport infrastructure, intensification of agriculture, and extreme natural events (such as floods, wild forest fires, and wind catastrophes). Understanding and measuring these landscape transformation processes is crucial in sustainably managing them. With this purpose, there have been developed a considerable amount of landscape monitoring initiatives focusing on the land cover properties of a territory (Feranec, 2016).

The spatio-temporal dynamics of land-cover within a region is advocated to be useful in developing effective concepts for sustainable land management strategies (Reger et al, 2007). According to Mücher (2009), monitoring activity consists of a procedure which implicates systematic measurements of a phenomenonin time. The measurements have to be performed at least twice to enable quantitative and qualitative assessment of alterations of the targeted objects leading to thoughtful ideas on the processes that are behind these changes.

LULC change is accepted an essential part of monitoring the global environmental changes, consequently on important measurable target in sustainability research. This cross-disciplinary research area aims to examine the dynamics of LULC as a joined human-environment system in order to address theory, concepts, models, and applications significant to environmental and societal complex problems (Turner et al, 2007).

There are different monitoring projects and initiatives aiming to track the landscape dynamics in a global scale. For example, Global Land Cover (GLC) 2000 being developed by Joint Research Centre (JRC) and relying on the Food and Agriculture Organization (FAO) Land Cover Classification System (LCCS), combines context-specific thematic inputs and a generalized global classification method. GLC stresses on the boundary condition among ecosystems such as forest, grassland, and areas of agriculture. Even though it cannot be categorized as a pure monitoring procedure since it is an assessment not targeted to be performed periodically, definitely, it is one of the core LC datasets being utilized in the Millennium Ecosystems Assessment. At the very end, it succeeds to deliver an essential framework of land monitoring (Haubold and Feranec, 2016). More in detail, Mora et al. (2014) provide a further comprehensive review on global LC inventory.

1.2.3 LC and LU monitoring programs in Europe

Harmonized European Land Monitoring (HELM) project systematically documents the current and past of landscape monitoring in Europe (Blanes and Green, 2012), which are summarized by Ben-Asher et al. (2013). Some of the most important LULC monitoring initiatives in European scale are included in the following paragraphs. The presented European LULC cover monitoring programs are tabulated in Table 1.1, giving ground for a comparative reading among them.

First, the LU and LC monitoring project known as CLC (CoORdination of Information on the Environment- CORINE Land Cover) was initiated in the European Union in 1985 as a centralized, remote sensing based LC mapping effort finalized with its first LC dataset of CLC1990. CORINE was thus the first pan European LC mapping process with a coherent nomenclature and since then it has been the standard for a pan-European land monitoring system aiming to ensure consistency of such information and compatibility of data among all stakeholders (Heymann et al, 1994). CLC relies on satellite data from Landsat, Indian Remote Sensing (IRS), and Satellite Pour l'Observation de la Terre (SPOT, Satellite for observation of Earth) as well as ortho-photos and topographic maps. CLC data have been integrated to the harmonized observations of Earth at a global scale by Global Earth Observation System of Systems (GEOSS) via Copernicus Land Monitoring Services (Feranec, 2016).

Copernicus Land Monitoring Services (EEA) is another pan-European monitoring project which delivers five High-Resolution Layers (HRLs). Currently, they are incomplete without covering the whole European map. The surfaces are classified by their properties such as imperviousness, forests by their tree cover density and forest type, permanent grassland, wetlands, and permanent water bodies. IRS-P6, Resourcesat, and RapidEye are the primary remote sensing satellites which provide the main data sources in 20-m resolution of satellite images. The LULC mapping is performed with a Minimum Mapping Unit (MMU) of 1 ha and is produced in a semi-automated way.

Another monitoring program is Monitoring Land Use/Cover Dynamics (MOLAND) performed by the Institute for Environment and Sustainability at the JRC. MOLAND program monitors landscape dynamics for 40 urban dominated territories within Europe. The workflow starts with dataset production which documents the current and previous LU evolution in selected areas (urban, region, corridor, etc). As a second step, socioeconomic statistical datasets are integrated with the maps. Finally, different scenarios of urban transformations are forecasted to assess the sustainability of the development of urbanized regions in European. Barredo et al. (2003) give a detailed methodological description about MOLAND model, which relies on a bottom-up approach of spatial dynamics and can be categorized as Cellular Automata (CA) model (Petrov et al, 2009). As a result, estimations of future LU alterations and its impact on the environment serves as guidance for environmental policy.

A further monitoring program dealing with the urban scale is Urban Atlas (UA), which is produced as part of the EEA—coordinated Copernicus land services as part of Global Monitoring for Environment and Security (GMES) (Montero et al, 2014). Within the scope of UA, there are generated LC maps with 17 urban (MMUs of 0.25 ha) and 10 rural and (semi) natural surfaces (MMUs of 1 ha) classes. SPOT-5, Formosat-2, Kompsat-2, and ALOS satellites provide the primary data. At this stage there exist available spatial data for 2006 and 2012, being linked to the Urban Audit of EUROSTAT covering most municipalities with more than 50,000 inhabitants (Haubold and Feranec, 2016).

The last monitoring program worth to be mentioned here is the Land Use/Cover Area Frame Statistical Survey (LUCAS) coordinated by European Statistical Office (EUROSTAT) and carried out in 2001 and 2003 in the European Union (EU15). It does not rely on a remote sensing methodology; instead it deals with field surveys within an area frame of 270,000 locations in a regular grid. LUCAS utilizes statistical methods to provide data for monitoring of agro-environmental indicators in Europe through LC and LU mapping in the EU. The work started in 2001 within a framework of a cooperative effort between EUROSTAT and General Directory of the EU for Agriculture (DG AGRI) supported by the JRC (Haubold and Feranec, 2016). LUCAS is particularly advantageous for area estimation in geographic units that do not match with administrative regions. For example, it is of use to coastal areas within a 10 km buffer zone from the coastline (Gallego and Bamps, 2008).

Table 1.1 presents a full listed overview of the major LC and LU monitoring programs in the global and European scales. CLC is the pioneering program initiated in 1985, followed by GLC 2000 started ten years later. The innovative programs such as CLC, GLC 2000, and MOLAND provided geospatial data of a coarse scale, varying in resolution between 1 and 25 ha. Later programs such as Urban Atlas, LUCAS, forest cover map for Europe deliver data at a finer spatial scale at a resolution varying between 0.1 and 1 ha. The need for going finer in spatial scales is an indispensable result of the insufficiencies of the former one such as CLC, to deliver reliable evidence in support of environmental problems at finer scales (Haubold and Feranec, 2016).

Table 1.1 : Pan-European and Global land monitoring initiatives (Haubold and Feranec, 2016).

Title of Monitoring Program	Beginning of Activity	Reference Years	Spatial Resolution
CORINE Land Cover (CLC)	1985	1990, 2000, 2006, 2012	25 ha
Copernicus High Resolution Layers (5 themes)	2011	2006/2009/2012 (varies per theme)	1 ha
Copernicus local component (urban atlas, riparian zones)	2009, 2014	2006, 2012, 2012	0.25–1 ha and 0.5 ha
MOLAND	1998	Varies per study area	1 ha
Forest cover maps for Europe	1990	1990, 2000, 2006	25 m
LUCAS	2001	2006, 2009, 2012	270,000 points
Copernicus global component (five topics)	2009		1 km (varies per product)
GlobCorine	2002	2005, 2009	300 m
GlobCover	2002	2005, 2009	300 m
Global Land Cover 2000 (GLC 2000)	1995	2000	30 arc seconds

This fact is discussed as a critical part within each study presented in the thesis. Furthermore, the further development of the presented methods at finer spatial scales is set as a future step for each case study. For example, the critical fragmented regions highlighted within Chapter 2 are targeted as areas to be studied at finer scales in order to further investigate the fragmentation condition among broad-leaved forest surfaces. Similarly, the endangered natural landscape patches identified within the article presented in Chapter 5, are targeted as focal study areas to be further investigated at finer spatial scale.

1.2.4 CORINE land cover (CLC) monitoring program

Co-Ordination of INformation on the Environment (CORINE) is a monitoring program approved by the European Commission (EC) on June 27, 1985 with the objective of creating a thematic information system about the state of the environment within the European Union (EU). Another purpose of this program was the establishment of a common ground with shared compatible data about the pan-European among EU member states. In 1990 European Environment Agency (EEA) has been founded with the primary expertize to coordinate actions within CORINE program. European Environment Information and Observation Network (EIONET) was established by EEA, aiming to integrate all results of the CORINE program produced by national teams into a common European system (Feranec, 2016).

1.2.4.1 The History and Evolution of CLC projects

The CLC1990 project was the first delivery implemented under the support of the EC. There were 27 countries in total collaborating in it between 1986 and 1998. The next three CORINE projects (2000, 2006, and 2012) have been supported by 39 European countries. A full list of participating countries for each CLC project packages is provided in the Table A.1 (App). Detailed technical specifications about the satellite data used, time consistency, geometric accuracy of the satellite images and the CLC data, MMU, thematic accuracy, production time, documentation, data accessibility, and participating countries for each CLC project package are presented in Table 1.2.

After the first successful experience of CLC project shared as CLC1990 data, the EEA and the JRC launched the IMAGE2000 and CLC2000 joined project. The main objective of I&CLC 2000 project was to provide a satellite image of Europe (IMAGE2000), an up-to-date LC database for the year 2000 (CLC2000), and information on general LC transformations in Europe during the period between 1990 and 2000 ($CLCC_{1999-2000}$) (Steenmans and Perdigão, 2001; Feranec et al, 2007).

Table 1.2 : Evolution of the CLC Projects (Büttner, 2014).

	CLC1990 Specifications	CLC2000 Specifications	CLC2006 Specifications	CLC2012 Specifications
Satellite data	Landsat-4/5 TM (in a few cases Landsat MSS) Single date	Landsat-7 ETM Single date	SPOT-4 and/or IRS LISS III two dates Dual date	IRS P6 LISS III and RapidEye Dual date
Time consistency	1986–1998	2000 ± 1 year	2006 ± 1 year	2011–2012
Geometric accuracy satellite images	≤50 m	≤25 m	≤25 m	≤25 m
CLC minimum detecting unit/ width	25 ha/100 m	25 ha/100 m	25 ha/100 m	25 ha/100 m
Geometric accuracy of CLC data	100 m	Better than 100 m	Better than 100 m	Better than 100 m
Thematic accuracy CLC data	≥85% (not validated)	≥85% (validated; see Büttner and Maucha, 2006)	≥85% (not checked)	≥85%
Change mapping CLCC	Not implemented	Boundary displacement min. 100 m; change area for existing polygons ≥5 ha; isolated changes ≥25 ha	Boundary displacement minimum 100 m; all changes ≥5 ha are to be mapped	Boundary displacement min. 100 m; all changes ≥5 ha are to be mapped
Thematic accuracy, CLCC	–	Not checked	≥85% (Büttner et al., 2011)	≥85%
Production time	10 years	4 years	3 years	2 years
Documentation	Incomplete metadata	Standard metadata	Standard metadata	Standard metadata
Access to the data (CLC, CLCC)	Unclear dissemination policy	Dissemination policy agreed from the start	Free access for all users	Free access for all users
Number of European countries involved	27	39	39	39

According to the Table 1.2, there is an obvious continuous progress in some of the specifics of CLC project through years. For example, the progressive improvement rate is inferable from the specification on "production time", which track a continuous decline from 10 years to 2 years of time span for production. Similarly, the geometric accuracy of CLC data is improved in 2000, 2006, and 2012 compared to that of 1990. Further comparing the same years, the number of involved countries have raised from 27 to 39. This fact implies for a pan-European territorial coverage of available CLC data, which is very crucial for trans-boundary environmental assessment and management policies. A last but not least advancement among CLC project is related to the availability or public accessibility of CLC data. The open access policy on CLC data availability is very crucial not only for transparency and public information but also a tremendous opportunity for scientific research at all levels to explore further utilities of CLC data.

1.2.4.2 CLC nomenclature and classification method

Heymann et al. (1994) give a thorough report on the CLC nomenclature methodology in the Technical Guide. The fundamental objective is the organization of landscape units into groups by their hierarchical relationships as shown in Figure 1.1 (McConnell and Moran, 2001). Other goals of the taxonomy were; classifying all landscape surfaces to a certain category, the heading classes should be compatible with the goals of environmental agendas, and it should be clear enough to avoid any vague term.

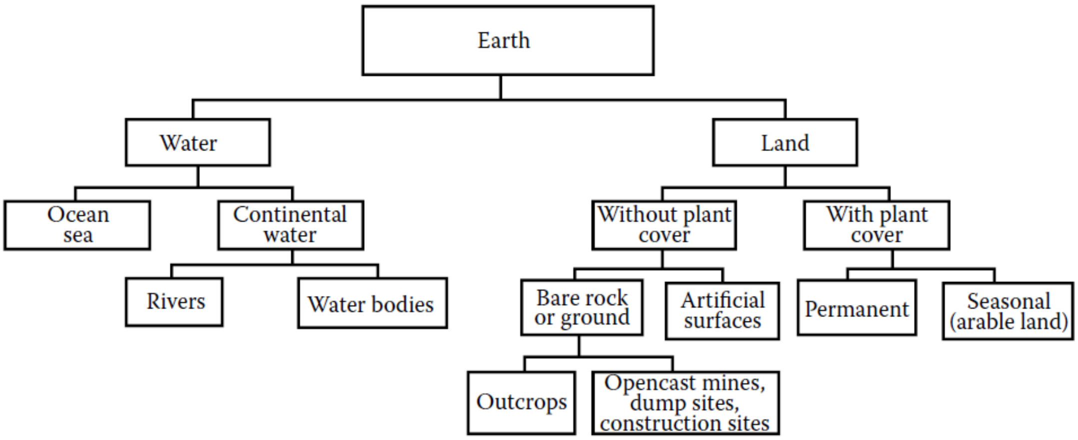

Figure 1.1 : Theoretical schematic construction of a land cover nomenclature. (Heymann et al, 1994).

First, landscapes on the Earth surface are clustered into two basic groups: Water and Land, further specified: Ocean and Sea, Continental water, Land without plant cover, Land with plant cover, and so forth. CLC nomenclature groups these sets of objects into 5 classes of the first level (see Table 1.3), 15 classes of the second level, and 44 classes of the third level (Feranec et al, 2016). It is important to be mentioned that at the final level CLC taxonomy includes several combinations of LC and LU simultaneously (Di Gregorio and O'Brien, 2012). A detailed information on the nomenclature composition and the brief explanation for each LU and LC classes is provided in Table A.2 (App).

While CLC data up to the 3rd level has been successful enough to deliver land cover evidence in pan-European and national scales, it remains insufficient to support decision making processes at national and local scales. Consequently, many efforts have been spent to develop further detailing procedures in refining the CLC data towards the 4th and the 5th level (Hazeu et al, 2016). For example, Slovakia has been among the pioneering countries to develop a national LC database extending CLC data by 105 classes at the 4th level (Feranec and Otahel, 1998). Similarly, there exist similar projects producing CLC data at the 4th level for Turkey as well (Sertel et al, 2017), which extends with 75 classes. Yet, within the scope of article 4 (Chapter 5) which makes the case of the Turkish Mediterranean coast it has been decided to proceed with the data of the 3rd level nomenclature. This is due to the goal of the study to develop a universal model applicable to other study areas using the equivalent CLC data available as an open source via EIONET portal.

Table 1.3 : Physiognomic attributes relevant for identification of CLC classes (Feranec et al, 2016).

Main CLC Classes (1st Level)	Description of 1st Level CLC Classes
Urban fabric areas	Size, shape, and density of the buildings, share of supplementing parts of the class (e.g., square, width of the streets, gardens, urban greenery parking lots), character of transport network, size and character of neighboring water bodies, arrangement of infrastructure, size of quays, character of the runway surfaces, state of the dumps, and arrangement and share of playgrounds and sport halls
Agricultural areas	Share of dispersed greenery within agricultural land, arrangement and share of areas of permanent crops, relationships of grasslands with urban fabric, occurrence of dispersed houses (cottages), arrangement and share of agricultural land (arable land), grasslands, permanent crops and natural vegetation (mainly trees and bushes), irrigation channel network
Forest and seminatural areas	Character (composition), developmental stage and arrangement of vegetation (mainly trees and bushes), share of grass and dispersed greenery (composition density)
Wetlands	Character of substrate, water, and vegetation
Water bodies	Character (shape) of water bodies

Regarding the scale, CLC data at the 3rd level is appropriated for 1:100 000 spatial scale. The size of the smallest identified area (MMU) of classes CLC is 25 ha and the minimum width of the linear feature is 100 m. In case of smaller patches than MMU (less than 25 ha), a generalization procedure is applied to rely on the similarity between a small object and the valid objects in the neighborhood (Bossard et al, 2000). For example, a small vineyard is joined to neighboring non-irrigated arable land rather than to a discontinuous urban fabric. It can be inferred that the generalization process is relatively easier for an experienced photointerpreter than the automated generalization (Büttner, 2014). Even though the 25-ha MMU is obligatory in the European CLC datasets, in Finland and Sweden, a semi-automated method of interpretation was applied to generate LC data with an MMU less than 25 ha. Yet, before being delivered they were integrated into the standard European CLC dataset by being generalized into objects with the 25-ha MMU (Engberg, 2005).

Regarding the methodology used, in the conventional procedure CLC mapping is performed manually by the photo interpreter. He defines landscape objects by their properties (shape, size, color, texture, and pattern) and assigns CLC classes as natural, modified, or human-created (see Table 1.3). The spatial/contextual relationships between landscape objects make it possible for the interpreter to comprehend the content of patterns specific to individual CLC classes. Meanwhile, technical circumstances and user requirements of CLC have changed considerably since the beginning. There has been an increasing number of countries that have started to adopt semiautomatic approaches of CLC production instead of the conventional visual photointerpretation. Basically, this is done to avoid high labor costs of photointerpretation and to improve reproduction and consistency among national datasets (Feranec et al, 2016).

Although the position of methods of digital processing of satellite images in identification of LC classes and their changes has several advantages as mentioned above (Coppin et al, 2004; Rogan and Chen, 2004; Treitz and Rogan, 2004; Chen et al, 2012; Pouliot et al, 2012), visual photointerpretation and computer-assisted photointerpretation (CAPI) methods remain important as well (Steenmans and Perdigao, 2001). Produced data goes through quality control (QC) and quality assurance (QA) processes to (i) verify and (ii) validate the CLC delivery. Verification the first QA/QC activity having a corrective goal during the production process. Via its feedback loops, it is a tool for geometric correction and thematic harmonization of CLC data. A further type of QA/QC activity is validation being a post-production process. It relies on data higher in resolution compared with those used during the production process. According to the results of QA/QC activities produced CLC data are either accepted, conditionally accepted, or rejected (Büttner et al, 2016).

Regarding the material used for CLC data production, before settling on satellite images, during the feasibility studies of 1985 many tests have been performed utilizing ground survey or aerial photos. The advantages of the remote sensing approach are evident since it delivers synoptic views of the Earth's surface by providing information for much larger regions than the aerial survey method. Furthermore, the ability to replay exactly the same observation in a periodical basis gives floor to land use/land cover (LU/LC) changes to be periodically monitored (Soukup et al, 2016). For mapping purposes of CLC data production there are used high-resolution sensors of 10-30 m of pixel size.

1.2.4.3 Landscape transformation via CLCC

Besides the CLC core data, CORINE Land Cover Change (CLCC) is periodically being produced as an opportunity to analyze and assess the European landscape changes as a consequence of socioeconomic and natural processes (Feranec, 2016). Basically, it is a spatial comparison between two consecutive sets of CLC data. The differences between CLC spatial data of two different years provide evidence on the landscape transformation during a specific period. At the moment, there are three CLCC datasets available; $CLCC_{1990\text{-}2000}$, $CLCC_{2000\text{-}2006}$, $CLCC_{2006\text{-}2012}$.

As previously mentioned, in CLC data production methodology it has been applied an MMU of 25 ha. Whereas, for CLC change (CLCC) mapping, it was necessary to reduce the MMU for changes to 5 ha to produce the policy-relevant information at the European scale. This resulted in a much more detailed CLCC layer than is possible in the CLC status layers (MMU ratio is 25/5 = 5) (Büttner et al, 2002). Alteration in spectral reflectance of two different satellite images of the same territory is the major factor in identifying changes in LC. Shape, color, texture, and pattern are among changing characteristics of identifying parameters of an image that can define alteration in LC. There are two methods being used for finding out the LC changes (EEA-ETC/TE, 2002) such as (i) CAPI and (ii) semiautomated methods. Updating or backdating of an LC data layer becomes crucial at this stage (see Figure 1.2; Feranec et al, 2005). For further details regarding the methodology, the workflow by Feranec et al. (2005) is represented in Figure A.1 (App).

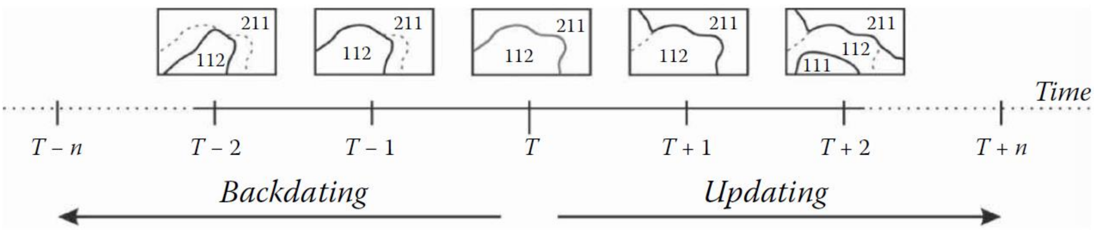

Figure 1.2 : Basic principles of Updating and Backdating (Feranec et al, 2005).

By comparing the former and the current land cover class of alternated patches, it is possible to track the thematic spatial distribution of land cover transformations in Europe. For example, an area within a city in 2006 could be classified as arable land

(CLC-210), but during the following six years, the area could have been built, and thus it can be classified in 2012 as discontinuous urban fabric (CLC-112). Figure 1.3 presents the changing rates distribution of LC among European countries based on $CLCC_{2000-2006}$ data. Referring to the chart in Figure 1.3, Portugal is the country with the highest rates of landscape transformation between 2000 and 2006. This rate is in accordance with the severity of forest fire events during the summer season in Portugal which every year transform tremendous amount of natural surfaces into burned area.

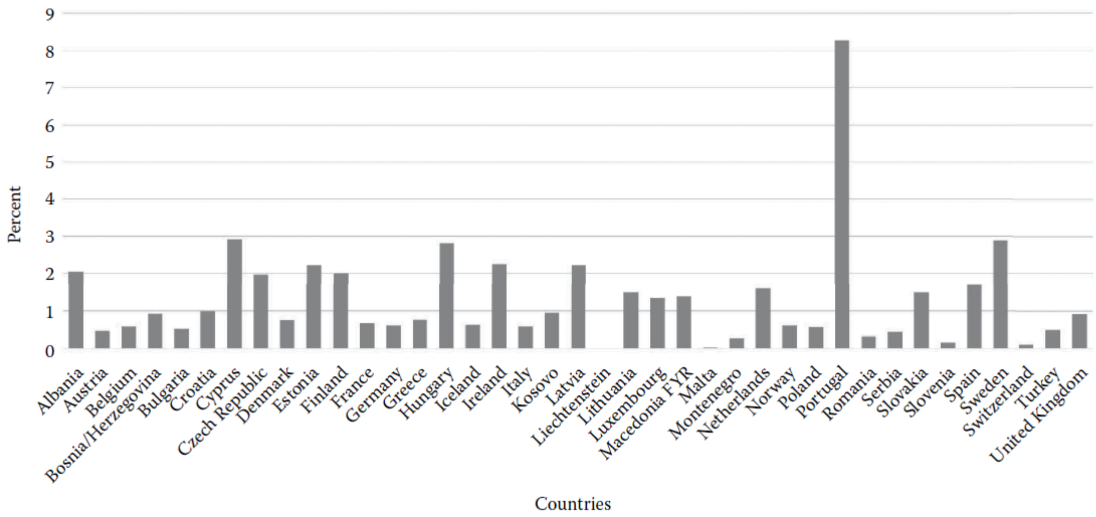

Figure 1.3 : Percentage of a country’s surface affected by LC changes in 2000–2006 (Soukup et al, 2016).

1.2.4.4 CLC utilization in environmental problems at coarse spatial scale

CLC utilization in scientific research work is obvious through the presence of CORINE land cover keyword in the international scientific indexes such as SCOPUS (Figure 1.4). CLC data is reported to have been successfully used in different environmental problems on European scale. Among the most successful ones are; Trend of Land Cover Changes in Europe in 1990–2012 (Soukup et al, 2016b), Landscape Fragmentation in Europe (Jaeger et al, 2016), Ecosystem Mapping and Assessment (Erhard et al, 2016), High Nature Value Farmland and the Common Agricultural Policy (Martins et al, 2016), Land and Ecosystem Natural Capital Accounts (Weber and Jaffrain, 2016), and Land Use and Scenario Modeling for Integrated Sustainability Assessment (Lavalle et al, 2016). CLC methodology is being successfully adopted to other cases outside Europe such as Tunisia, Central America, Colombia, Burkina Faso, Gabon, Mali, etc (Jaffrain, 2016).

Furthermore, CLC data have been useful in revealing the trends of landscape transformation in a longer time span, covering a series of CLC data. In other words, besides the changing rates comparing two consecutive LC data, it is important to recognize the main alteration trends in the European landscape during the entire period 1990–2012 which includes four CLC and three CLCC data.

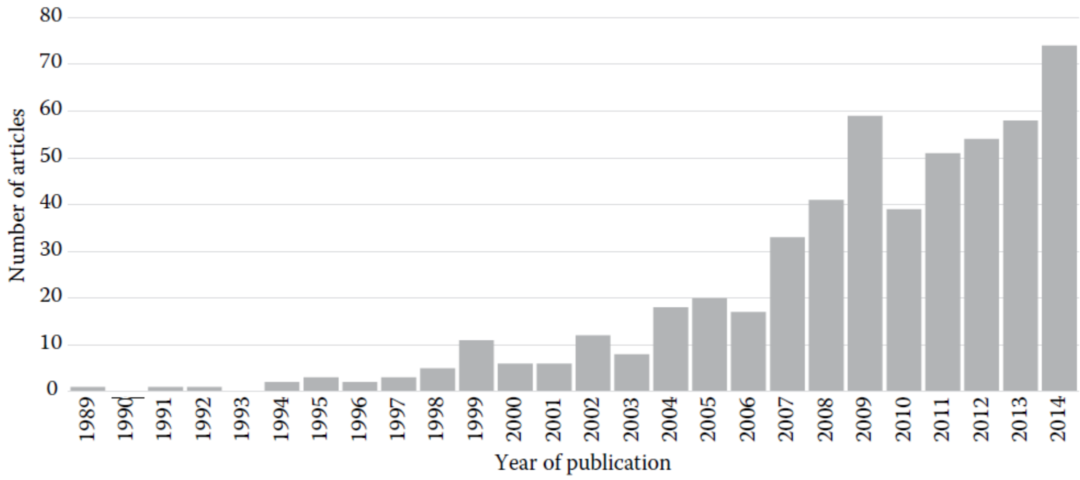

Figure 1.4 : Number of journal articles using the term CORINE land cover extracted from SCOPUS (Feranec et al, 2016).

Principally, LC is indissoluble from landscape; it reveals its state in various stages of transformation. Consequently, it is a relevant information source in assessing the processes (flows) of the landscape within a territory. Haines-Young and Weber (2006) in their work convert LC changes into LC flows (LCFs) based on the second level of CLC data and present the spatial distribution of LC alterations through LCF intensity maps. The changes, categorized into LCFs, represent seven major LU processes (Feranec et al, 2010); Urbanization (LCF1), Intensification of Agriculture (LCF2), Extensification of Agriculture (LCF3), Afforestation (LCF4), Deforestation (LCF5), Construction and Management of Water Bodies (LCF6), and Other Changes (LCF7) (Soukup et al, 2016b). For example, Figure 1.5 presents the spatial distribution of deforestation processes (LCFD5) in Europe in the periods of 1990-2000, 2000-2006, 2006-2012.

Referring to the map in Figure 1.5, there are certain regions that are highlighted for the highest rates of deforestation processes (Ex; Portugal, western France, Latvia, etc.). In the case of Portugal, the information delivered in Figure 1.5 supports the previously discussed idea of landscape transformation caused by wildfire forest fires, against natural lands such as forest surfaces. Yet, even though the overall CLC experience is evaluated as a very successful pan-European monitoring program, its utilization in different decision making and management processes of environmental problems is not enough explored.

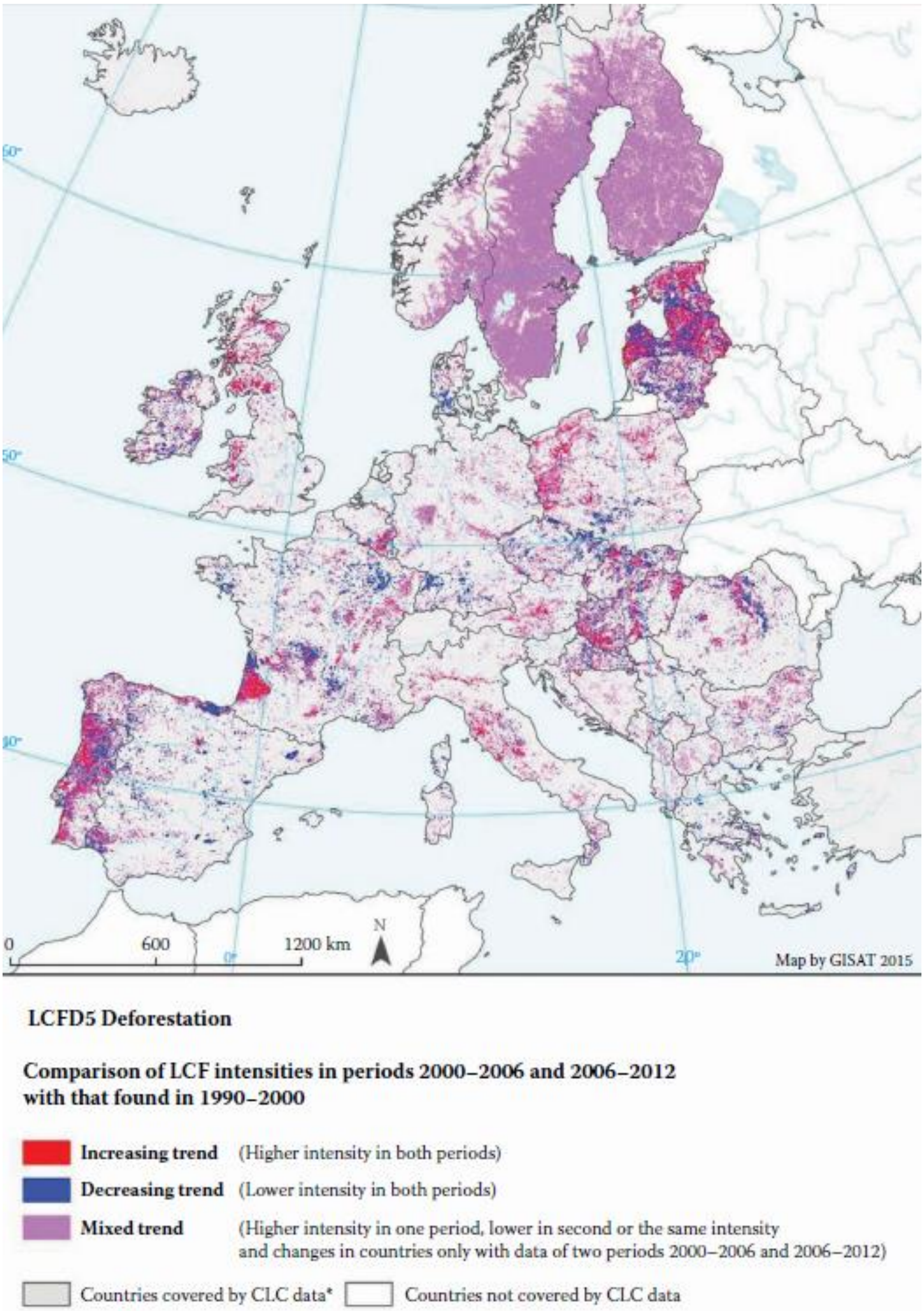

Figure 1.5 : Spatial distribution of deforestation in European countries in 1990–2000–2006–2012 (Soukup et al, 2016b).

1.3 Research Questions and Hypothesis

The major query of this thesis is to question the utility of CLC beyond its fundamental monitoring purpose. The question is expanded by defining more than one problem, leading to at least three diverse cases of CLC utilization in decision making processes in spatial planning and management. Besides this major question, each chapter (2 to 6) which presents different case-problems, brings their specific research questions as an extension to the major former one.

The main question of the work presented in Chapter 2 is how landscape fragmentation at a landscape scale can be quantified using CLC data via Geographical Information Systems (GIS). Chapter 3, tries to find answers to how CLC data can assist the process of a Territorial and Administrative Reform (TAR) in reducing natural landscape fragmentation caused by local administrative borders. First, CLC data are tested as a measure to quantify the landscape fragmentation caused by the existing local administrative boundaries. Later, they are asked as boundary definer means in deciding on the local borderline within TAR processes.

CLC data utilization in Disaster Risk Management and Fire Safety processes (DRMFS) for forest wildfire phenomena is examined in Chapter 4. The main question of this chapter is how to develop a multi-criteria indexing method for forested areas (as derived from CLC data) by their wildfire ignition probability and wildfire spreading capacity. In other words, what are the likelihood of each subarea within a forested landscape patch to have a wildfire event occurring and the danger that the occurrence be further spread.

Finally, CLC data utilization is questioned within coastal zone management. The main hypothesis of the work presented in Chapter 5 and Chapter 6 is that coastal zones should be analyzed in their transversal structure besides their longitudinal one. Especially, within Integrated Coastal Zone Management (ICZM) and Sustainable Coastal Tourism (SCT) the expanding of the coastal zone in the transversal direction is very crucial. More specifically, using CLC data as the raw data of the analytical workflow, the article presented in Chapter 5 questions the transversal structure of natural landscapes along the Turkish Mediterranean coastal zone, by highlighting the current potentials and threats. Whereas, the question on how to develop an automated toolbox in ArcGIS/ ModelBuilder applicable for any coastal zone case study, is aimed at the Chapter 6.

1.4 The Research Process of the Thesis

A crucial step of the research process of this thesis is the definition of the case problems in which CLC data could be thoughtfully utilized. In fact, the case problem selection process has not been at one specific time during the thesis research timeline. On the contrary, the case problems are defined within a spread in a time period between 2015 and 2018. Yet, the main objective during this searching for relevant problems has remained the same as to define diverse case problems of spatial decision making and management in which CLC data could be utilized for.

1.4.1 Definition of case problems

First, the research process was oriented towards the topic of "landscape fragmentation" phenomenon at a gradient of spatial scales proceeding in a descending order from coarse to fine scales. At this stage, CLC data emerged to be a raw material which is reliable and open source. Due to its spatial scale and minimum mapping unit (MMU), it figured out to be appropriate for landscape fragmentation assessment at the coarser spatial scale. The initial work of the first research article presented in Chapter 2, was based on the abovementioned preparatory work. The research process of the first article was performed between September 2016 and May 2018, being presented at the conference of Digital Landscape Architecture (DLA) in Bernburg, Germany.

After the first research article (Chapter 2), based on the objective of the thesis to search for methods of CLC data utilization in various case problems, instead of proceeding with a finer scale[2], it has been decided to explore other case problems where CLC data could be used. The second[3] case problem selection was initially motivated by a will to attend to an important international scientific event such as MEDCOAST conference[4]. As a result the analysis of landscape properties with a main focus on the landscape fragmentation/ connectivity within the coastal context based on CLC data, has been targeted as the second case problem. Due to financial problems, the work could not be

[2] This has been targeted within the first article as a future step of the research.
[3] Chronologically the 2nd . in the thesis it refers to the article 4 and article 5 (chapter 5 and chapter 6)
[4] http://medcoast.net/

presented at the event, but it was improved further and published at Ocean & Coastal Management journal. The research process of this article was performed between April 2017 and May 2018.

The next case problem (Chapter 3) emerged as a result of some research questions raised from a debate happening in Albania between 2013 and 2015 regarding the new territorial and administrative reform the country should adopt. Still, the main question remains landscape fragmentation, but in this case, it refers to the one caused by administrative borders. The main focus of this study is the cross-border natural surfaces as derived from CLC data. While the study presents the landscape fragmentation assessment within the national territory, the application of the proposed method of redefining environmental friendly local administrative borders was tested in the case of Tirana municipality. Among the selection criteria are; capital city, a large number of neighboring municipalities, and considerable total surface area.

The final case problem was identified during my engagement as a researcher in an Erasmus+ project called K-Force, Knowledge FOr Resilient soCiEty[5]. This experience has boosted a research interest on disaster risk management and fire safety engineering at the landscape scale. As a result, it has emerged the idea of developing a multi-criteria indexing method for forested areas based on their wildfire ignition probability and wildfire spreading capacity. CLC data served as the study area identifying mean, as well as the reference while defining the MMU of the presented method. At this stage, the method is tested in a broad-leaved forest surface within Albanian territory. The specific forest surface was selected based on the following criteria; the moderate surface area of the forested landscape patch, its regular form, the presence of a later burned area within its surface.

1.4.2 Selection of study areas

The study area selection has been a decision taken not separately from the case problem definition process. In other words, the defined case problem generally emerges as a result of a phenomenon within a specific physical context. For example, the assessment of the transversal landscape connectivity within the coastal zone (Chapter 5) suggested the Turkish Mediterranean coast among the most relevant study

[5] http://kforce.uns.ac.rs/

areas within the northern Mediterranean coastal areas. The length of the coastline and the considerable depth from the coastline to the inner continental lands enabled a transversal scan of the coastal landscapes. The Spanish Mediterranean coast is projected as a potential study area too, which is included in the future steps of this research. Furthermore, there are other specific characteristics of the Turkish Mediterranean coastal zone, which are presented in Chapter 5 of this thesis.

Besides the Turkish Mediterranean coast, a second physical context is the territory of Albania which has been used as the study area for the studies presented in Chapter 2, Chapter 3, and Chapter 4 of this thesis. The study area selection has been driven by the specifics of the case problem. For example, the case problem of landscape fragmentation caused by territorial and administrative reform (TAR) (Chapter 3), emerged as a vivid case discussion already happening in Albania during recent years. Thus, the Albanian TAR has been selected as a current case in which CLC data be suggested as environmentally sensitive decision making facilitator during the local administrative borders definition phase.

Whereas, in Chapter 2 and Chapter 4, Albania is selected for its moderate-sized territory being appropriate for rapid conceptual approach development. Another crucial aspect suggesting Albania as a relevant study area is the fact that there is a lack of similar studies for the Albanian territory. Indeed, the Albanian territory bears within many unexplored potentials of natural and cultural landscapes.

Albania is positioned within the western Balkan countries, being bordered by Montenegro on the northwest, Kosovo on the northeast, the Republic of Macedonia on the east, and Greece on the south. The western part is bordered by the Adriatic and Ionian Seas as part of the larger context of the Mediterranean Sea (Eftimi, 2018), facing the Apennine Peninsula (Figure 1.6). It covers a geographic area between 42° and 39° N, and 21° and 19° E, covering a surface area of 28,748 km^2 (11,100 square miles).

Albanian natural landscapes are characterized by a diverse typological structure due to the variety of topographical features, climate, and natural resources. Albania is mainly a mountainous geography consisting; 28% of mountains. 47% of hills, and 25% of plain areas that do not exceed 300 m of altitude. The average altitude of the topography is 708 m, doubling the average of the European continent (Mullaj et al, 2017). Even though it covers not more than 0.3% of the European territory, it makes a home for more than 30% of flora and fauna types existing in Europe (Mullaj et al, 2017). But, currently, due to many reasons the natural sites are facing considerable threats from different sources.

Figure 1.6 : The geographical location of Albania (Google Maps, 2018).

Deforestation processes due to excessive and often illegal timber harvesting (Naka et al, 2002) and natural monuments degradation due to the lack of maintenance are among the core factors raising the risk. Furthermore, Albanian natural landscapes are under threat of mega projects of infrastructural character. For example, within the cascade of Vjosa and the valley of Valbona there are hydropower plants under construction. These are considered as threats to the most significant natural and cultural landscapes of Albania which is arising a lot of debate. Another megaproject putting at risk another unique case of natural and cultural landscapes is the Trans-Adriatic Pipeline (TAP) which is in the final phases of implementation. The TAP pipeline tracks along the Osumi valley which is a unique touristic attraction not only for its natural beauty but also for its rich and diverse cultural landscapes within the Albanian context.

The Albanian cultural landscapes can be classified into the following types; (i) historical areas, (ii) revived sites, (iii) and livable neighborhoods. The first category includes examples dating back to Hellenistic, Roman and Ottoman periods such as;

archeological sites, castles, settlements, etc. This category of cultural landscapes is the purest example of traditional landscapes in a territory (Antrop, 1997), being physically in the most harmonious adaptation with the surrounding natural landscapes. This type of cultural landscapes includes historical neighborhoods within some Albanian cities like Berat, Gjirokastra, Korca, Shkodra, Elbasan, etc. These inhabited historical urban clusters are considered a real demonstration of the socio-cultural characteristics of Albanian urban life. Yet, they have been under continuous pressure from unregulated urban developments during the post-socialist period. The last group of cultural landscapes consists of the post-WWII developments which are can be split into two subcategories; socialist and post-socialist periods (Dervishi and Hysa, 2018).

First, according to Rugg (1994), there are four communist legacies in the Albanian natural and cultural landscapes transformation. The Myzeqe Plain, as one of the most significant landscape transformation examples, has been altered from "a desolate wasteland covered with spreading water areas and impassable swamp forests" (Veith, 1920), into a fertile irrigated land. In the land use/ land cover maps of 1928 by H. Louis, Albanian territory consisted of 10.4 % in lakes and swamps, 19 % cultivated, 57 % in pasture, and 13.6 % in forest and brushwood (Zavalani, 1938). Due to the agricultural, industrial and demographic expansion between 1959 and 1993, the forest area decreased by 20 % (Meta, 1993). Meanwhile, during the socialist period due to reforestation programs, there have been reforested more than 100 000 ha in total (World Bank, 1996) peaking at 5000 ha/year in the 1970s (Çarçani, 1994). A final type of cultural landscapes emerging during the socialist period is of security or military character such as; bunkers, tunnels, and other dominant army facilities. There are 173,371 bunkers documented to have been built till 1983, being still present as unique elements of Albanian cultural landscapes testimony (Stefa and Mydyti, 2012).

Whereas the first two decades of the post-socialist period (the 1990s and 2000s) were dominated by a process of "anarchical" urban, and peri-urban sprawl being related with the free domestic migration processes during the same period (Strazzari, 2009). According to Aliaj and Lulo (2003), Tirana spatially grew by 37% while its suburbs expanded by 400%, between 1995-1999. The urban expansion is dominated by multi-family housing units. Referring to Pojani and Baar (2016), there have been built more than 100 000 condominium units only in Tirana by the year 2015. The rapid transformation dynamics of the territory from socialist to the post-socialist period have been shown in the study by different authors by comparing the land cover data of 1988. 1996, and 2003 (Müller and Sikor, 2006; Sallaku et al, 2009) as represented in Figure 1.7.

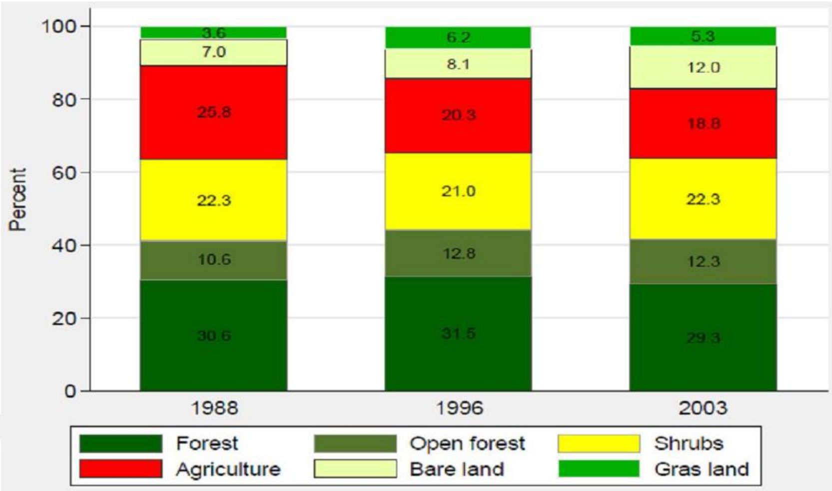

Figure 1.7 : Land cover changes during the period 1988/2003 (Sallaku et al, 2009).

Yet, applaudable efforts have been made after 2013 in institutionally/ officially by considering the landscape quality as a crucial objective of national development strategy. Initially, there have been activated institutions responsible for the management of the territory, such as; National Agency of Territorial Planning (AKPT), National Authority of Geospatial Information (ASIG), National Agency of Environment, National Agency of Protected Areas, National Inspectorate on Environment, Forests and Waters. Furthermore, the Territorial and Administrative reform (2014) was a tangible effort on reducing decision making fragmentation of the territory through join up of 374 administrative units into 61 municipal districts (Ndreu, 2016). Another crucial step towards landscape conservation has been the law that temporary suspensions all construction permits in national level between 2014- 2016 providing enough time to reflect on the past experiences.

According to the State of Environment Report (SoER) prepared by National Environmental Agency (NEA), one of the main priorities of the Government over recent years has been the designation of new Protected Areas at national level. This intention has resulted in a progressive extension of protected areas within the national territory, starting from 6.4% of coverage in 2005 to 12.57% in 2009 (Haska, 2010), and 16% in 2013 (NEA, 2015). According to Haska (2010), the protected areas in Albania consist of;

- 2 Nature strict reserve/scientific reserves (NStR/ScR);
- 14 National parks (N.P.);
- 750 Natural monuments (NM);
- 22 Nature reserve managed (NRM);
- 5 Protected landscapes (PL);
- 4 Protected area of Nature Resource Managed (RAMSAR).

Generally, the efforts in national scale are a consequence of an enforcement by the international agendas to which Albania strongly aims to adhere. For example, Albania is a collaborating member of the European Environment Agency (EEA). Thus, there exist different periodical assessment reports focusing especially on environmental quality. The only assessment method related to landscape assessment is the CLC data regularly produced in 6 years interval. CLC data availability has motivated a few numbers of studies focusing on the land cover dynamics of Albanian territory (Teqja et al, 2017). Yet, at international level Albania has to improve since it is one of seven countries among 47 member states of Council of Europe, not signing the European Landscape Convention.

1.4.3 Materials and logistics utilized during the research process

CLC data is the main raw material used in all case problems presented in this thesis. Initially, their acquisition is done for free as an open source via EIONET Central Data Repository portal provided by EEA. The year interval of the data being selected and downloaded depends on the objective and scope of each case problem as will be explained in detail in the materials and methods section of each study (Chapter 2 to Chapter 6). Spatial data about the administrative maps of study areas are acquired from Eurostat portal. This data have been crucial for the case problem focusing on the territorial and administrative reform (Chapter 3).

ArcGIS 10.2.2 has been the main interface for visualizing, managing and analyzing the spatial data during all phases of this research. In specific case problems, specialized extension toolboxes have been used via ArcGIS. For example, MatrixGreen toolbox has been used for assessing the landscape fragmentation (Chapter 2) and ModelBuilder has been utilized for modeling the analytical workflow of the study presented in Chapter 5 and Chapter 6. Apart from GIS technologies, Meteonorm software is used in order to acquire reliable environmental (weather) data for the study focusing on wildfire events (Chapter 4).

Since the size of the study area and the CLC data complexity can vary, they can directly affect the computation processing time during the process. As a consequence, the performance of the machine becomes a crucial criterion affecting the results and the speed of the process. The main and the most complex analytical computation processes within this study have been performed via a machine possessing the properties presented in Table 1.4. The more powerful the computer, the shorter the time of processing during spatial analyst stages. Thus, a workstation machine can enable much faster processes than those reported in this thesis.

Table 1.4 : Parameters of the machine utilized during major analytical processes of this thesis research.

parameter	**details**
Computer	64 bit- based PC
Processor	4 cores, 8 threads, 2.80 GHz, (Max Turbo, 3.46 GHz)
Installed memory	6.00 GB (ddr3)
System Type	64-bit Operating System
Graphic Card	1 GB dedicated
Monitor	Generic PnP Monitor (19 inch)

1.4.4 Difficulties and limitations

The main difficulty faced during the process has been the definition of relevant case problems in which CLC data could be utilized as a part of the problem-solving scheme. A second difficulty faced during the thesis research process has been the moderate level of the performance of the machine. As stated before a more powerful computing machine could enable much faster and much broader spatial analysis during the research. A further difficulty is related to the process of targeting relevant scientific journals for each article to be published. The diversity in publishing houses[6], submission systems, submission formats, review and revision processes has been an important challenge to be covered besides the core research work. Another difficulty experienced during the process is related with the unconventional format the thesis

[6] Since the articles included in this thesis are published in four different publishing houses; Elsevier, SpringerNature, Taylor& Francis, and Wichmann.

should have as prepared out of individual published articles. The lack of similar thesis submitted to GSSET did not give the opportunity to refer to previous examples.

Besides the abovementioned difficulties, there have been some limitations related to data acquisition. In principle, field work is accepted to be very crucial in landscape research studies. On the contrary, this thesis brings cases of research performed on laboratory medium instead of fieldwork. In fact this is dictated by the spatial scale of the main raw material being CLC data (1:100000). Yet, at the very end, the research work in this thesis is not served as the ideal solution. Instead, it tends just to develop and present a set of CLC data based novel conceptual approaches towards a diversity of problems in spatial decision making and management processes.

A specific limitation is related to the article focusing on the wildfire event presented in Chapter 4. For example, the fuel type (forest cover detailed data, tree-cover density, etc.), dump areas, electricity lines, and lightning regimes, are among criteria which are accepted as crucial factors for wildfire ignition and wildfire spreading capacities. However, due to unavailable data regarding these criteria for the selected study area, at this stage, the study does not include them. Yet, their inclusion within the method is targeted as further improvement of the method in the future steps of the research.

1.5 The Structure of the Thesis

The thesis is composed of seven chapters. Chapter 1 introduces the main goals and objectives of this research work. A brief theoretical basis is delivered within Chapter 1, showing the importance of land cover monitoring in sustainable spatial decision making and management processes. Introduction chapter shares the main experience during the research process, explaining key phases of the work and the difficulties and limitations faced during the research process.

The following five chapters (Chapter 2 to Chapter 6) present five research works being prepared in the format of five articles. Each of these chapters is organized in subsections following the classic structure of an article manuscript giving in detail the rationale, methods, materials, results, discussion, conclusion and future steps of each paper being published.

Chapter 2 presents the article titled “Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data”. The main goal of this work is to explore a new method of measuring an adverse environmental phenomenon such as landscape fragmentation using CLC data combined with a specific tool such as MatrixGreen toolbox (ArcGIS). The main emphasis is made on measuring the disconnection among broad-leaved forest surfaces (clc-311) within the territory of the Republic of Albania. Even though, there exists a possible conflict between the scale of CLC data and the landscape fragmentation phenomena, the study resulted successful in developing a rapid method of graphically and numerically measuring landscape fragmentation at a coarse spatial scale (Hysa and Türer Başkaya, 2017). The presented work has been labeled as the first step of a cross-scale landscape fragmentation methodology, which is targeted as a future step of the study presented in Chapter 2. This paper has been presented at the annual conference of Digital Landscape Architecture 2017, in Bernburg/ Germany, being published as a research article in the Journal of Digital Landscape Architecture (JoDLA-2017).

Chapter 3 presents the study titled “Land Cover Data as Environmentally Sensitive Decision-making Mediator in Territorial and Administrative Reform”. This study initiated as an extension of the first one, by questioning the landscape fragmentation caused by the local administrative divisions. Even though it brings a specific case of the current territorial and administrative reform (TAR) in Albania, it presents a method which can be applied to other geographies as well. First, it depicts the existing fragmentation among natural landscapes split via administrative borders. Further on, it brings forward a proposal for utilizing CLC data as an environmental friendly mean to define the local administrative borders in order to minimize the landscape fragmentation among natural landscape patches caused by local administrative divisions, being tested in the case of Tirana (Hysa and Türer Başkaya, 2018c). This article is published in the journal of Cogent Environmental Science (Taylor & Francis).

The next chapter presents the third article which is entitled “A GIS-Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity”. This study focuses on the utilization of CLC data as the raw material of a new classification method for broad-leaved forests, within the goals and objectives of disaster risk management and fire safety in forest fire events. The forested surface is divided into subunits, each of which is valued according to social, environmental, and physical criteria as derived from the territorial context. The study consists of three main stages; multi-criteria inventory for each location (data gathering), relative weighted values through AHP and reclassification through Jenks natural break classification method (data analysis/ interpretation), and indexing (assigning risk factor values) (Hysa and Türer Başkaya, 2018d). At this stage, the study makes a specific case of a broad-leaved forest surface in the northern Albania, but the proposed method can be applied to a variety of geographies. This study is published in the journal Modeling Earth Systems and Environment (Springer Nature).

Besides CLC data utilization, the first three articles share the study area as well (Albania). The study selection is guided by data availability, lack of similar studies in Albania, and the familiarity of the author with the local dynamics such as TAR processes. Another, common aspect of the first three works is the usage of GIS technology especially during the analytical phases of the process. The software used is ArcGIS 10.2.2. Certain steps of the workflows are modeled in ModelBuilder extension of ArcGIS.

Chapter 5 presents the article titled "Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean Coast". The main goal of this study is to introduce CLC data as the raw material of a novel method of analyzing the landscapes in the coastal zone. Different from the well-known longitudinal approach towards analyzing the coastal landscapes, this study puts forward a transversal analysis of the landscapes in a wider coastal zone. The transversal spatial emphasis of the method expands the width of the classical coastal zone by including further inland continental landscapes. The study at this stage makes the case of the Turkish Mediterranean coast. The study area is selected based on data availability, long coastal line, and the familiarity of the author and the supervisor with the Turkish context. The article is published in the journal of Ocean and Coastal Management (Elsevier). The developed method is highlighted by blind reviewers and the editor of the journal (V.N. de Jonge) as bringing remarkable and novel approach in the existing literature in coastal zone studies and management (Hysa and Türer Başkaya, 2018a).

The whole workflow is modeled and developed as a toolbox in ModelBuilder (ArcGIS). The model is applicable to any coastal area, possessing two raw data inputs; the coastline and the land cover spatial data. The detailed explanation of the tool as developed step by step via ModelBuilder is published as an article in the journal MethodsX (Elsevier). It is titled “A GIS-Based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone”, and is included in its published version as the Chapter 6 of this thesis (Hysa and Türer Başkaya, 2018b).

Finally, Chapter 7 concludes with a brief summary and a general evaluation of all articles. Since each chapter (2 to 6) includes dedicated results, discussion, and conclusion parts, Chapter 7 is focusing on the final common concluding remarks. Furthermore, in this chapter certain inconveniences and drawbacks are highlighted as further improvement and the next step of this research. Specific graphical materials (maps) and detailed statistical data (tables) are provided in the appendixes section and are referred accordingly throughout the thesis.

To sum up, this dissertation is a collection of five scientific articles studying diverse cases of CLC data utilization in decision making and management processes. Detailed bibliographic information about each article is presented in Table 7.1.

30

2. LANDSCAPE FRAGMENTATION ASSESSMENT UTILIZING THE MATRIX GREEN TOOLBOX AND CORINE LAND COVER DATA[7]

While Land Cover data are usually used for visualizing and quantifying the surface coverage properties of a territory, in this study, they are utilized to graphically and numerically assess the land-scape fragmentation and/or connect-ability. The main goal of the proposal is to visualize and quantify landscape fragmentation based on CORINE Land Cover (CLC), utilizing the Matrix Green (MG) toolbox in combination with Density Analyst tool of ArcGIS package. MG toolbox is tested here as a responsive technology in assessing landscape fragmentation. Open source CLC data provided via EIONET, of Albanian territory, are used as the main input for this experiment. The specimen target of the study is the broad-leaved forested lands encoded as 311 under CLC classification. The workflow of the process consists of ten steps which are applied to data of three different years; 2000, 2006, and 2012. As a result, there are produced two types of outputs. First, it is generated a set of maps which visually represents the spatial distribution of patches, links and indirectly the fragmentation of a specific land cover class. Second, it is produced a series of statistical data measuring patch and edge to edge links quantity in three respective years. Interpretation of the results have led to remarkable conclusions about the proposed methodology and the context analyzed, in the scope of landscape fragmentation assessment.

2.1 Introduction

Although there are studies that advocates for non-negative effects of human impact on environment (Taylor, 2002; Marull et al, 2015) especially considering the vitality of agro-forestry systems (Schroth, et al, 2013), in majority landscape fragmentation is accepted to be an adverse phenomenon majorly caused by human interaction with the natural environment (Bogaert et al, 2005). Settlement development, alteration of forested lands to agricultural use (Fahrig, 2001) and transportation infrastructure

[7] This chapter is based on the paper: Hysa, A., and Başkaya T., F. A. (2017). Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data. *JoDLA-Journal of Digital Landscape Architecture, 2*(1), 54-62.

expansions (Geneletti, 2004) are accepted to be the major human activities causing fragmented landscapes. Recently, there is an increase in the consciousness about the importance of landscape fragmentation analysis. Furthermore, it is highlighted and advocated to be integrated to decision and policy making practices such as transportation and regional planning (EEA, 2011). Thus, the fragmentation assessment in a territory is essential.

The success of measuring landscape fragmentation is dependent upon the objectives of the study being performed (Taylor, 2002). In the scope of this study, the landscape is analyzed by its structural instead of functional properties (Jongman et al, 2004; Hess and Fischer, 2001), as conceptualized in a matrix-patch-corridor paradigm pioneered by Forman and Gordon (Forman, 1991). In this work, the matrix-patch-corridor concept is practiced by constructing the landscape network (matrix) of CORINE Land Cover (CLC) feature classes (patches) and connecting links (corridors). Consequently, landscape fragmentation is analyzed through the reversed process of connect-ability, enabled via an edge to edge linking method as provided by Matrix Green (MG) toolbox (Bodin and Zetterberg, 2010). MG is tested here as a responsive technology (Cantrell and Holzman, 2016) in the process of landscape fragmentation assessment (LFA) by measuring the responsiveness of fragmentation behaviors in reference to land cover alterations.

Furthermore, the study extends to a comparative analysis in terms of time-dependent variances. Open source data via EIONET, provides sufficient CLC records of three sequential periods covering an interval of twelve years in-between: respectively 2000, 2006, and 2012.

The target case of this experiment is the broad-leaved forested lands (CLC-311) of Albanian territory. The main selection criteria is the lack of relevant studies for this geography. Furthermore, Albania is a developing country facing high ratios of unsupervised conflicts between development pressures and conservation goals. This results in a dynamic and fragile structure of natural lands, which is remarkable to be assessed. The broad-leaved forested surfaces are selected to be the specimen of this study due to their dominant biodiversity and ecological values among other land cover classes (Hilli and Kuitunen, 2005). Yet, by this we don’t mean that forestation is always a good, because prior studies have shown that forest recovery attempts may lead to reduction of landscape quality (Marull et al, 2015).

2.2 Methodology

This study employs a combination of methods and tools to achieve the predefined goals. First, it utilizes ArcGIS software as me the main analytical medium especially by applying the Kernel density mapping of fragmentation. Besides the core package of ArcMAP the study makes use of MatrixGreen toolbox to generate the potential links between fragmented patches. The later are derived from CLC data as acquired as an open source from EIONET portal. All phase of the procedure are structured into a workflow.

2.2.1 Workflow of the experiment

The process of landscape fragmentation assessment in this study consists of 10 work packages (Figure 2.1). The workflow steps can be clustered into three main groups; ArcGIS modifying tools (1, 5, 6, 7, 8, 9), MG operations (2, 3, 4), ArcGIS Spatial Analyst (10). All steps have to be performed for each data clc-2000, clc-2006 and clc-2012.

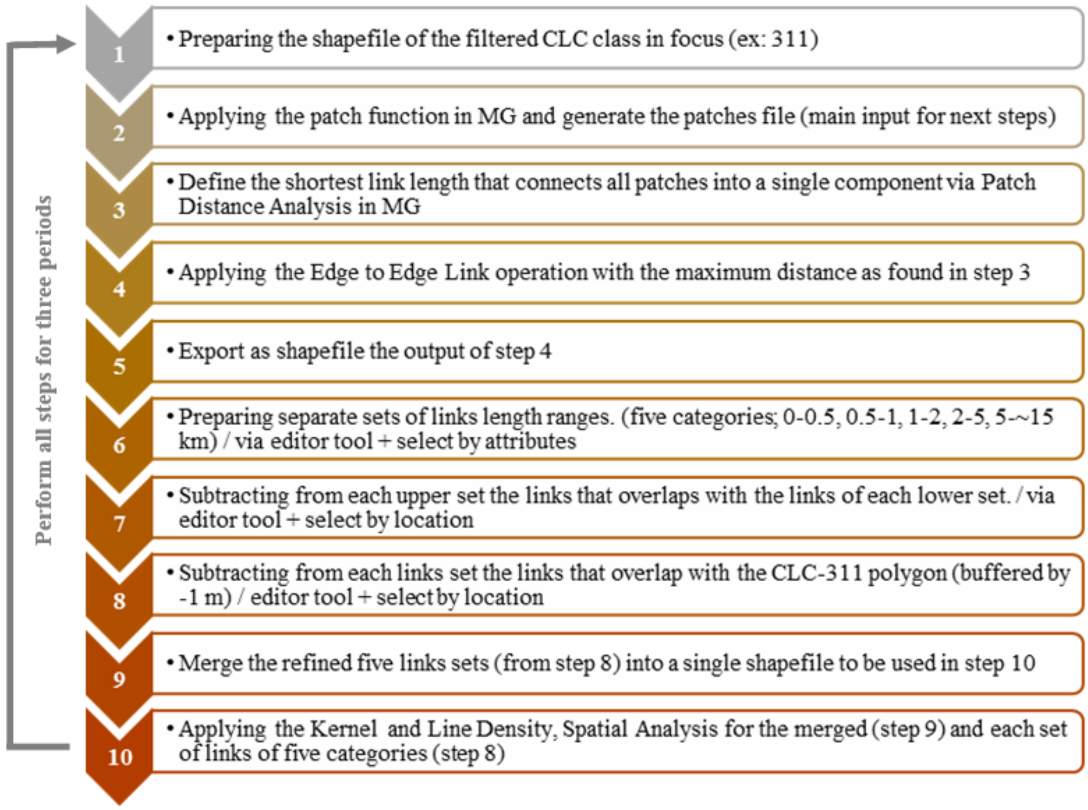

Figure 2.1 : Workflow of Landscape Fragmentation Visual Assessment utilizing Matrix Green toolbox.

2.2.2 Utilizing CORINE land cover

Usually, CORINE land cover data are used to visualize and measure the land surface properties of a territory and for monitoring the change in landscape through time. In this study, they are utilized as landscape fragmentation assessment means. The connection capacities between patches of land cover classes through the closest edge to edge links indirectly highlight the prevailing fragmentation among them.

CLC uses as the minimum mapping unit of 25 ha and 100 m for linear features (JRC-EEA, 2005), providing information relatively in a much coarser scale compared to other land cover monitoring methods such as MURBANDY/MOLAND (Valera et al, 2007) and LUCAS (Gallego and Bamps, 2008). Even though, at first look there exists a conflict between the scale of information provided via CLC and the landscape fragmentation assessment goals- as a phenomenon happening in a gradient of spatial scales-, it is decided to proceed using CLC data due to availability of information about Albanian territory. Furthermore, the work presented in this paper is conceptualized as the first step of a multi-scale Landscape fragmentation assessment.

2.2.3 Utilizing Matrix Green toolbox

Matrix Green is an ArcGIS extension tool developed by Bodin and Zetterberg at Stockholm Resilience Centre- KTH, which supports network based analysis of fragmented landscapes (Bodin and Zetterberg, 2010). The toolbox generates patches and three types of links. Utilizing them, it can perform certain analysis. A specific analysis performed via MG is Patch Distance Analysis (PDA) as shown in Figure 2.2.

The tool generates information about the total area of the patches, the area of the largest component, the ratio among both in percentage, and the number of components generated at each interval distance applied. PDA assists primarily on understanding the threshold edge to edge distances between fragmented landscape patches that enables abrupt boost in landscape patches connectivity, thus, the component size.

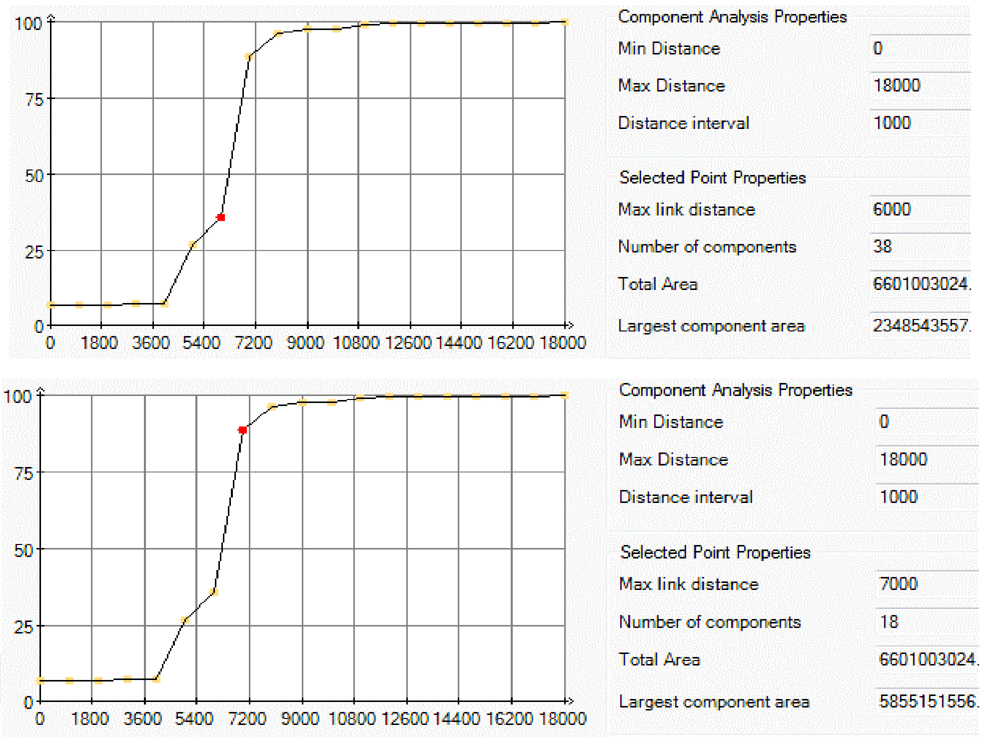

Figure 2.2 : PDA charts highlighting two thresholds up to 6 km (left) and up to 7 km long (right); links between broad leaved surfaces (311) in 2012.

2.2.4 Refining the output data of MG toolbox

In step 4, it is erected a polyline features set consisting of linkages between the closest points of each peer of fragmented landscape patches up to a certain defined distance. As a result, functionally meaning, there are generated a redundancy of links. In other words, any link that intersects with any other link or overlapping any fragmented landscape patch, should be subtracted from the set of compulsory links. The refining process of MG generated links is performed in three stages as shown in Table 2.1.

Table 2.1 : The refining process of the EE links as generated by MG.

	Aim	Example	Output
1	preparing the sets of ranges of link distances between patches	LEE(0-5000) - LEE(0-2000)= LEE(2000-5000)	LEE(0-500), LEE(500-1000), LEE(1000-2000), LEE(2000-5000)
2	Subtracting links of each upper set that intersects with links of each lower set	LEE(2000-5000)- Intersect(LEE(2000-5000)and LEE(0-2000))= LEE(2000-5000)$_{SUB}$	LEE(0-500)$_{SUB}$, LEE(500-1000)$_{SUB}$, LEE(1000-2000)$_{SUB}$, LEE(2000-5000)$_{SUB}$
3	Subtracting links of each set that intersects with the main landscape patch	LEE(2000-5000)$_{SUB}$ - Intersect(LEE(2000-5000)$_{SUB}$ and Landscape Patch)= LEE(2000-5000)$_{SUB/BUFF}$	LEE(0-500)$_{SUB/BUFF}$, LEE(500-1000)$_{SUB/BUFF}$, LEE(1000-2000)$_{SUB/BUFF}$, LEE(2000-5000)$_{SUB/BUFF}$

LEE= Edge to Edge link, SUB= Subtracted, BUFF= Buffered

2.2.5 Utilizing the density spatial analyst as visual LFA tool

In the final step, the refined data of landscape links are tested through the Kernel and Line Density tool utilizing ArcMap 10.2.2. The toolbox generates rough graphics highlighting the most dominant zones urging for links, subsequently emphasizing the present fragmentation. The red to green gradient of 20 classes is selected to highlight the most fragmented landscape. Whereas, the greyscale gradient of 10 classes is used to visually represent and compare five sets of links produced in step 8. The darkest parts of the map are implying the concentration of connecting links thus, the most fragmented landscape areas.

2.3 Results and Discussion

The results of this work can be categorized as visual and numerical information. The first group consists of a series of maps generated via MG operation as well as ArcGIS Spatial Analysts, density analysis tool. Illustrations of these graphics are included in Figure 2.3 and Figure 2.4. Whereas, the second set consists of statistical data from two main sources; PDA (MG) and feature class statistics of both network elements; links and patches.

2.3.1 Visualizing the fragmentation of Albanian broad leaved forests

The main contribution of landscape fragmentation mapping is the spatial distribution of landscape fragmentation in the territory. For example, it is hard to derive the dispersal information from the map of land cover patches and links in Figure 2.3 (a). But, the spatial concentration of the links- fragmentation, becomes evident enough in Figure 2.3 (b-c-d). Referring to Figure 2.3, it can be stated that the highest level of landscape fragmentation among Albanian broad-leaved forested surfaces exists in the southern part. In Figure 2.3 (d), via line density spatial analyst tool by population field set as “none”, it is produced a finer graphical information compared with the kernel density (b). Whereas, if the population field is tested as “line length”, the map highlights the links densification by their length properties, as shown in Figure 2.3 (d). Consequently, it can be stated that the longest landscape links concentrate on the central west of Albania. Comparing Figure 2.3 (c) and (d), there are certain zones becoming paleness (ex; zone “x” and “y”). This change can be justified by the high amount of short links close to the zone x and y.

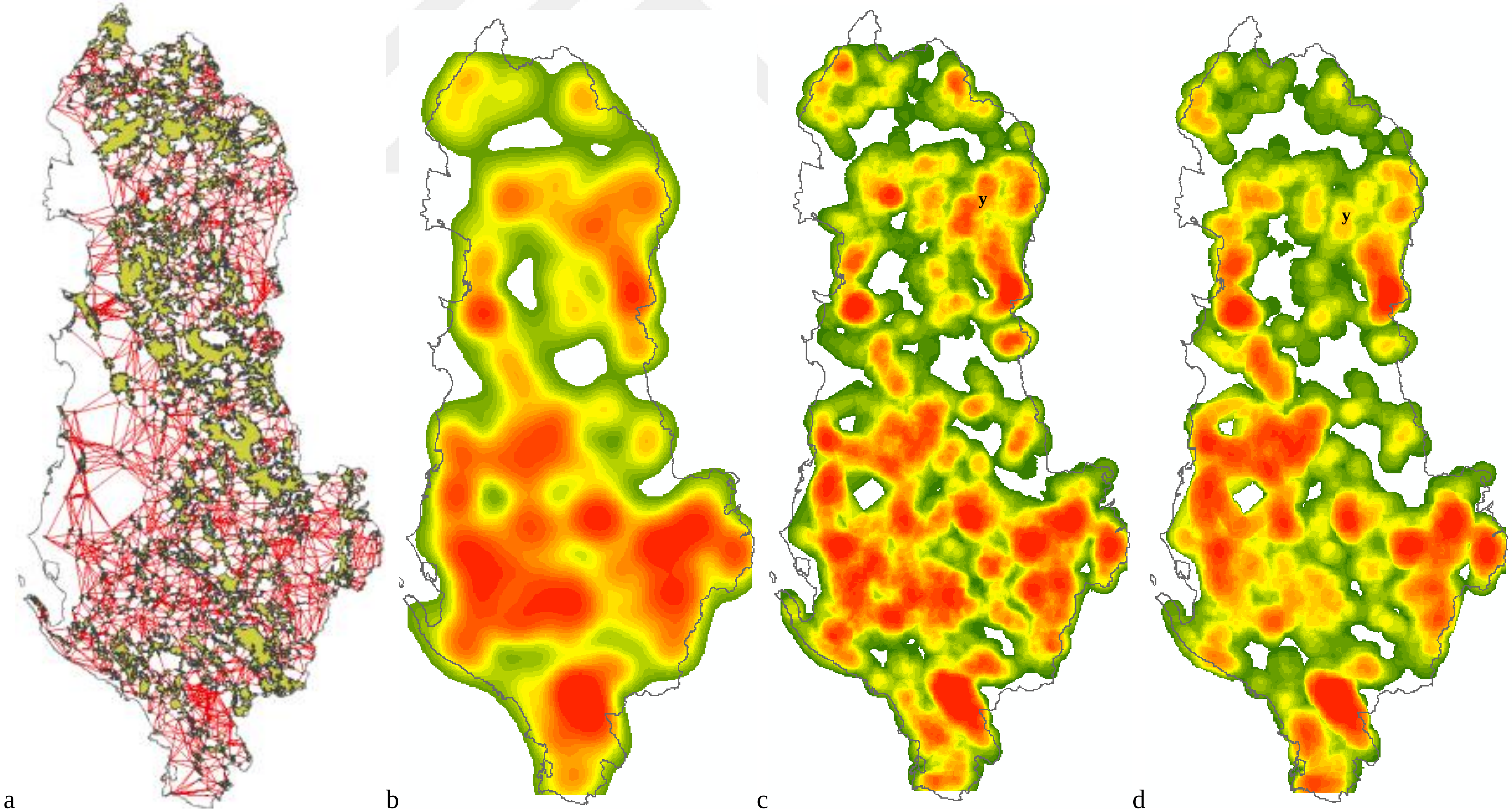

Figure 2.3 : clc-311 2012 and 5 km links via MG (a); Weighted Fragmentation; kernel density (b); line density with population field; none (c), line length (d).

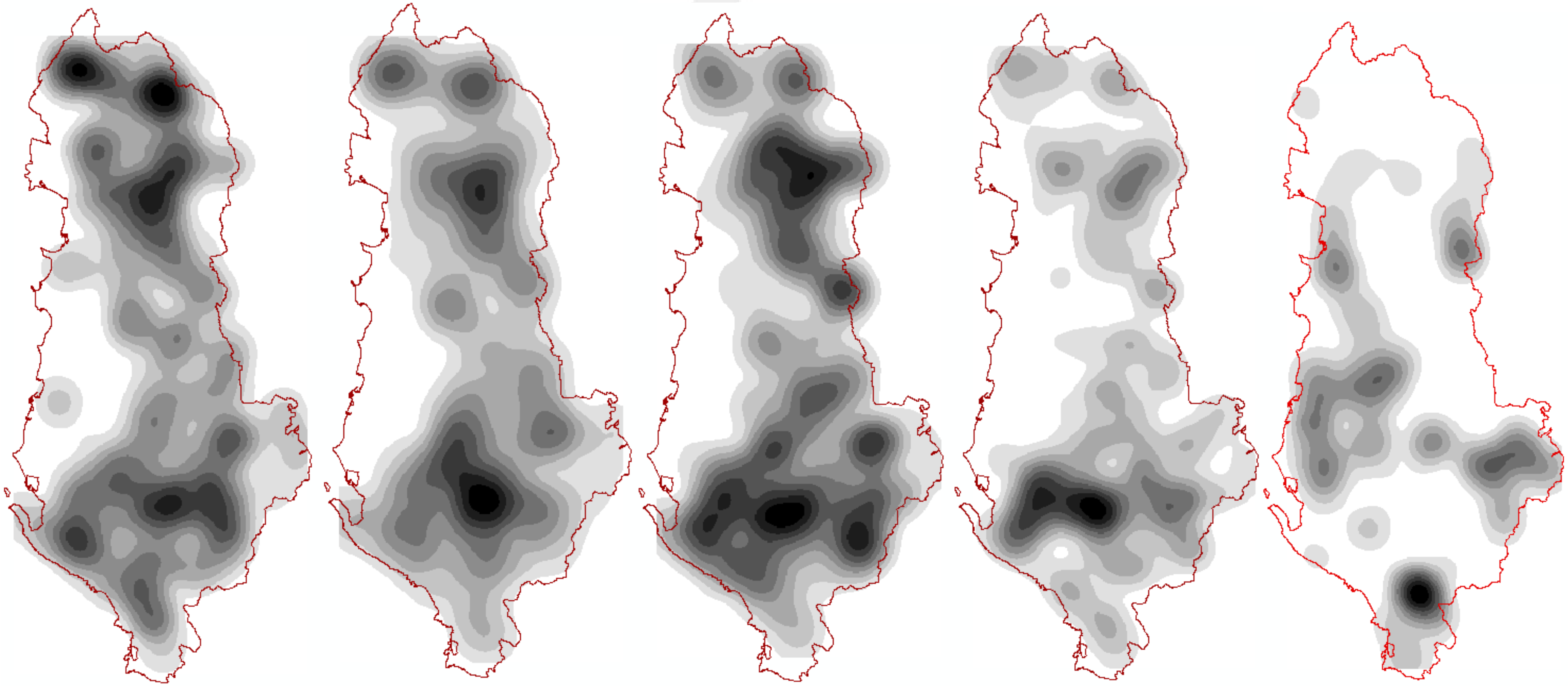

Figure 2.4 : Kernel Density maps of links of five length groups. Respectively left to right; 0-0.5 km, 0.5-1 km, 1-2 km, 2-5 km, and 5-18 km. CLC-311, 2012, Albania.

Further on, in Figure 2.4 there are presented the kernel density mapping of five links classes as defined in the step 6 of the workflow, highlighting the spatial distribution density of links classified by their length. Responsively, it can be concluded that the fragmented landscape patches that are the closest to each other (0.5-1 km), are concentrated in the northern Albania. Whereas, fragmented surfaces that are no closer than 5 km to each other are mostly in the central part of the territory.

The visual assessment could expand by comparing between the density mappings of each year. But, due to the scale of the study the difference among three periods is visually imperceptible. Instead, the comparative assessment based on time-dependent variances is crucial in the numerical assessment of landscape fragmentation.

2.3.2 Quantifying the fragmentation of Albanian broad-leaved forests

Statistical data on landscape patches and links are crucial in the process of comparison between the cases of three years; 2000, 2006, 2012. The numerical data is analyzed under three main themes; feature-patch statistics, links measurements, and PDA indicators.

First, Table 2.2 represents numerical data regarding the dynamics of feature and patch classes during three periods. According to records, there is an increase of 23 features and 20 patches of broad-leaved forested surfaces from 2000 to 2006, indicating the rise of the fragmentation amount of this specific land cover type. Referring to sum areas of features and patches it can be concluded that there exists a continuous decrease of the area of broad-leaved surfaces by 5760 ha between 2000-2006 and 2928 ha in 2006-2012. Another fact to be highlighted from Table 2.2, is the decrease of the mean area of features and patches. The average surface area of clc311 has decreased with 18 ha from 2000 to 2012, implying the shrink of the broad-leaved surfaces and the increase of landscape fragmentation.

Table 2.2 : Feature and Patch feature class statistics for 2000, 2006, 2012 data.

year	features	f_diff	f_sum_area	f.s.a_diff	f_largest_area	f.l.a_diff	f_mean	f_st.dev.	patches	p_diff	p_sum_area	p.s.a_diff	island area	i.a._diff	p_largest_area	p_mean	p_st.dev.	top link (m)
2000	1331		632275		47707		475	2301	1393		666093		33818		51673	478	2452	13497
2006	1354	23	626515	-5760	42870	-4837	462	2147	1413	20	660051	-6042	33536	-282	46360	467	2300	13359
2012	1363	9	623587	-2928	42371	-499	457	2161	1413	0	660100	49	36513	2977	45596	467	2320	17957
	features								patches									

On the other hand, Table 2.3 illustrates statistical data regarding the links generated by MG in the step 4. According to these records, in 2012 there are 1057 links more than 2000, and 953 more than 2006, implying the increase of fragmentation during this period. The links longer than 2 km and shorter than 5 km have increased in number by 30 % from 2006 to 2012. Referring to the mean length of the links, in 2012 the average length of all links groups increase by 25 %. This is mainly dedicated to the category of links longer than 5 km, while the other four links length classes remain almost the same.

Table 2.3 : Links measurements as generated via Matrix Green toolbox; 2000, 2006, 2012.

year	top link (m)	EE_0-top	EE_0-top_mean	EE_0-top_st.dev	EE_0-0.5 km	EE_0-0.5_diff	EE_0-5_mean	EE_0-5_st.dev.	EE_0.5-1 km	EE_0.5-1_diff	EE_0.5-1_mean	EE_0.5-1_st.dev.	EE_1-2 km	EE_1-2_diff	EE_1-2_mean	EE_1-2_st.dev.	EE_2-5 km	EE_2-5_diff	EE_2-5_mean	EE_2-5_st.dev.	EE_5-top km	EE_5-top _diff	EE_5-top _mean	EE_5-top _st.dev.
2000	13497	7099	4661	3847	1168		199	131	477		745	145	716		1473	292	1298		3394	868	650		8752	2346
2006	13359	7203	4610	3804	1148	-20	200	129	461	-16	746	146	703	-13	1471	292	1300	2	3388	860	541	-109	8728	2460
2012	17957	8156	5753	4883	1168	20	204	133	455	-6	742	147	696	-7	1471	290	1691	391	3409	863	681	140	9980	3442
distance ranges classification					very close				close				moderate				high				very high			

The third part of statistical assessment of landscape fragmentation is based on Patch Distance Analysis via MG as shown in Table 2.4. First part of the board includes information about the connect-ability behavior of the patches based on the threshold distance intervals (Figure 2.2) for each year. Number of components, largest component area, coverage percentage, are statistics for both lower and upper distances of the threshold interval. Accordingly, it can be concluded that the Albanian broad-leaved surfaces in 2012, are primarily distanced via 6000- 6500 m long links. This is the interval where the connect-ability of this land cover class increases by almost 3 times (35.6% to 87.0%). On the other hand, the number of unconnected landscape components is reduced from 38 to 27. In 2012 there is a decrease of components areas of both lower and upper thresholds.

Table 2.4 : PDA indicators as generated via Matrix Green toolbox; 2000, 2006, 2012.

year	longest link [m]	threshold [lower]	l_components	l_comp. area	l_% coverage	threshold [upper]	u_components	u_comp. area	u_% coverage		500	largest comp [ha]	1000	largest comp [ha]	2000	largest comp [ha]	5000	largest comp [ha]	top	largest comp [ha]
2000	**13497**	**7500**	**19**	361814	**54.3**	**8000**	**15**	620720	**93.2**		**1370**	51673	**1309**	51673	**902**	51989	**102**	172738	**1**	666093
00_diff							-4	258906	38.9				-61	0	-407	316	-800	120749	-101	493355
2006	**13359**	**7500**	**17**	404945	**61.4**	**8000**	**15**	635416	**96.3**		**1393**	46360	**1327**	46580	**914**	47004	**97**	195978	**1**	660051
06_diff							-2	230471	34.9				-66	220	-413	424	-817	148974	-96	464073
2012	**17957**	**6000**	**38**	234854	**35.6**	**6500**	**27**	574253	**87.0**		**1393**	45596	**1329**	45652	**915**	45812	**96**	178297	**1**	660100
12_diff							-11	339399	51.4				-64	56	-414	160	-819	132485	-95	481803

The second part of Table 2.4 represents the PDA indicators at each threshold length of five links groups, respectively; 500, 1000, 2000, 5000, and top length (m). There is an increase of remaining unconnected components at the first three thresholds from 2000 to 2006 and 2012, numerically indicating a rise in landscape fragmentation. Whereas, the components that remain disconnected via up to 5000 m links are less in 2012 than previous years. Thus, the fragmentation advancement seems to have happened in closer distances.

2.4 Conclusions and Further Improvements

This study presents a method for visualizing and quantifying the physical landscape fragmentation utilizing the Matrix Green toolbox and density spatial analyst of ArcGIS. This is achieved by investigating the connect-ability of patches through potential edge to edge links. The specimen of this experiment is the set of broad-leaved surfaces of Albanian territory, utilizing CORINE land cover data of 2000, 2006, and 2012.

The visual results represent the spatial distribution of landscape fragmentation in the territory. Whereas, the quantitative assessment through feature-patch statistics, links measurements, and PDA indicators designate numerical proofs on the responsiveness of landscape fragmentation upon the land cover alterations.

Even though the process tested in this study is useful for landscape fragmentation assessment there is space for further improvements. A weak point of this work is the possible conflict between the scale of information provided via CLC and the objectives of LFA- as a remarkable occurrence at a gradient of spatial scales. Thus, this experiment should be considered as the first step of a multi-scale Landscape fragmentation assessment methodology.

Finally, beyond the methodological and technical achievements or failures, this paper is a contribution to the inclusion possibility of similar analysis to territorial management in general. This is crucial in countries similar to Albania, where the disconnectedness between the spatio-temporal studies and landscape management/planning strategies is an urgent handicap to overcome.

3. LAND COVER DATA AS ENVIRONMENTALLY SENSITIVE DECISION MAKING MEDIATOR IN TERRITORIAL AND ADMINISTRATIVE REFORM[8]

This paper presents a multi-criteria conceptual framework for decision making processes during Territorial and Administrative Reform (TAR) relying on sustainable development principles. In general, TAR processes highly consider socio-cultural and economic factors, but they lack responsiveness to environmental dynamics of the context. While this practice achieves a fair allocation of the new administrative units' centers, the border defining criteria are indistinct. Thus, we turn a spotlight on the environmental factors as fundamental criteria in TAR decision making processes, especially the boundary definition stage. Topography, watershed, land cover, and natural conservation areas are among the proposed environmental measures. The research makes a real case of land cover data utilization as environmentally sensitive decision making mediator. First, the CORINE Land Cover (CLC) data of 2012 serves as an evaluation criteria of the recent TAR (2014) in Albanian territory, based on the landscape fragmentation caused by the new spatial division. Second, the CLC data generates an alternative municipal boundary of the Albanian capital. The results show that a TAR process not taking into account the environmental criteria leads to functionally disconnected territories which in the long run may lead to physically fragmented natural landscapes. Furthermore, the new alignment for municipal borders of Tirana, shows a successful result in minimizing natural landscape fragmentation caused by local administrative boundaries. The proposed multi-criteria conceptual framework and the application via CLC utilization presents a methodical approach which may assist decision making processes of TAR in other developing countries, conform sustainable territorial management principles.

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[8] This chapter is based on the paper: Hysa, A., and Başkaya T., F. A. (2018). Land Cover Data as Environmentally Sensitive Decision-making Mediator in Terrıtorıal and Administrative Reform. *Cogent Environmental Science, 4*(1), 1-17.

3.1 Introduction

The conflict between the political borders and cross-boundary ecoregions is a well-known issue in conservation studies (Kark et al, 2015). The main contradiction relies on the transboundary character of ecological services (Hoffman et al, 2009), while specific governmental bodies perform the conservation planning practice within the boundary jurisdiction. This practice significantly brings uncoordinated interventions (Jantke and Schneider, 2010) and sometimes even interfering/overlapping/duplicating each other (Gordon et al, 2013). Certainly, there is an emphasis on the collaboration among a variety of actors as well as across spatial borders (political, regional, municipal and others) (Mace et al, 2000). Moreover, the natural conservation issue is of a multi-range character including a variety of shareholders acting at different spatial scales (Guerrero et al, 2014) such as, global, regional or local. In the global scale, the international collaboration in natural conservation agendas might be the only solution towards cross-border conservation goals. This is due to the fact that the national borders apparently are a product of the most extreme conflicts (wars) among the humankind (Harvey and Most, 1976), and their readjustment is the last considerable alternative on the table.

Differently, in the local scale, the administrative boundaries within the national borders and the subdivision of the territory into local administrative units are a vibrant topic continuously consuming a serious discussion. One of the most tangible platforms of the debate is the Territorial and Administrative Reform (TAR), which is still scholarly under-estimated (Kuhlmann and Wollmann, 2011). The reforms of the local administration and the territorial reorganization were first applied during the ‘60s and the ‘70s (Norton, 1994) for the western European countries, and after the ‘90s for the post-socialist countries (Wollmann, 2010). The TAR process follows certain criteria to perform the territorial subdivision. Generally, the socio-cultural and economic factors are seriously considered during the decision making processes of TAR. However, the case is not the same with the environmental criteria which are substantially ignored, despite being advocated to be the third pillar of sustainable development (Giovannoni and Fabietti, 2013; Hens, 1996).

This practice results in justified decisions on the amount and centers’ location (urbanized areas) of the new administrative units. But, it remains insufficient in reasonably defining the administrative boundary line, especially while crossing through natural lands. As a consequence, the borders defined, based only on the socio-cultural and economic factors, result in functionally divided natural landscapes, which later might lead to permanent physical landscape fragmentation. In this study, the landscape fragmentation stands for the phenomenon not caused by physical barriers; it is a breakup of the interest and the consumption methods towards a specific CPR (Ostrom, 2010) split among different, local administrative units (Swianiewicz, 2010). In the long-run, the split management and administration of a specific natural landscape surface may lead to physical landscape fragmentation.

In this context, the study focuses on the local scale, first, by conceptually discussing the multi-criteria character of the decisions within TAR processes. Furthermore, we propose a conceptual framework based on sustainable landscapes principles (Buttimer, 2001). Even though, it still relies on three fundamental pillars (social, economic, and environmental) of sustainable development, sustainable landscapes notion brings a decoupling between “sustainability” and “development” by implying that the former already bears the later within itself (Blaschke, 2006). In consequence, we structured the criteria of the proposed framework into three main groups: the socio-cultural, the economic, and the environmental criterion. Each category consists of several sub-criteria being organized by their role and scope within the TAR process.

Beyond the conceptual multi-criteria approach, the paper presents a demonstrative application of the framework by utilizing land cover data as an environmental sub-criteria in the decision making process of TAR, especially during local administrative boundary definition phase. The experiment relies on CORINE Land Cover (CLC) data of 2012 applied upon the recent TAR of Albanian territory (2014). CLC data is currently labelled as a well-established and reliable information source in support of environmental policy making (Steenmans, 2016). The spatial relationship between CLC data and the current, local administrative borders provides pieces of evidence of landscape fragmentation caused by the reform. Furthermore, CLC data is empirically put forward as local administrative boundary definition mean as shown here for the case of Tirana. The experiential stages of this study are performed utilizing ArcGIS 10.2.2 software.

3.2 Case Study: Territorial and Administrative Reform in Albania

In 2014, Albania ratified the administrative and territorial reform as a demand by the European Union within the decentralization processes of local administration (Reçi and Ymeri, 2016). The new divisions, referred to as development zones, are responsible for the funds' management on economic and social development of candidate countries (Ghinea and Moraru, 2006). The territory is re-organized from 374 (65 municipalities and 309 communes within 36 localities joining into 12 prefectures) (Figure 3.1b) administrative units to 61 municipal districts (Ndreu, 2016) (Figure 1c). The local administration reform of decentralization reduced distinctly the institutional ties and dependency between central and local governments. Moreover, the new reform annihilated a core administrative unit of the pre-reform version such as "rreth", reported as administratively ineffective (Saltmarshe, 2001). According to the new local administrative map of Albania, provided via the geoportal by the Albanian State Authority of Geospatial Information, the new layout decreased the local administrative borders cumulative length by more than 50%, specifically from 7766 km to 3583 km (ASIG, 2015).

The recent Albanian TAR is criticized for being highly driven by electoral interest (Krasniqi, 2014), which is a well-known concern having earlier been addressed by different scholars even in western European regions such as Flanders (De Peuter et al, 2011). This is due to the fact that the reform process may lead to alterations of political posts, job security and prestige (Swianiewicz, 2010). Beyond the political discourse, the official technical report of TAR in Albania highlights to have considered a variety of social and economic criteria during the decision making process. For example, the concept of Functional Zones defines a territorial area characterized by dense and substantial interaction between citizens and institutions with economic, social development and cultural interest (MLA, 2014). Any area that have a relatively distinctive and considerable level of economic and unique cultural identity, deserves to become a local administrative unit under the new division. Furthermore, the ethnic minority rights have been an important drive leading to independent local administration units for certain minority groups (example of Greek minorities) located in the southern Albanian territory. Ethnic minority rights is a fragile issue and should be carefully considered during TAR decision making processes, especially in South

Eastern European context, as experiences from multi-ethnic geographies such as FYROM has shown before (Kreci and Ymeri, 2010).

However, referring to the same report, the environmental criteria are absent from the decision making process during the recent TAR in Albania. The consequences of this fact, are reported to have led to a less fair distribution of the core natural resources comparing spatial division schemes of pre (36 rreth) and post reform (61 municipality) (Hysa, 2018). The study shows that broad-leaved forest surfaces (clc-311) considered as a crucial part of the natural capital (Costanza et al, 2016), head the least fair distributed natural surfaces among local administrative units. The anthropocentric approach, predominantly focusing on the economic and socio-cultural assets, might delineate the number of the new administrative units and their corresponding center locations. However this approach fails to address the environmentally sensitive definition of the administrative boundaries at the rural and at the natural landscape level.

While the recent administrative reform in Albania has apparently neglected the environmental concerns, the new local administration law 115/2014, dated 31.07.2014 (QBZ, 2014) has raised the natural assets' value. The new law exclusively assigns the management of Forested Lands to the municipality (as the new local administrative unit) lodging them. Moreover, referring to the Directive by the Albanian Ministry of Environment, the local government can give for rent areas from the Forest and Pastures Fund contributing directly to their institutional budgetary income (MEA, 2016)[9].

Commercializing the ecological services (Costanza et al, 2011), brings new financial opportunities for local government based on the natural attributes of the lands under their jurisdiction. Yet, it boosts a serious conflict between development interest and conservation goals. Furthermore, the HELVETAS (2016) organization monitoring the TAR implementation, reports on an official transfer of the Fire Safety and Evacuation (FSE) services, from the central government's responsibility to the local administration.

[9] While this can be seen as a great opportunity within the decentralization goals of local government, if not reasonably managed can cause irreversible consumption of natural resources.

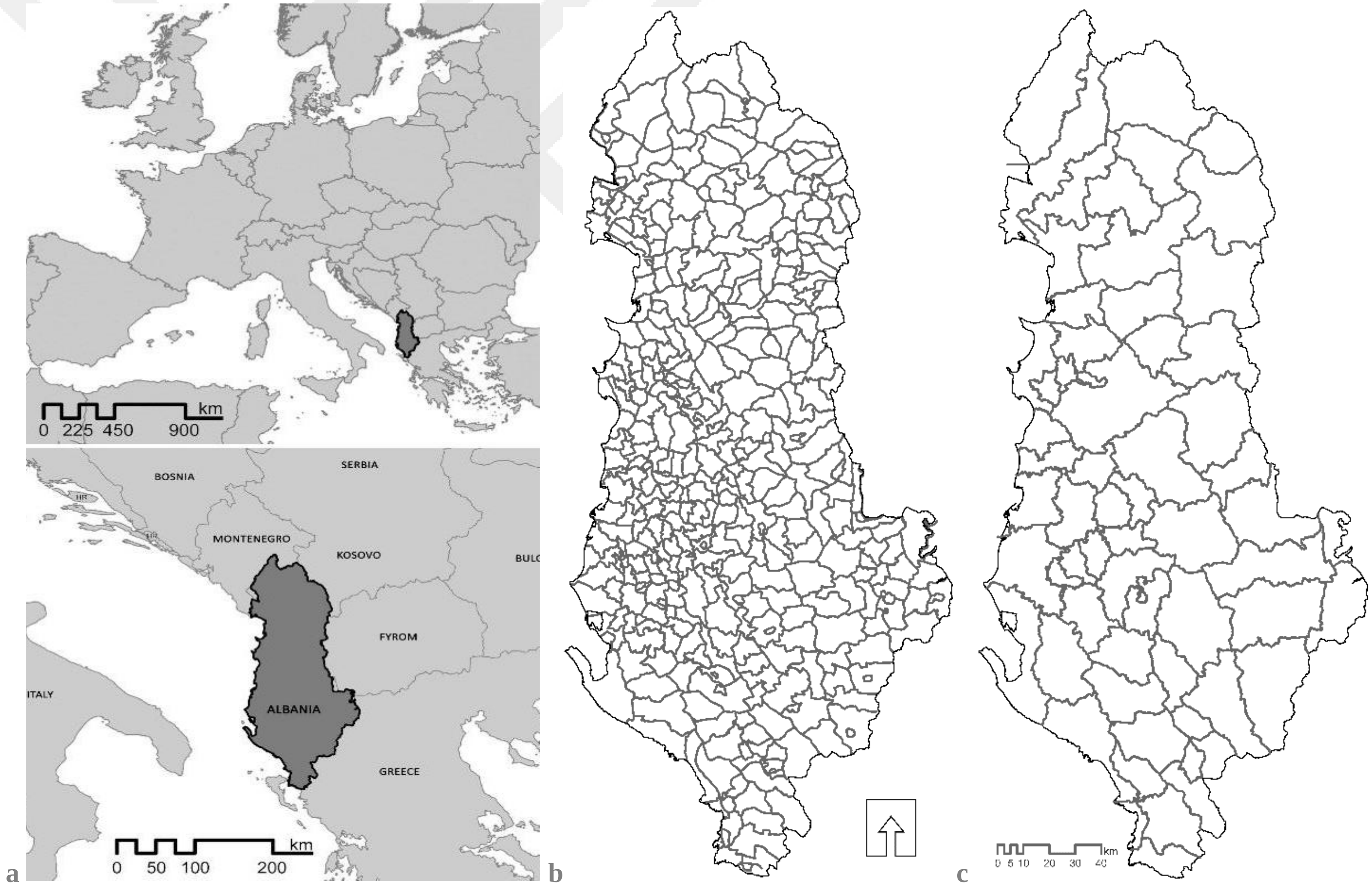

Figure 3.1 : Location of Albania (a) and the Albanian local administrative maps; pre-TAR (b), post-TAR (c).

The responsibility dissolution of the Forest and Pasture Fund management and the FSE service among local government units, implies uncertainty for natural landscapes. For instance, a natural land surface patch crossed by administrative borders, functionally splits into parts of distinct local administrations. Thus, uncoordinated decisions on the usage of Forest and Pasture fund may lead to over consumption of resources. Similarly, in case of a wildfire in a disrupted forest surface, as the firefighting service responsibility ends within the administrative boundary, it might cause an uncontrolled wildfire situation beyond the border. In order to minimize the split of natural landscape patches, the proposal highlights the land cover pattern of the territory as a decisive criteria in local administrative boundary definition phase of TAR process.

3.3 Methods and Materials

This study follows a multi-criteria methodological approach in accordance with the sustainable development principles cited previously. We highlight the environmental factors as a significant, yet neglected aspect of the TAR processes. Our objective is to test the land cover data set as an environmental factor which might serve as a measure to criticize and improve the current, local administrative reform in Albania (Figure 3.2a). The study utilizes GIS technologies as a tool for the data management and analysis.

In the first part of this empirical study we assess the landscape fragmentation resulting from the new local administrative map of Albania. Furthermore, the numerical data on the count and surface area of intersected CLC patches split via local administrative boundaries present information about spatial coverage distribution of fragmented land cover surfaces (Figure 3.3). This step aims to validate our hypothesis: a TAR process neglecting the environmental concerns during the decision making stages, leads to function-wise fragmented natural landscapes.

In the second part, we propose a new alignment for the administrative boundary of the Albanian capital, Tirana. Assuming that the TAR process has significantly considered the socio-cultural and economic criteria, we put forward the land cover pattern as a boundary defining reference in order to reduce the landscape fragmentation. The landscape patches intersecting with the actual borders are the core focus of the study, leading to a modified administrative boundary line. The alteration follows two rules: (i) the new border should track the land cover patch boundary it overlaps with, and

(ii) the smaller (in terms of area) parts of split patches, should spatially transfer to the neighboring administrative unit already containing the largest portion (Figure 3.4).

3.3.1 Multi-criteria framework for Sustainable Territorial and Administrative reform

The environmental factors complement the socio-cultural and economic criteria, all of which comprise the sustainable management of the territory. However, the TAR decision making processes either refer minimally or totally neglect the environmental ones. We posit that the environmental criteria when taken in consideration in a TAR process leads to a sustainable management of cross-border natural landscapes. Our approach (Figure 3.2) follows the “sustainable landscapes” notion, standing as a holistic as well as anthropocentric model, considering the social, economic, and environmental dimensions of the landscapes all at once (Blaschke, 2006). Landscape sustainability is strongly related with both the ecological and community scales. Yet, an obstacle in achieving sustainable landscapes is the discordance between responsibility boundaries among agencies or stakeholders (Saunders and Briggs, 2002).

Figure 3.2a presents a conceptual scheme of sub-criteria distribution per each main category (social, economic, environmental) according to their shared fields of relevancy. For example, we categorize the demographical data, social and cultural background within the social criteria boundaries. Similarly, industry, commerce, and technology fall under the economic factors. Furthermore, we consider the land cover, watershed, topography, water features, and protected areas as environmental features of the territory. Besides, certain shared criteria fall within the common ground of two main sets. For instance, a common criterion across the economic and environmental factors is the natural capital. Similarly, we propose the ecological services as a shared factor of social and environmental, whereas the agricultural activity falls within the common ground of social and economic criteria.

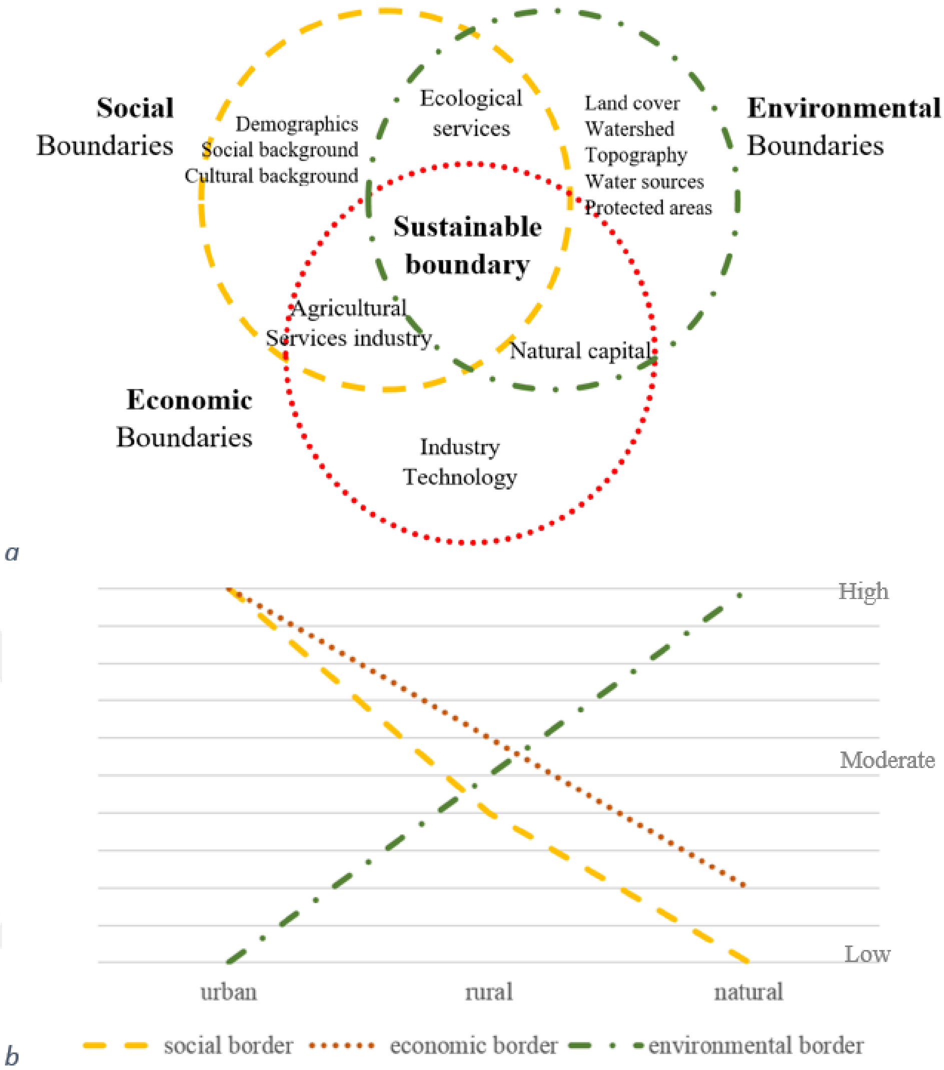

Figure 3.2 : Conceptual diagram of sustainable boundary derived from multi-criteria boundary dynamics (a), and hypothetical impact rates of social, economic, and environmental factors at urban, rural and natural context (b).

Further analyzing the criteria by their relative significance weight at different spatial scales and context, like urban, rural, and natural, we state that the socio-cultural and economic factors are primarily more decisive in the urban context (Figure 3.2b). The aforementioned factors, predominantly associate with anthropogenic dynamics, which are spatially concentrated around the urbanized areas of the local administrative units. Whereas, the environmental criteria are more influential in the rural and natural environments extending in the municipal territories' peripheral areas. Although our hypothetical assumption might motivate future studies on the issue, it stands on the same line with the distribution scheme of each criterion to TAR process stages as proposed in Table 3.1.

Table 3.1 : Multi-criteria framework presented by their relevancy to decision making process stages of TAR.

	OBJECTIVE	**SOCIAL**	**ECONOMIC**	**ENVIRONMENTAL**
STAGE 1	*1-a. Define the amount of new administrative units* *1-b. Define the center of each administrative unit*	S1-Settlements S2-Cultural (collective memory S4- Minority rights	E2-Economic zones E3-Infrastructure	
STAGE 2	*2-a. Define the Hinterland of each administrative unit*	S3-Accessibility/ Transport	E1-Agriculture activity	EN1-Natural capital distribution
STAGE 3	*3-a. Define the border line* *3-b. Define the boundary buffer*	S5- Property		EN2-Watershed/ Topography EN3-Land Cover EN4-Watercourses/ Waterbodies

The proposal outlines three main stages of the TAR process: (i) defining the number and the local administrative units' centers locations, as a macro-scale judgment, (ii) defining each unit's hinterland, as a mezzo-scale finding, and (iii) defining the local, administrative boundary lines, as a micro-scale decision. Referring to Table 1, the socio-cultural and economic criteria are concentrated in the Stage 1 and the Stage 2, supporting the hypothesis in Figure 3.2b. Whilst, the environmental factors are predominantly present in the Stage 2 and the Stage 3 of TAR process. Finally, by taking into account all the criteria, we promote a condition which defines new administrative borders conform the sustainability principles.

3.3.2 Measuring Landscape Fragmentation Caused by Territorial Division of Administrative Reform

The recent Albanian TAR process is performed within the scope of the decentralization policies in post-socialist countries. It generated a new map of local administrative organization by reducing the number of units from 374 to 61. Principally, the shrinkage in number of the administrative units, thus their amalgamation or territorial upscaling (Askim et al, 2017) in the scope of TAR, stands effective in reducing the landscape fragmentation within the territory (Ojima and Chuluun, 2008). However, if TAR does not consider the environmental features of the territory, it cannot guarantee the minimum fragmentation among natural lands. In this study, we experiment with CLC data as a mean to assess the landscape fragmentation caused by the territorial and administrative reform. We analyze the spatial relation among the land cover patches and the local administrative borders as illustrated in Figure 3.3.

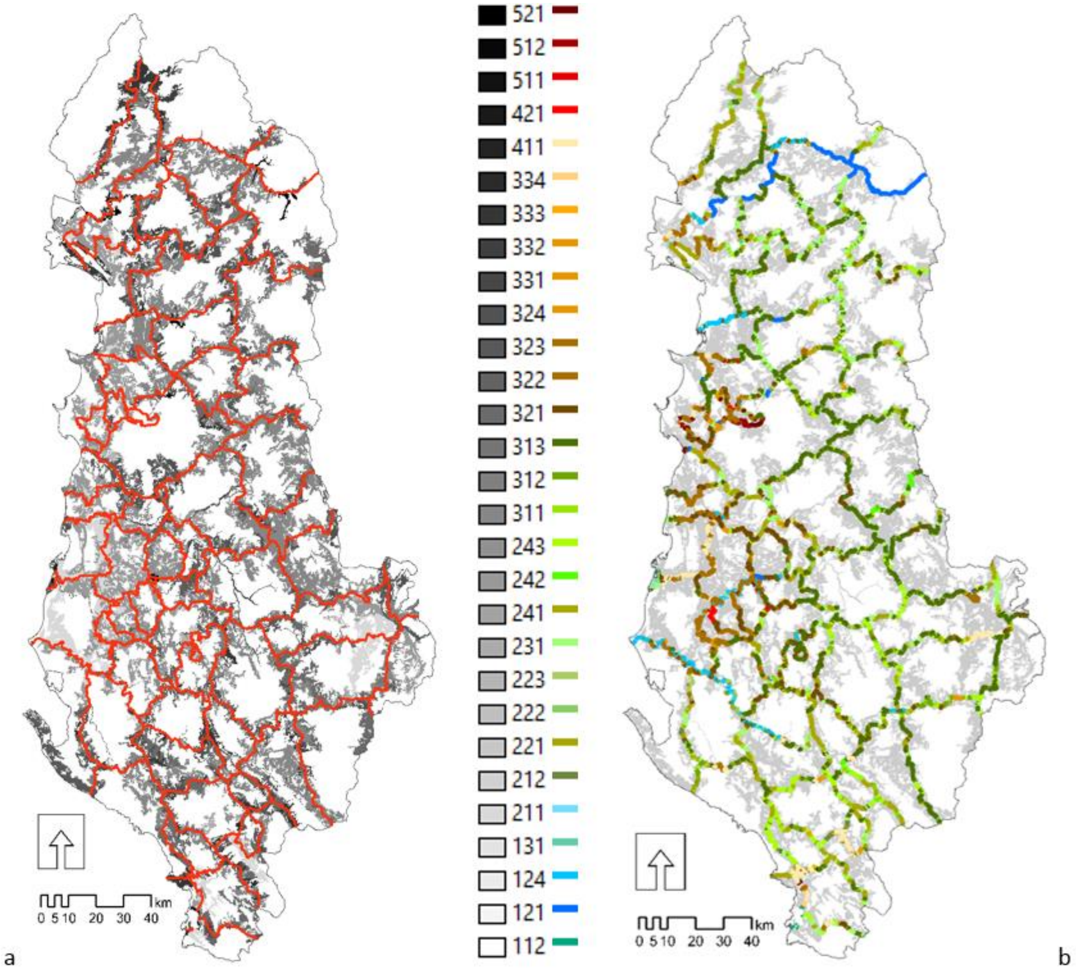

Figure 3.3 : The intersection of local administrative borders with CLC feature classes (a), by their length and count (b)[10].

Land cover properties of a territory may give reliable facts on the state of its natural assets. Previous studies (Zhang et al, 2015) use the land cover statistics to analyze the

[10] 112-Discontinuous urban fabric; 121-Industrial or commercial units; 122-Road and rail networks and associated land; 123-Port areas; 124-Airports; 131-Mineral extraction sites; 132-Dump sites; 133-Construction sites; 141-Green urban areas; 211-Non-irrigated arable land; 212-Permanently irrigated land; 213-Rice fields; 221-Vineyards; 222-Fruit trees and berry plantations; 223-Olive groves; 241-Annual crops associated with permanent crops; 242-Complex cultivation patterns; 243-Land principally occupied by agriculture, with significant areas of natural vegetation; 244-Agro-forestry areas; 311-Broad-leaved forest; 312-Coniferous forest; 313-Mixed forest; 321-Natural grasslands; 322-Moors and heathland; 323-Sclerophyllous vegetation; 324-Transitional woodland-shrub; 331-Beaches, dunes, sands; 332-Bare rocks; 333-Sparsely vegetated areas; 334-Burnt areas; 335-Glaciers and perpetual snow; 411-Inland marshes; 412-Peat bogs; 421-Salt marshes; 422-Salines; 423-Intertidal flats; 511-Water courses; 512-Water bodies; 521-Coastal lagoons; 522-Estuaries; 523-Sea and ocean

changes of the natural capital through certain temporal sequences due to land use alterations. In our study, we employ the land cover statistics to assess and discuss the landscape fragmentation caused by the new administrative reform in Albania. The fragmentation analysis relies on the intersection condition between the CLC data and post-reform local administrative map as illustrated in Figure 3.3a. We ground our findings on the statistical results from the cross-split operation between both data. First, the statistics about the length of local administrative boundaries split through the overlapping CLC patches (Figure 3.3b), highlight the borders in conflict with natural land surfaces. The assessment expands by measuring the surface areas of split land cover patches overlapping with the local administrative boundaries.

3.3.3 Land Cover Data as Environmental Criterion in Deciding the Borders of the Local Administrative Units

The geography literature defines landscape[11] as the external surface of the earth beneath the atmosphere, and merely being an outward manifestation of the factors at work in the area (Hartshorne, 1939). The study introduces land cover data as an evidence of the landscape surface properties, which might be utilized as an environmental parameter during decision making processes of TAR.

Our experiment relies on CLC data, which provide structured typological spatial information on the land cover classified under specific categories. CLC nomenclature is organized in three hierarchical levels of surface cover types. The first divides the land surfaces into five main categories; artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and waterbodies (Büttner and Kosztra, 2017). Finally, CLC provides information about land coverage properties under 44 classes of the 3rd level. Open source spatial data derived from EIONET database, provide useful spatial information about the land cover types of six years intervals. In this study, we decided to proceed with the data of 2012, as they coincide with the timeline of the recent TAR decision making process performed in Albania, between 2013 and 2014. As presented in the multi-criteria framework, we applied the land cover data especially during the local administrative boundary definition phase.

[11] Landscape here is used following the definition in European Landscape Convention (ELC), as an area whose character is the result of the action and interaction of natural and/or human factors.

In this study, we discuss the boundary concept referring to Finch's articulation. The first one is based on the natural features of the context, which he calls "eternal", caused by the "physical geography of the soil". It is equivalent to the "antecedent boundary" concept theorized by Hartshorne in his evolution of boundaries theory (Dikshit, 1975). The second is the "variable" as caused by the "power of man" (Finch, 1844). In our research, we first borrow the dichotomy between natural and manmade, during the division of CLC classes into two groups of land cover surfaces. The artificial (CLC-100) and agricultural lands (CLC-200) are classified as surfaces transformed via anthropogenic factors. Whereas, forests and semi-natural areas (CLC-300), wetlands (CLC-400), and water bodies (CLC-500) are categorized as natural surfaces demarcated by eternal boundaries.

The conceptual dichotomy leads the study to highlight two aspects of the multi-criteria frame, as the most definitive input while deciding the boundary line between two local administrative units. First, the boundary condition between two artificial land cover patches belonging to their respective adjacent administrative units, can be defined as a border line based on the socio-cultural and economic criteria, such as private property. We accept the property lines as definitive indicators of the local administrative boundary dividing the artificial surfaces. As we assume that TAR considers all the socio-cultural and economic factors, including the property rights, the actual municipal borders passing through artificial land cover patches are considered successful, thus, outside the scope of this work.

However, we propose that the border line passing among natural lands should track according to the land cover pattern, following certain rules. The procedure starts with the identification of the existing overlapping condition between the municipal borders of the reference map (post-reform local administrative map of Albania), and the natural landscape patches as derived from CLC data of 2012 (Figure 3.4).

Via a split operation, we subdivide the cross-border patches into at least two components (x and y) falling inside different adjacent administrative units (A and B) (Figure 3.4b). Figure 3.4 illustrates diagrammatically the fundamental rule of the proposal: the smaller (in surface area) split patches are combined with their larger sibling patch, thus being spatially transferred to the neighboring administrative unit (Figure 3.4c). Finally, the new local administrative border should follow the boundary line of the patch it previously split through (Figure 3.4d).

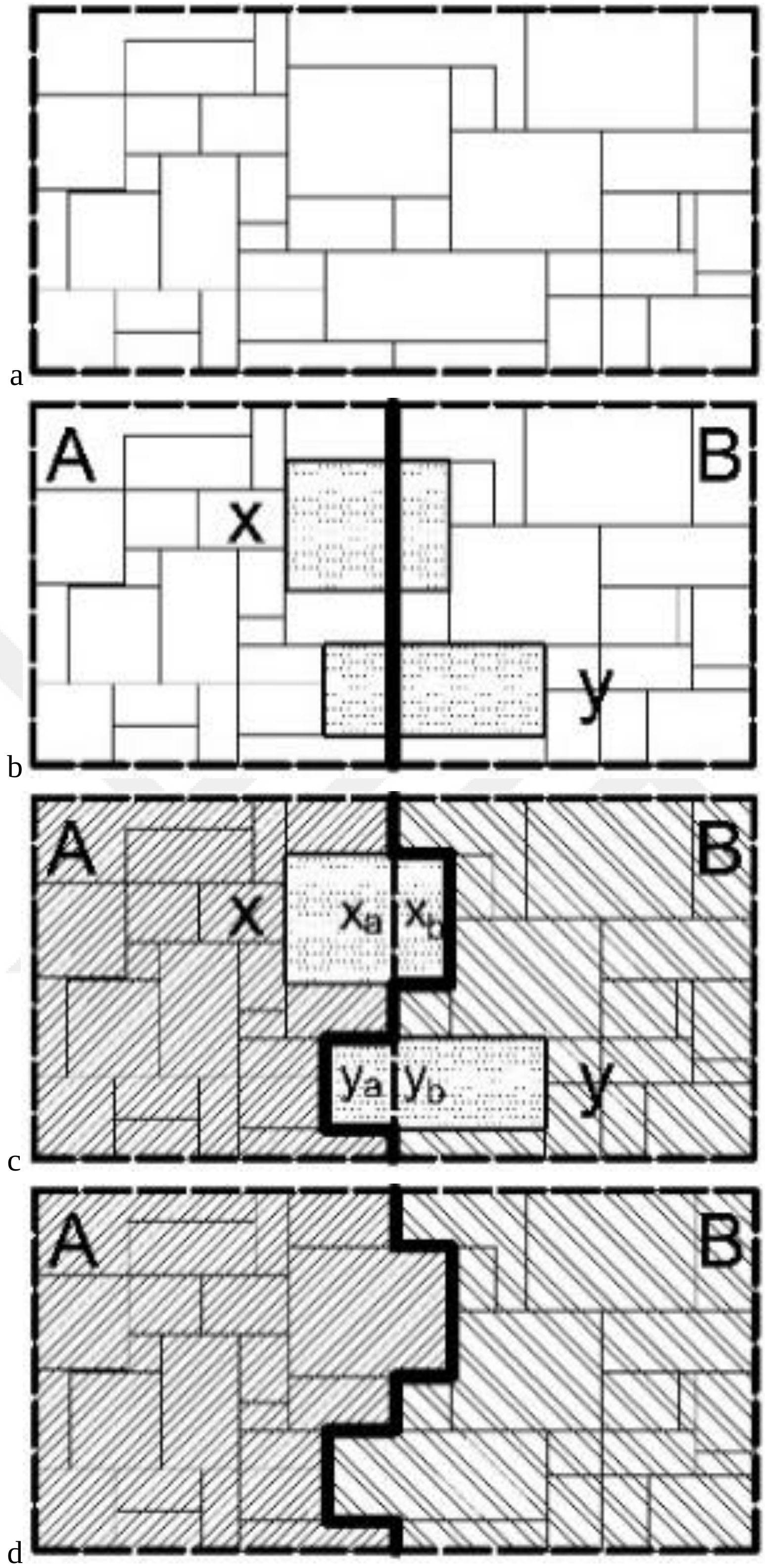

Figure 3.4 : Conceptual model for Boundary definition via CLC; (a) landscape mosaic in a territory facing TAR, (b) border defined via socio-economic criteria between administrative units A and B and fragmentation of patch x and y, (c) transference of smaller split patches (d) and the final boundary proposal.

3.3.4 Utilizing GIS technology in boundary definition of local administrative units

The study utilizes ArcGIS 10.2.2 software during the empirical steps of the research. Initially, we assess the landscape fragmentation generated by the new layout of administrative map, via spatial statistics in ArcMap. Apart from the default toolbox of ArcGIS package, the research applied two extension tools. As a first step, the ModelBuilder utility automates the process of generating the map of split cross-boundary landscape patches. ModelBuilder utilization varies, however in this research we customize it as a unique tool according to the goals of our study (Allen, 2011). The workflow of the model relies on two input variables: (i) the local administrative map and (ii) CLC data (shp). The model produces a new polyline shapefile presenting an improved version of the reference administrative borders' map following the rules explained before. Furthermore, we applied the Matrix Green toolbox (Bodin and Zetterberg, 2010) while preparing the island-free patches of transferred landscape surfaces, as the patches to be reclassified may consist of other patches within them. In such cases all island patches face the same transfer with the patch they fall within.

3.4 Results and Discussions

We organize the results of this research into two main tiers. First, it delivers information about the landscape fragmentation caused by the current, local administrative borders with an emphasis on the natural landscapes. Second, it presents a revised version of the municipal borders of Tirana, based on the unique pattern of the natural land cover mosaics. Finally, we discuss significant drawbacks as further development of the work presented in this article.

3.4.1 Measuring landscape fragmentation caused by TAR in Albania

The overlapping condition between administrative boundaries and land cover patches provides ground for the assessment of functional landscape fragmentation caused by the new TAR in Albania. First, we use the "selection by location" tool in ArcMap, to filter CLC patches that intersect with the local borders' lines. As a result, we derive numerical information about the number of patches (count) and their surface area as illustrated in the Table 3.2. Next, local boundary polyline feature split by the geometry of the filtered CLC patches provides statistical evidence about the total border length per land cover type. Further on, the filtered CLC polygons split by the polyline feature of the local borders, prepare the spatial basis for the local boundary definition method as explained in Figure 3.4.

Table 3.2 : Statistics of landscape patches being fragmented by administrative borders.

CORINE Land Cover Class	CLC	Length [km]	Length %	Count	Count %	Average [km]	Area [ha]	Area %
Discontinuous urban fabric	**112**	51	1.42	56	2.64	0.9	18844	1.56
Industrial or commercial units	**121**	8	0.21	7	0.33	1.1	1173	0.10
Airports	**124**	2	0.07	2	0.09	1.2	602	0.05
Mineral extraction sites	**131**	12	0.35	4	0.19	3.1	1769	0.15
Non-irrigated arable land	**211**	157	4.38	67	3.15	2.3	73953	6.11
Permanently irrigated land	**212**	5	0.14	3	0.14	1.7	1100	0.09
Vineyards	**221**	5	0.15	7	0.33	0.8	763	0.06
Fruit trees and berry plantations	**222**	22	0.60	22	1.04	1.0	2884	0.24
Olive groves	**223**	51	1.41	46	2.16	1.1	10816	0.89
Pastures	**231**	53	1.49	63	2.96	0.8	13811	1.14
Annual crops associated with permanent crops	**241**	2	0.06	1	0.05	2.0	117	0.01
Complex cultivation patterns	**242**	308	8.60	113	5.32	2.7	145189	12.00
Land principally occupied by agriculture	**243**	254	7.08	195	9.18	1.3	79076	6.54
Broad-leaved forest	**311**	691	19.27	249	11.72	2.8	372227	30.77
Coniferous forest	**312**	96	2.67	66	3.11	1.4	25625	2.12
Mixed forest	**313**	58	1.61	47	2.21	1.2	13285	1.10
Natural grasslands	**321**	448	12.51	304	14.31	1.5	135648	11.21
Moors and heathland	**322**	22	0.60	11	0.52	2.0	6268	0.52
Sclerophyllous vegetation	**323**	367	10.23	261	12.28	1.4	98347	8.13
Transitional woodland-shrub	**324**	399	11.13	312	14.68	1.3	108923	9.00
Beaches, dunes, sands	**331**	69	1.92	45	2.12	1.5	11327	0.94
Bare rocks	**332**	9	0.26	8	0.38	1.2	6538	0.54
Sparsely vegetated areas	**333**	243	6.78	181	8.52	1.3	53612	4.43
Burnt areas	**334**	13	0.36	15	0.71	0.9	3281	0.27
Inland marshes	**411**	2	0.04	4	0.19	0.4	540	0.04
Salt marshes	**421**	3	0.10	6	0.28	0.6	1527	0.13
Water courses	**511**	113	3.14	13	0.61	8.7	8529	0.71
Water bodies	**512**	119	3.31	14	0.66	8.5	11851	0.98
Coastal lagoons	**521**	3	0.08	2	0.09	1.5	2174	0.18
Sea and ocean	**523**	1	0.02	1	0.05	0.7	0	0.00
	Total	3584		2125			1209798	

Table 3.2 illustrates that 74% of new administrative borders overlap with natural surfaces. Referring to the same evidence, the list of border length per land cover type is headed by boundaries crossing; broad-leaved forests (CLC-311), natural grasslands (CLC-321) and transitional woodland-shrub (CLC-324), comprising about 43% of the total boundary length. Comparing percentage distribution of borders length and land cover patch count values, the highest difference belongs to broad-leaved surfaces (19.27% - 11.72%), water courses (3.14% - 0.61%) and water bodies (3.31% - 0.66%). These numbers, are on the same line with the average length values per surface type, respectively being; 2.8, 8.7, 8.5 km. The high rates of broad-leaved surfaces indicate that the forested landscape patches are larger in surface area in comparison to other land cover types, resulting in longer border lines they overlap with.

The numerical data of Table 3.2 in accordance with the visual information in Figure 3b, point out a possible consideration of the water resources as decision making criteria during the last TAR process in Albania. According to the statistical data in Table 3.2 and Figure 3.3b, 113 km of administrative borders overlap with watercourses (CLC-511, southern Albania) and 119 km are tracking through waterbodies (CLC-512, northern Albania). This fact implies a sharing of the freshwater resources among neighboring administrative units. Although water sources are among the only environmental criteria relatively considered during the reform, unfortunately it is not explicitly included in the technical report of TAR.

While, three quarters of the total administrative borders are overlapping with the natural land cover surfaces, the remaining 26% of local administrative boundaries cross over artificial (CLC-100) and agricultural (CLC-200) surfaces. More precisely, agricultural surfaces dominated by complex cultivation patterns (CLC-242) and non-irrigated arable land (CLC-211), overlap with 24% of total administrative borders. The remaining 2% of the total administrative borders overlap with the artificial surfaces, which are dominated by discontinuous urban fabric (CLC-112), industrial and commercial units (CLC-121), and mineral extraction sites (CLC-131).

The dominance of natural landscapes and the minimal presence of artificial surfaces intersecting administrative borders might serve as a validation to the hypothesis illustrated in Figure 3.2b and the Table 3.1. Accordingly, we might assert that the environmental criteria is the most significant drive during the Stage 3 or boundary definition phase, specifically at the rural context. As a consequence, the results show that the TAR processes of Albania which apparently neglected the environmental properties of the territory have led to extensive functional fragmentation, particularly among natural landscapes.

3.4.2 CLC data as Reference for defining the Boundaries of Local Administrative units

Beyond the conceptual approach and the assessment of landscape fragmentation caused by the new administrative division under the recent TAR in Albania, the study makes a demonstrative case of readjusting the municipal borders of the capital city, Tirana (Figure 3.5). The experiment stands on the assumption: if the existing version of local administrative map, was an output of a process that has significantly considered the socio-cultural and economic features of the context during the decision making process of TAR. While, the land cover data as an environmental criteria is proposed as the final step of local boundary definition/refinement stage as conceptually targeted in the Table 1. Based on this postulation, the boundaries dividing two artificial surfaces are considered successful, consequently, out of the scope of the experiment.

The focus of the alteration are the border segments of the recent administrative map of Tirana municipality (Figure 3.5) that overlap with the natural lands of CLC data. The borders crossing over artificial land surfaces are excluded, since, as proposed in the multi-criteria framework, the boundaries of artificial and agricultural land cover surfaces are dictated by the cadastral property line rather than the land cover pattern of their mosaic. Furthermore, if urbanized areas (CLC-112), as shown in Figure 6, are considered within the readjustment process, it results in transferring of the adjacent smaller urbanized zones causing a total cancellation of the neighboring administrative unit. Since the consequence is in conflict with the socio-cultural criteria of the Stage 1 and the Stage 2 of the multi-criteria framework (Table 3.1), the urbanized and artificial land cover surfaces are excluded from the readjustment procedure.

According to the overlapping operation between CLC data of 2012 and Tirana municipality border line, there are 143 cross-border land cover patches shared among Tirana and other neighboring municipalities (Figure 3.6). Among patches split by local administrative border, 49 are artificial surfaces covering an area of 38265 ha (31%). The remaining 94 patches are natural lands of a total area of 84707 ha (69%). According to the above mentioned rationale, in the further steps of the experiment the artificial surfaces are excluded. First, the natural land cover surfaces (CLC-311; CLC-312; CLC-321; CLC-323; CLC-324; CLC-331; CLC-333; CLC-512) are filtered from the set of patches intersecting the administrative borders of Tirana (Figure 3.6). The selected natural patches are split via the current administrative border line. A comparison among split parts of each cross-border natural land cover patch is performed, in order to identify the smaller portions to be deported to the neighboring administrative unit consisting the larger part. This condition is based on the rules of the proposed method, where the smaller fragments of split patches have to be joined with the largest sibling portion (Figure 3.7).

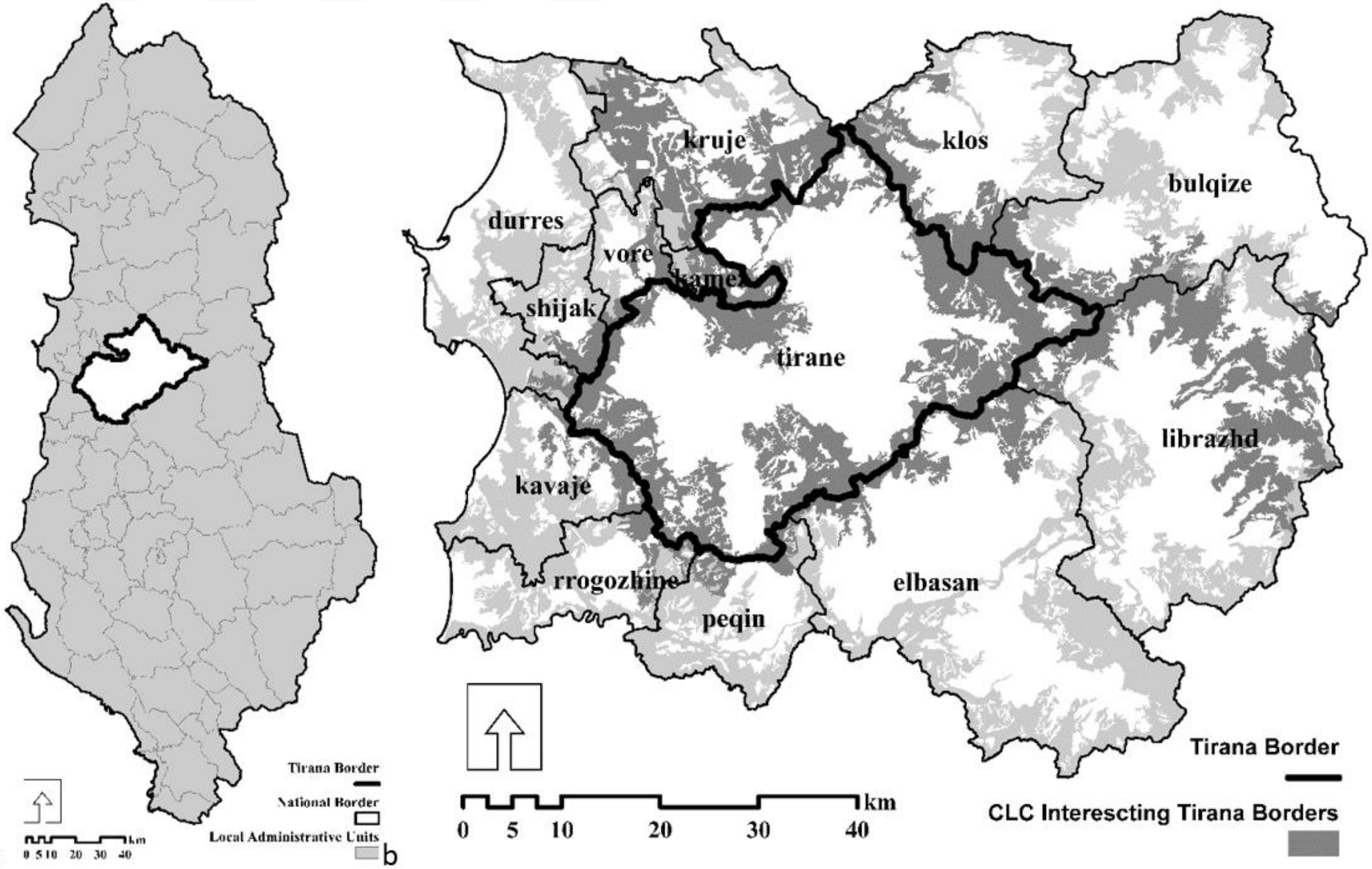

Figure 3.5 : Location of Tirana municipality (a) and the shared municipal borders overlapping with CLC patches (b).

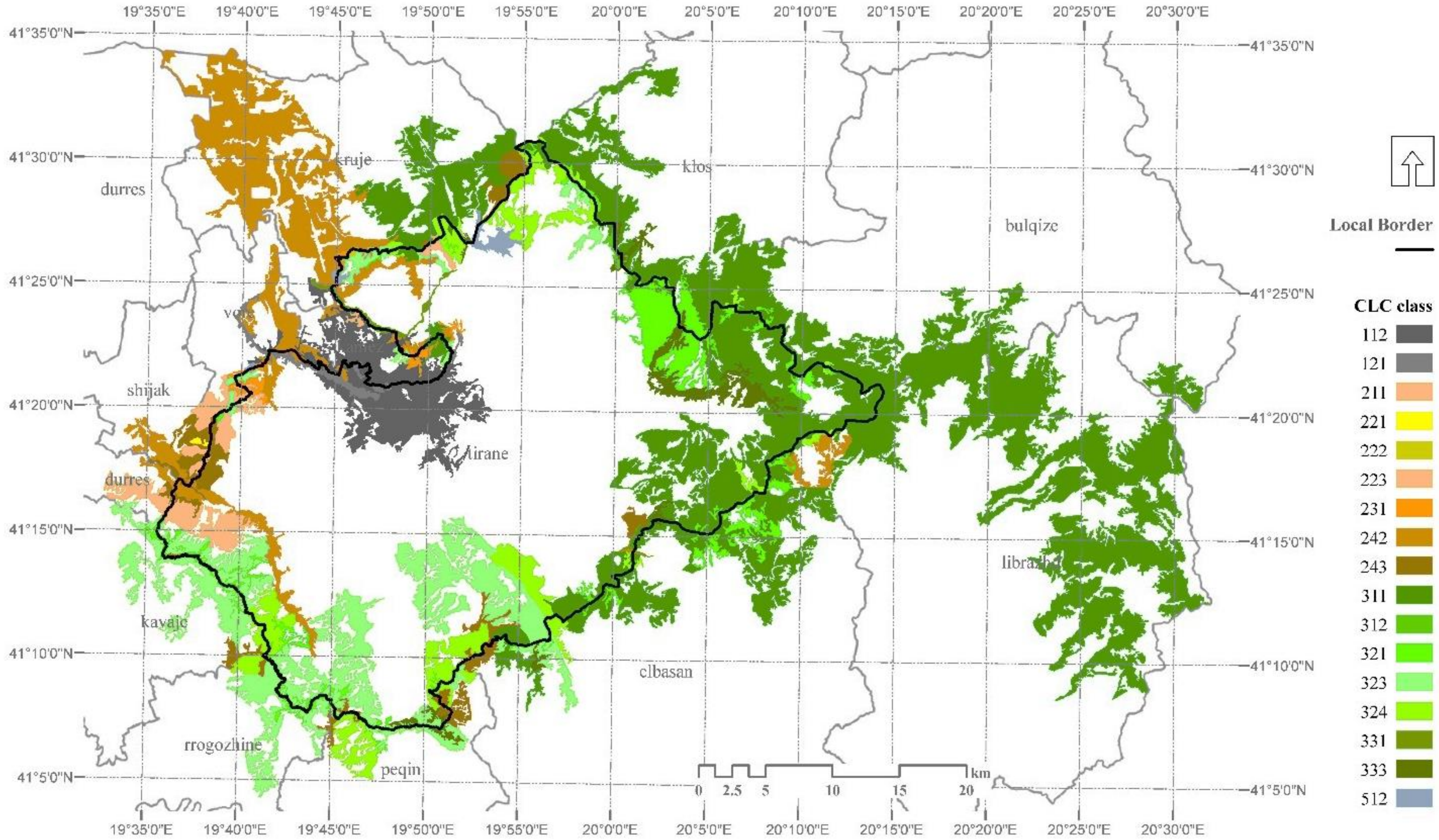

Figure 3.6 : CLC patches intersecting with the current municipality borders of Tirana.

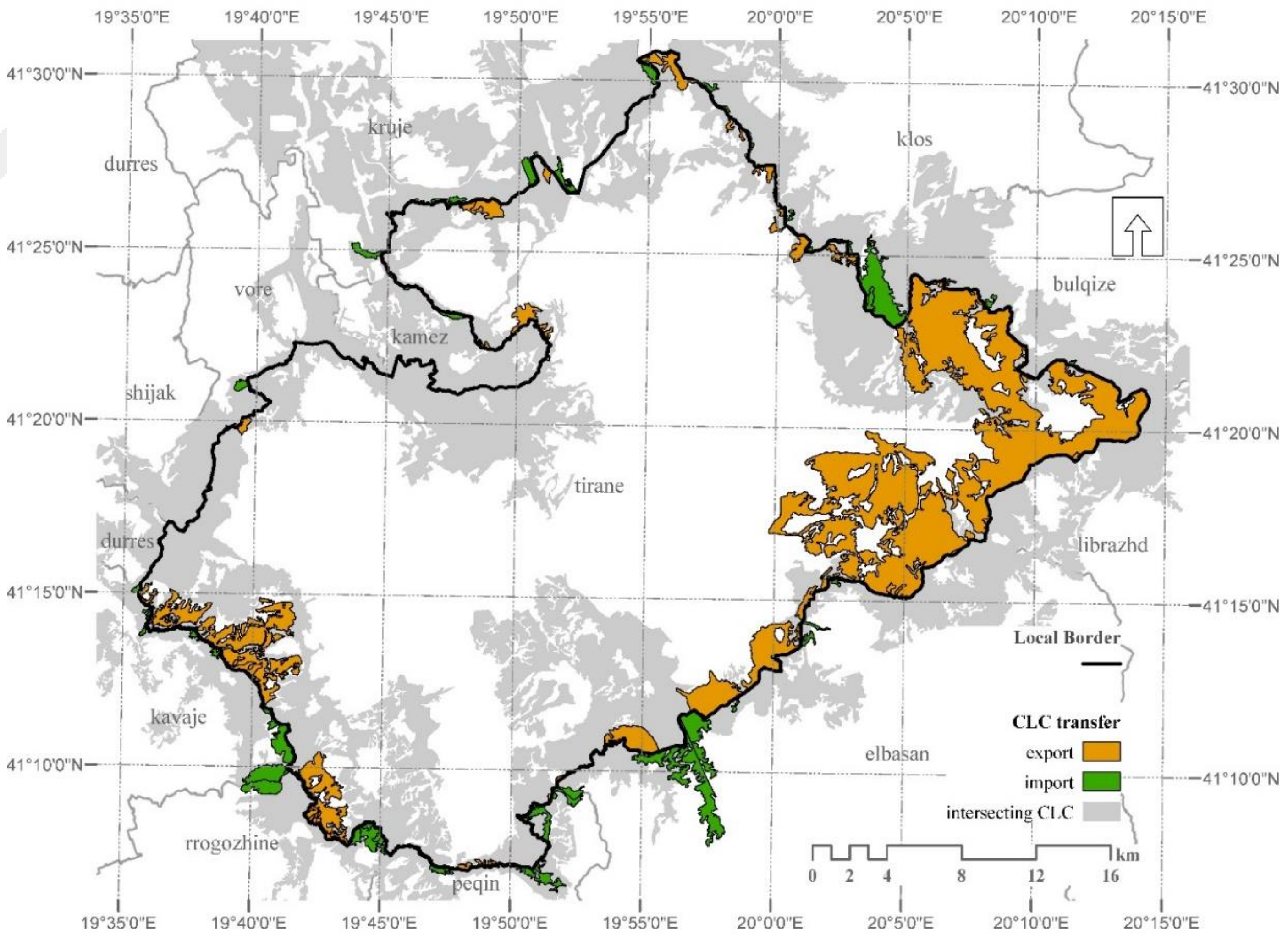

Figure 3.7 : Import and Export of cross-border natural landscape patches in case of Tirana.

According to the map shown in Figure 3.7 and numerical data included in Table 3.3, Tirana is exporting 38 patches (orange) of natural land cover with a total area of 13825 ha. On the other hand, Tirana is importing 56 patches (green) covering 3003 ha of surface area. As it is shown in Figure 3.7, the largest patch to be exported located in the eastern corner of the municipal border, consists of certain island patches within it (indicated by "x" in Figure 3.7). These areas are accepted to be transferred following the destination of the same patch they spatially fall within. Thus, if the island areas are included, the total exported area is updated to 15103 ha, implying for an island lands of 1300 ha. Consequently, according to the proposed methodology Tirana municipal surface area is decreased by 12100 ha, which makes about 11% of the total municipal surface area.

Table 3.3 : Statistics of imported and exported landscape patches according to new proposal of Tirana Municipality borders.

	CLC	**311**	**312**	**321**	**323**	**324**	**331**	**333**	
import	area (ha)	0	28	784	787	1080	140	184	3003
	count	0	3	26	9	10	4	4	56
	%	0	0.9	26	26.2	36	4.7	6.1	100
export	area (ha)	11504	0	233	1953	89	0	45	13825
	count	9	0	13	9	6	0	1	38
	%	83.21	0	1.7	14.1	0.64	0	0.3	100

3.5 Discussion and Further Improvements

First, considering that the process results in patches to be imported and exported simultaneously, one may expect a certain balance in the cumulative change of the local administrative territories' surface areas. In this context, referring to the results of the study, the reduction of the surface area of Tirana municipal territory by 11%, in principle, is beyond the expectation. This dominant difference between imported and exported patches is dictated by a special case of the largest exported surface in the eastern part consisting of broad-leaved forested areas (CLC-311). The patch alone has an area of 9677 ha (about 9% of the total municipal area). At the same time, it is a smaller portion of a large cross-border patch (ID="AL-10469") which covers a total surface area of 29115 ha and is concurrently split among four neighbor administrative units. Moreover, a major part of this patch is part of national protected areas being subject of central government management. Considering these reasons, the patch "AL-

10469” and similar other patches might be excluded from the transferring procedure, consequently improving the results of the study.

Furthermore, the modified municipal border might result in conflict with the other criteria, the socio-cultural or economic properties of the territory. For instance, such a conflict emerges in case when the smallest (in terms of surface area) portion of a cross border natural landscape patch, has a linear layout perpendicular to the splitting border by continuing deep into the central territory of the administrative unit (Figure 3.8). This is due to the fact that the transferred patch may overlap with crucial elements such as local transportation network, cultural heritage sites, rural settlements that traditionally may be connected with the other urban center. Consequently, the paper calls for further research on analyzing these conflicting case. In order to avoid similar divergences, the methodology might improve by bringing other restricting parameters such as: surface area, shape of patch, the national scale interest and status of large patches.

Finally, we acknowledge a possible contradiction between the rigid form of the administrative boundaries and the evolving character of land cover properties of the territory. As previous studies have shown, the transformation of land cover pattern of the territory within a relatively short period of time does not only result out of anthropogenic reasons, but also by changes in the systemic cycles in the natural environment such as global climate change (Davidson et al, 2012) or ecological succession (Parker et al, 2003; Alonso and Sole, 2000). The concept of dynamic local administrative boundary might be elaborated as a further step of the study.

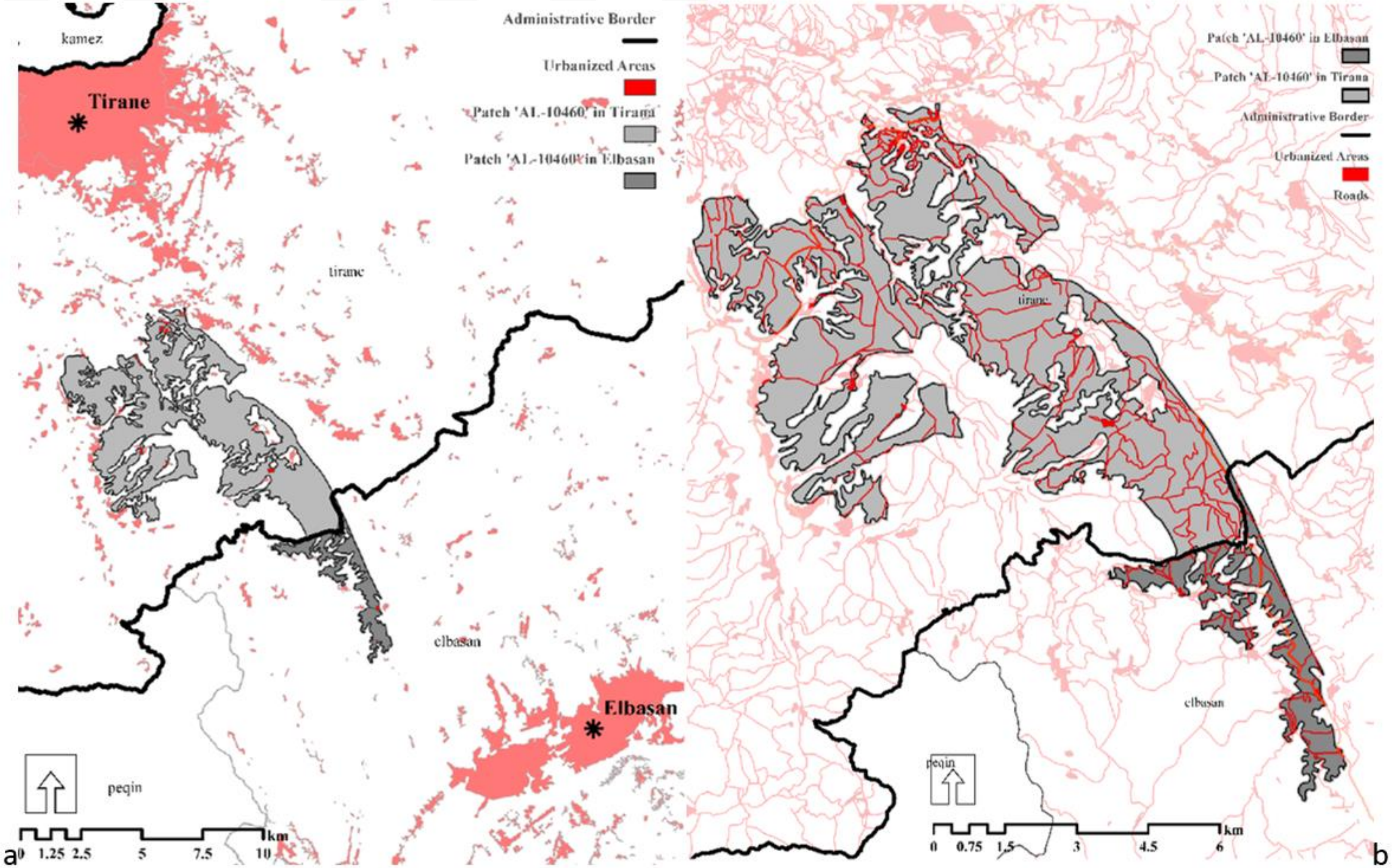

Figure 3.8 : Patch ID=AL-10460 in relation with urban centers (a) and with rural settlements and transportation network (b).

3.6 Conclusions

This paper demonstrates a case of the local administrative boundaries re-organization, based on land cover data introduced as a territory's environmental feature. Principally, the methodology relies on a proposed multi-criteria framework which consists of socio-cultural, economic, and environmental features of the context. The multi-criteria framework aims at providing a comprehensive structure for considering the complete properties of a territory undergoing the process of territorial and administrative reform.

The results of the study show that a local administrative division process which disregards the environmental factors of the territory, leads to functionally fragmented landscapes. The fragmentation consists of a division of responsibilities and interest on a certain landscape patch as a natural capital asset, among different administrative units. In the long run, this practice is forecasted to lead to uncoordinated changes in the landscape structure, thus potentially resulting in physically fragmented landscapes.

The study has shown that the fragmentation among the landscape patches minimizes when TAR processes consider the land cover properties of the territory, thus the landscape mosaic structure, as a decisive criteria during the local administrative boundary definition phase. The proposed method generates a different administrative division which avoids any condition of cross-border natural landscape patches. Hence the landscape fragmentation significantly reduces at the CLC data scale. While the method results successful in most of the small and moderate sized land cover patches, it is debatable in conflicting cases between large natural landscape patches and the socio-economic priorities of region.

The study proposes a multi-criteria framework highlighting the environmental features of the territory facing TAR processes, along with the socio-cultural and economic, converging with the principles and goals of sustainable development. The proposed method for defining the local administrative borders based on multi-criteria basis by utilizing land cover data can be applied in future TAR processes, especially in post-socialist countries. Finally, the CLC data provided an appropriate spatial information to define the local boundary based on sustainable land management principles, within the scope and objectives of TAR.

4. A GIS BASED METHOD FOR INDEXING THE BROAD-LEAVED FOREST SURFACES BY THEIR WILDFIRE IGNITION PROBABILITY AND WILDFIRE SPREADING CAPACITY[12]

This article presents a method useful for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spreading capacity at a coarse spatial scale. The framework consists of three phases; inventory, analysis, and indexing. First, the study utilizes a multi-criteria inventory procedure investigating the existing broad-leaved forest areas of the landscape based on a variety of social, environmental, and physical parameters. Beyond the statistical inventory records, the research brings forward a division between ignition probability and spreading capacities of wildfire events during the analysis phase. At this stage, particular criteria figures out to have higher impact in either ignition or spreading phases of wildfire event. At the final phase, the model is aiming to generate indexing maps categorizing the broad-leaved forest surfaces by their wildfire ignition probability index (WIPI) and wildfire spread capacity index (WSCI). Broad-leaved forest landscape patch as derived via CORINE Land Cover (CLC) data, is converted into a raster data with a pixel size of 500 m (25 ha). The centroid of each pixel act as the reference point for all measurements during all phases of the study. The presented method is aimed to be of assistance in decision making and management processes of Disaster Risk Management and Fire Safety (DRMFS) agendas at landscape scale.

4.1 Introduction

Planet Earth bears within innately inflammable conditions due to its cover vegetation rich in carbon, seasonal dry climates, oxygen abundance in its atmosphere, and extensive lightning and volcanic ignitions (Bowman et al, 2009). Consequently, wildfires are considered as natural phenomenon. They are key part of ecosystem cycles of many biomes on earth and integral part of many terrestrial ecosystems (Pausas and

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[12] This chapter is based on the paper: Hysa, A., and Başkaya T., F. A. (2018). A GIS Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity. *Modelling Earth Systems and Environment*, *x*(x), xxx-xxx. DOI: 10.1007/s40808-018-0519-9 (published online in October the 11th, 2018)

Keeley, 2009; 2014). For instance, in the Mediterranean ecosystem wildfires are accepted to be a major ecological dynamic influencing the evolutionary traits of plants, ecological succession of vegetation, erosion, as well as human perceptions towards the landscape (Naveh, 1975). Besides the natural cycles in earth systems, recent research has related the increase in number of forest fires in Mediterranean countries to anthropogenic causes as well as to climate change (Moreno et al, 1998; Pausas and Vallejo, 1999; Keeley et al, 1999; Pausas, 2004; Gonza´lez and Pukkala, 2007; Abatzoglou and Kolden, 2013; Pereira et al, 2013; Rodrigues et al, 2013). Through history, the Mediterranean landscapes have been modified through human and livestock pressures, including burning, cutting and grazing (Vannière et al, 2008). Regarding the burning processes, in the Mediterranean region the majority of wildfires are reported to be intentionally or unintentionally caused by human activities (Martı´nez et al, 2009; San-Miguel-Ayanz et al, 2013). In overall, wildfires in Mediterranean Europe can be accepted to be influenced by both human and physical determinants (Levin et al, 2016).

However, the anthropogenic and natural causes do not act equally during different phases of wildfire event. This study follows the fundamental differentiation between ignition and spreading factors in wildfire patterns and regimes (Cardille et al, 2001; Gasull et al, 2011). Each of them is dependent on different sets of influencing dynamics. Previous studies have shown that there is a difference between the factors explaining large wildfires and wildfire occurrence frequency (Turco et al, 2014). According to Levin et al. (2016), the variables affecting fire ignition such as; lightning, controlled burns, arson, negligence, can be different from those motivating fire spread, which may include characteristics of the fuel, weather conditions, topography, and capacities of fire suppression. Altitude, aspect, latitude, slope and topographic position influence microclimatic properties, such as temperature, precipitation, direct solar radiation, wind exposure, etc., which in turn influence the moisture content of fuel (Dillon et al, 2011). Indirectly, topography can affect ignition probability because steep slopes, ridge tops, and south-facing slopes are all characterized by drier fuel conditions (Haire and McGarigal, 2009).

The areas close to settlements are accepted to be more exposed to wildfire ignition probabilities (Garcia et al, 1995; Syphard et al, 2007; Krawchuk et al, 2009; Ricotta and Di Vito, 2014). The case of Portugal have shown that wildfires events are concentrated close to the densely populated areas, near roads, within the urban–rural fringe, or close to agricultural areas (Moreira et al, 2010). The dominance of anthropogenic factors on wildfire ignition phase is demonstrated via further extreme human activities such as military training (Levin and Heimowitz, 2012) and ‘‘nationalistically motivated’’ arsons (Zerubavel, 1996). Previous studies on wildfires in Spain, Portugal and Italy have shown that population density, accessibility (distance from roads), and changes in recreation patterns are the key determining factor of fire ignitions (Romero-Calcerrada et al, 2008; Catry et al, 2009; Sirca et al, 2017; Sá et al, 2018). Based on these issues the acknowledgment of the significance of the wildland–urban interface (WUI) in fire management and fire risk analysis has grown during the last two decades (Radke, 1995; Cohen, 2000).

However, after the ignition phase, the extensive spread of fires more frequently take place in zones with low density of inhabitants, in forests or shrub lands, and areas of considerable distances from the transportation network (Ager et al, 2014). At the same time, fire behavior is strongly driven by weather conditions (Koutsias et al, 2012). Temporally speaking, the spreading of a wildfire is most common during transition seasons being characterized by specific atmospheric conditions such as; high temperatures, low humidity, and strong winds (Kutiel and Kutiel, 1991; Levin and Saaroni, 1999; Thompson and Spies, 2009; Kutiel, 2012). Humidity and temperature determine the rate at which fuels dry (Westerling et al, 2006; Finney et al, 2010; Xystrakis et al, 2014). Similarly, the wind contributes to fuels dehydration, affords oxygen to fire, and governs fire direction and spread rate (Bessie and Johnson, 1995). According to the dendrogram developed by de Sousa et al. (2015) the variables that mostly affect wildfires are; rainfall, sunlight and wind speed (de Souza et al, 2015). Besides the meteorological and hydrological factors, a further important criteria affecting the wildfire spreading regimes is suppression priority. It has a profound social character and is often determined by threats to property value, to human security, and to areas of high cultural and natural values. Consequently, it results in increased fire suppression near settled areas, while wildfires in relatively isolated areas often burn longer (Kasischke and Turetsky, 2006). Risk assessment of spreading regimes of a wildfire is set as a research priority since the current fire management strategies generally focus on the ignition and extinction phases (Badia et al, 2002).

In this context, the goal of this study is to develop a risk assessment method as a decision support tool in disaster risk management and fire safety for broad-leaved forests. It aims to integrate information on the occurring probability and impact rate of forest resource response to multi-criteria risks, so that to synthesize a conclusion about risk in support of decision making (Sikder et al, 2006). By their definition integrated wildfire risk assessments are dependent on a variety of ambiguous sources based on uncertainty with respect to fire ignition and spread behavior (Thompson et al, 2011).

This study aims to develop a method for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spread capacity. It relies on a workflow of three stages; (i) multi-criteria inventory, (ii) analysis based on data clustering procedure, (iii) calculating and mapping wildfire ignition probability index (WIPI) and wildfire spread capacity index (WSCI). The presented method is an improved and extended alternative to the existing fire risk mapping techniques specifically useful for study areas lacking well archived background data about forest fire events (You et al, 2017). A validation procedure is utilized by comparing the result of fire risk mapping based on 2000-2006 data and the reported burned areas within the same broad-leaved forest patch based on 2006-2012 data. Even though, the results of this study shows high rates of validity, possible pitfalls and further improvements are argued in the discussion part being highlighted as future steps of the work presented in this article.

4.2 Methods and Materials

The study utilized a variety of data collection, data clasturing, interpretation and analysis. All steps of the study are performed in ArcGIS software. CLC data, open street map, and weather data from Meteonorm software provides the raw material of this study.

4.2.1 Conceptual approach; multi-criteria framework for wildfire risk assessment

The estimation of forest fire risk in spatial means has become very crucial in forest protection and planning as well as wildfire management agendas (Wu et al, 2015). A fundamental information required for forest protection and planning is the zone of fire risk. There are two main approaches in forest fire risk mapping practices based on probabilistic models of fire ignition and fire behavior modelling tools (Finney, 2005;

Chuvieco et al, 2014). Both methods relies on long-term wildfire inventory databases. However, a third method is developed by You et al. (2017), dedicated to geographies lacking statistical background information about the forest fire events. They have developed a scheme for the assessment of fire risk through a synthetic forest fire risk index (FRI) grounded on twelve factors grouped under four main categories; topography, human activity, climate, and forest characteristics (You et al, 2017).

Our study follows the third method since the temporal data about the wildfire regimes for the broad-leaved forest areas in Albania- as our study area- are very limited. However, this article brings forward an upgraded version of the model developed by You et al. (2017), through differentiating between ignition probability and spread capacity of wildfire events. As a result, it leads to two extra indexing techniques as a dismantling operation of FRI into WIPI and WSCI. Since, the identification of analytical factors are site specific and majorly dependent on the data availability, this study relies on the multi-criteria inventory procedure for burned areas in Albania as developed by Hysa et al. (2017).

Based on literature review there are 14 variables shortlisted as the most common measurable affecting the wildfire processes. They are grouped into three main categories; social (S), environmental (E), and physical (P) as shown in Table 4.1. Besides the criteria listed here, soil moisture and vegetation (fuel) type are considered crucial in wildfire events (OMNR, 1982; Whitlock et al, 2003, You et al, 2017), but at this stage the study does not include them. This is due to the narrowed target of this study, focusing only on a specific forest type (broad-leaved forest) at a coarse spatial scale of 1:100000 according to the technical report on CORINE Land Cover (CLC) (Bossard et al, 2000). The lack of detailed data about the vegetation properties in our case study is another reason of not including the fuel type variable at this stage.

Listed variables are highlighted in previous studies by several scholars (Table 4.1) as crucial factors affecting wildfire behaviors. Our study brings a novel interpretation of temperature and wind direction variables considering their diverse impact on ignition probability and spread capacity of wildfire. First, while the maximum temperature values are more related with the ignition probability, the average temperature measures can be considered to have a greater effect on the spreading activity of the wildfire. Furthermore, the wind direction criterion dissimilar with previous studies is correlated with aspect (orientation) values of the terrain. More specifically, the impact of wind direction on the wildfire spread capacity is higher if the wind direction vector is confronting the orientation vector of the terrain. Numerically this is quantified by calculating the difference between both vector directions. The higher the difference the higher the WSCI value.

Table 4.1 : Relative and absolute values effects of each criterion on the wildfire occurrence and spreading capacities.

Criteria	type	Ignition	Spread	Literature References
Dist. to Urban Centers	S1	-1	1	(Vasconcelos et al, 2001; Kasischke and Turetsky, 2006; Ager et al, 2014)
Dist. to Settlements	S2	-1	1	(Catry et al, 2009; Krawchuk et al, 2009; Levin et al, 2016; Sirca et al, 2017)
Dist. to Main Transport	S3	-1	1	(Badia et al, 2011; Ager et al, 2014)
Dist. to any Road	S4	-1	0	(Kasischke and Turetsky, 2006; Catry et al, 2009)
Dist. to Agricultural Lands	S5	-1	0	(Vasconcelos et al, 2001; Oliveira et al, 2012)
Solar radiation	E1	1	1	(de Souza et al, 2015)
Precipitation	E2	-1	-1	(Xystrakis et al, 2014; de Souza et al, 2015)
Temperature (max/ average)	E3	1	1	(Levin and Saaroni, 1999; Westerling et al, 2006; Koutsias et al, 2013)
Relative Humidity	E4	-1	-1	(Díaz-Delgado et al, 2004; Westerling et al, 2006; Finney et al, 2010)
Wind direction- Aspect	E5	0	1	(Kutiel and Kutiel, 1991; Levin and Saaroni, 1999)
Wind speed	E6	0	1	(Bessie and Johnson, 1995; Kutiel, 2012; de Souza et al, 2015)
Slope	P1	1	1	(Haire and McGarigal, 2009; Fernandes et al, 2016; Levin et al, 2016)
Aspect (Orientation)	P2	1	1	(Dillon et al, 2011; Fernandes et al, 2016)
Dist. to Water sources	P3	0	1	(You et al, 2017)

4.2.2 Weighting through analytical hierarchy process (AHP)

During the analysis phase, each criteria is introduced into a filtering process and a weighting procedure. Both steps are performed through literature review and analytical hierarchy processing (AHP). First, a filtering process is performed based on the findings of previous studies which focus on the differentiation among criteria by their impact on either ignition or spread. Referring to Table 4.1, each criterion is assigned an impact factor indicating the relation it has with either ignition or spreading phases of wildfire. For example, distance to any road (S4) and distance to agricultural lands (S5) are considered as having great impact in the ignition phase of the fire but not having any considerable effect on the spreading phase of it. Similarly, while wind direction (E5) and wind speed (E6) are accepted as determinants of the spreading behavior of wildfire, they are almost irrelevant to the ignition probability calculations. Meanwhile, certain criteria such as relative humidity (E4) and solar radiation (S1) are effective on both phases of wildfire phenomena. The criterion having no impact is given a "0" factor. Furthermore, criteria related in a reverse ratio with the ignition or spread process are assigned "-1" factor. In other words, the smaller the distance to agricultural lands (S5), the higher the probability to face a wildfire ignition. Similarly, the higher the precipitation (E2) and relative humidity (E4) values, the lower the ignition probability and spreading capacity of wildfire. Factor "1" is assigned to all remaining criteria right-angled with either/both ignition probability or/and spreading capacity of wildfire phenomenon.

$$WIPI = \alpha_{s1}(S1) + \alpha_{s2}(S2) + \alpha_{s3}(S3) + \alpha_{s4}(S4) + \alpha_{s5}(S5) + \alpha_{e1}(E1) + \alpha_{e2}(E2) + \alpha_{e3}(E3) + \alpha_{e4}(E4) + \alpha_{p1}(P1) + \alpha_{p2}(P2) \quad (4.1)$$

Table 4.2 : Calculation of Coefficient (α) via AHP pairwise comparison method.

Criteria		**S1**	**S2**	**S3**	**S4**	**S5**	**E1**	**E2**	**E3**	**E4**	**P1**	**P2**	***(α)***
Dist. to Urban Centers	**S1**	1.0	0.1	0.2	0.1	0.1	3.0	7.0	5.0	5.0	9.0	3.0	0.081
Dist. to Settlements	**S2**	9.0	1.0	7.0	0.3	0.2	5.0	9.0	7.0	7.0	9.0	5.0	0.158
Dist. to Main Transport	**S3**	5.0	0.1	1.0	0.2	0.1	0.3	0.3	0.3	0.3	0.3	1.0	0.029
Dist. to any Road	**S4**	9.0	3.0	5.0	1.0	0.2	5.0	9.0	7.0	7.0	9.0	5.0	0.179
Dist. to Agricultural	**S5**	9.0	5.0	9.0	5.0	1.0	9.0	7.0	9.0	7.0	5.0	9.0	0.297
Solar radiation	**E1**	0.3	0.2	3.0	0.2	0.1	1.0	0.2	0.3	0.1	7.0	3.0	0.037
Precipitation	**E2**	0.1	0.1	3.0	0.1	0.1	5.0	1.0	0.3	0.3	5.0	3.0	0.045
Temperature	**E3**	0.2	0.1	3.0	0.1	0.1	3.0	3.0	1.0	3.0	9.0	5.0	0.064
Relative Humidity	**E4**	0.2	0.1	3.0	0.1	0.1	7.0	3.0	0.3	1.0	7.0	5.0	0.064
Slope	**P1**	0.1	0.1	3.0	0.1	0.2	0.1	0.2	0.1	0.1	1.0	5.0	0.030
Orientation	**P2**	0.3	0.2	1.0	0.2	0.1	0.3	0.3	0.2	0.2	0.2	1.0	0.017
		34.3	**10.2**	**38.2**	**7.6**	**2.4**	**38.8**	**40.1**	**30.6**	**31.2**	**61.5**	**45.0**	**1.000**

The first step led to two separate sets of variables affecting differently the ignition and the spread phenomena during wildfire events. Each set makes the basis for the WIPI and WSCI equations. According to the assessment based on literature review as represented in Table 4.1, there are 11 factors mostly affecting the ignition phase of a wildfire in broad-leaved forests. Distance to urban centers (S1), distance to rural settlements (S2), distance to main transportation network (S3), distance to any road (S4), distance to agricultural lands (S5), solar radiation (E1), precipitation (E2), temperature (E3), relative humidity (E4), slope (P1), aspect (P2) are shortlisted factors determining the ignition probability of wildfire. Based on the relative impact factor (α), each criterion is introduced into the calculation of WIPI value (equation 4.1). The weighted values of the coefficient "α" for each criteria is calculated via AHP pairwise comparison method (Mu and Pereyra-Rojas, 2017) (Table 4.2).

Similarly, the set of factors being correlated with the spreading processes of wildfire in broad-leaved forests are identified and integrated into the calculation equation for WSCI index. The WSCI value is defined to be depended on; distance to urban centers (S1), distance to rural settlements (S2), distance to main transportation network (S3), solar radiation (E1), precipitation (E2), temperature (E3), relative humidity (E4), wind direction- aspect (E5-P2), wind speed (E6), slope (P1), aspect (P2), and distance to water sources (P3). Meanwhile, spread phenomenon in a specific location within the broad-leaved forest area is depended on the WIPI value of the neighborhood. In other words, the higher the wildfire ignition probability of the neighboring location the higher the wildfire spreading capacity at a certain location. Thus, WIPI value is included in the equation of WSCI (equation 4.2), the value of which is assigned as 20 % relying on WIPI value and 80 % on all other factors.

$$WSCI= 0.2(WIPI) +0.8 [\beta_{s1} (S1) + \beta_{s2} (S2) + \beta_{s3} (S3) + \beta_{e1} (E1) + \beta_{e2} (E2) + \beta_{e3} (E3) + \beta_{e4} (E4) + \beta_{e5} [(E5)-(P2)] + \beta_{e6} (E6) + \beta_{p1} (P1) + \beta_{p2} (P2)+ \beta_{p3} (P3)] \tag{4.2}$$

Table 4.3 : Calculation of Coefficient (β) via AHP pairwise comparison method.

Criteria		**S1**	**S2**	**S3**	**E1**	**E2**	**E3**	**E4**	**E2**	**E3**	**P1**	**P2**	**P3**	***(β)***
Dist. to Urban Centers	**S1**	1.0	5.0	0.1	0.1	0.1	0.2	0.3	0.2	0.1	0.1	0.3	0.1	0.019
Dist. to Settlements	**S2**	0.2	1.0	0.2	0.2	0.1	0.1	0.3	0.1	0.1	0.1	0.3	0.1	0.012
Dist. to Main	**S3**	7.0	5.0	1.0	0.3	0.2	0.3	0.2	1.0	0.3	0.1	0.3	3.0	0.051
Solar radiation	**E1**	7.0	5.0	3.0	1.0	0.3	1.0	0.3	0.3	0.2	0.2	1.0	0.3	0.047
Precipitation	**E2**	7.0	7.0	5.0	3.0	1.0	1.0	1.0	3.0	1.0	0.3	3.0	3.0	0.117
Temperature	**E3**	5.0	7.0	3.0	1.0	1.0	1.0	0.3	0.3	0.2	0.2	3.0	0.3	0.060
Relative Humidity	**E4**	3.0	3.0	5.0	3.0	1.0	3.0	1.0	3.0	0.2	0.3	0.3	3.0	0.088
Wind direction	**E5**	5.0	7.0	1.0	3.0	0.3	3.0	0.3	1.0	0.1	0.2	0.3	0.2	0.053
Wind speed	**E6**	7.0	9.0	3.0	5.0	1.0	5.0	5.0	7.0	1.0	3.0	7.0	5.0	0.217
Slope	**P1**	7.0	9.0	7.0	5.0	3.0	5.0	3.0	5.0	0.3	1.0	3.0	0.3	0.160
Orientation	**P2**	3.0	3.0	3.0	1.0	0.3	0.3	3.0	3.0	0.1	0.3	1.0	0.2	0.059
Dist. to Water sources	**P3**	9.0	9.0	0.3	3.0	0.3	3.0	0.3	5.0	0.2	3.0	5.0	1.0	0.118
		61.2	**70.0**	**31.7**	**25.7**	**8.8**	**23.0**	**15.2**	**29.0**	**4.0**	**9.0**	**24.7**	**16.6**	**1.000**

4.2.3 Study area and data availability

The empirical part of this study is tested over a broad-leaved forest surface in Albania. Albanian forests are in vulnerable condition (Weiland, 2010). Fire control and mitigation agendas in Albania have been continuously suffering from a general tendency of reduction of public support (Naka et al, 2000). According to International

Forest Fire News (IFFN) report of 2003, among Mediterranean countries Albania has a relatively high rate (2.19) of annual average burned forest area (ha) per total national surface area (sq.km). The prevailing season of wildfire occurrences is between June and September, peaking with a soil surface maximum temperature of 65-70 ºC in July and August (Meta et al, 2003). Whereas, referring to IFFN report of 2008, during the period between 1997 and 2007, the average number of fire events is 580, peaking in 2007 by 1190 fire events. The average burned forest surface during the same period is 1824 ha, climaxing in 2007 by 5857 ha. The fire events are reported to have been initiated by human causes in 98.5 % of their cases (Hoxhaj, 2008). Year 2007 is recorded as the period with the highest number of occurrences and widest affected areas. The extremely unfavorable climatic conditions (high summer temperatures and wind) influenced the extent to which they occurred, both temporally and spatially. One of the most devastating events during the last decades have occurred in August 2007, being amplified by strong winds recorded in their highest speed levels above 15 m/s (Islami et al, 2009).

The study area is a selected broad-leaved forest surface (CLC-311) in the northern Albania (19.55904- 42.07221, SW; 19.88394- 42.32699, NE) as derived from CLC of 2006 (Figure 4.1). The selected patch (encoded as AL-725) has a surface area of 25048 ha and a perimeter of 684 km. The main selection criteria is the considerable surface area, the regular shape of the patch and consisting of a future burned area (according to CLC data of 2012) within it. According to the method explained in the previous section, the patch AL-725 is rasterized into 989 pixels of 0.5 km in resolution (Figure 4.2). In other words, the next inventory and analysis stage of the study will stand on the evaluation of 989 pivot centroid points according to each criterion.

The data required for GIS-friendly representation of each criteria are acquired from four main sources. First, CLC data being available as an open source via European Environment Agency (EEA) are utilized for identifying the broad-leaved forest surfaces being the main target of this study. Besides that, CLC data is providing spatial information about social criteria such as distance to urban centers (S1) and distance to agricultural lands (S5). Distance to roads (S2), distance to water sources (P3), are relying on open source data via Albanian State Authority of Geospatial Information (ASIG) portal. Whereas the physical criteria of slope (P1) and aspect (P2) depend on open source digital elevation model (DEM) global data of 30 m in resolution.

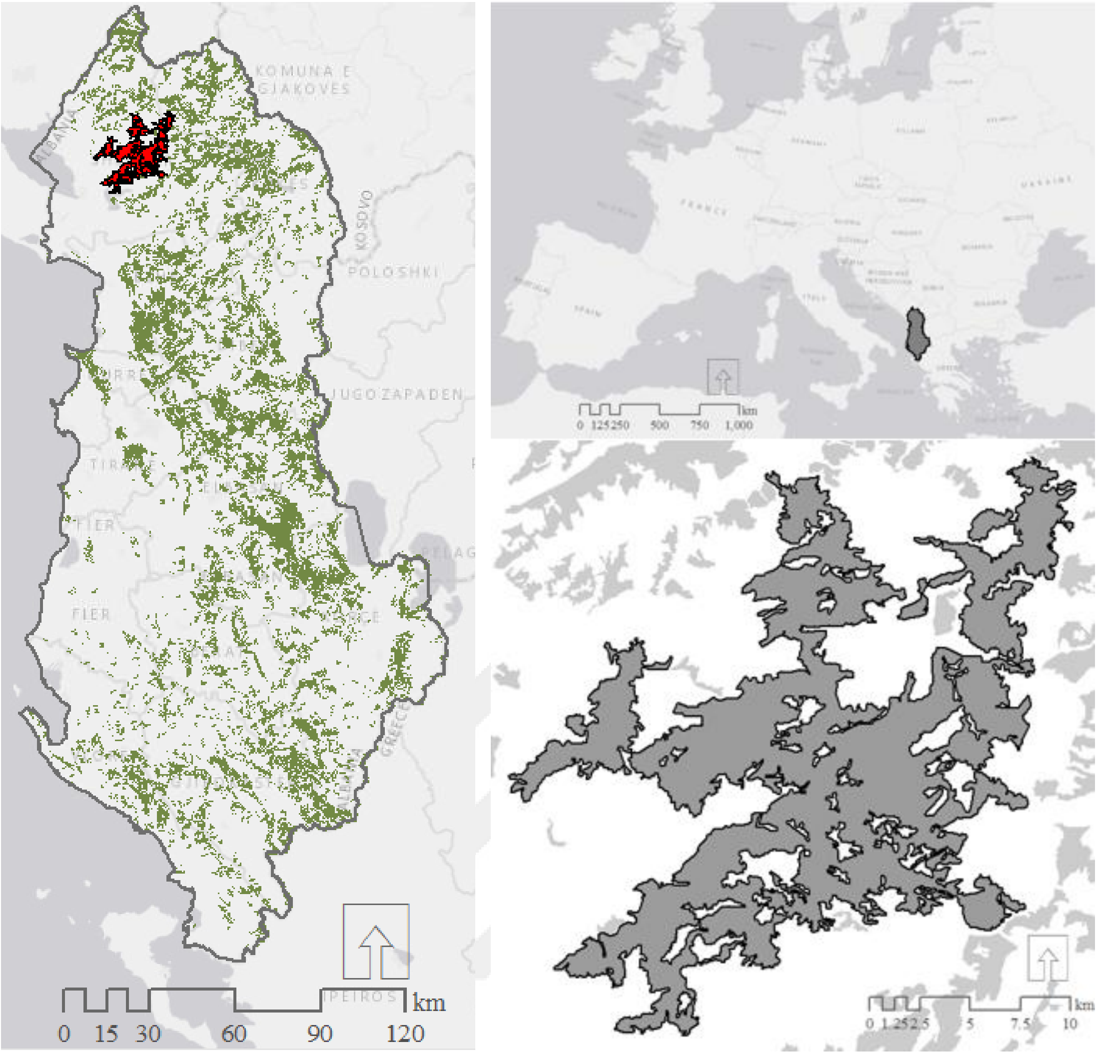

Figure 4.1 : Location of patch AL-725 among broad-leaved forest landscape surfaces (CLC) within the territory of Albania.

Finally, the environmental criteria are measured through weather data as obtained via Meteonorm 7.1.11. Meteonorm data are based on the measurements of 8.325 meteorological stations worldwide that provided periodical climatological means for eight parameters: global irradiance, ambient air temperature, humidity, precipitation, days with precipitation, wind speed, wind direction, sunshine duration (Bellia et al, 2015). For ground interpolation at a distance of 2 km the uncertainty is at 1% and of 100 km the uncertainty is generally at 6%. For distances larger than 2000 km the uncertainty is set constant at 8% (Remund and Müller, 2014). The climatic values of our study area are interpolated form three weather stations of Sjenica (112 km), Niksic (84 km), and Plevlja (123 km). The radiation values are collected from the database of 1991-2010 period. The temperature values are based on average values of the period between 2000 and 2009. Both periods include the year 2007 in which the highest drought, temperature and wildfire occurrence events have happened. The program at the moment does not support multi-location issuing, requiring individual definition for each location. For generating weather data for a single point it takes approximately 60 seconds, and for 989 point about 17 hours.

4.2.4 GIS utilization

The main medium of the study is ArcGIS 10.2.2 software. Each criterion of the multi-criteria framework is represented by a GIS-friendly data package, which are introduced into the workflow of the empirical work (Table 4.4). First, the selected broad-leaved forest patch is filtered from raw CLC dataset. The shapefile of the feature class is converted into a raster data of 0.5 km resolution, in compliance with the minimum spatial unit of CLC data being 25 ha (Büttner and Kosztra 2017). The raster file is converted into a point cloud consisting of the centroids of each pixel (Figure 4.2). Each point becomes the reference to measure the value of each factor, which are being attributed into their unique feature class properties (Table 4.5).

Table 4.4 : Steps of generating WIPI and WSCI values via ArcGIS application.

Step	Goal	Method
Step 1	Identification of the Study Area	Identification of the broad-leaved forest landscape Patch from CORINE Land Cover
Step 2	Data conversion	Shapefile to Raster (pixel size 500 m)
Step 3	Generate the point cloud of pixel centroids	Raster to Points
Step 4	Multi-criteria inventory	Calculating the values of all criteria for each point
Step 5	Data clustering	Clustering the values of each criteria into 7 classes according to Jenks natural breaks reclassification method via ArcGIS
Step 6	Calculating WIPI	Raster calculator (equation 4.1)
Step 7	Calculating WSCI	Raster calculator (equation 4.2)

Figure 4.2 : GIS-based geometry transformation from patch shapefile (a), to raster dataset (b), and to weighted point cloud of centroids (c).

4.3 Results and Discussion

The applied method presented in this article draws significant results as tested on the selected study area.

4.3.1 Multi-criteria inventory of AL-725 broad-leaved landscape patch

The first set of results of this study consist of the inventory regarding the measurements of each pixel centroid within the selected broad-leaved forest patch (AL-725) in relation with all 14 criteria. Table 4.5 presents the inventory results of the selected first, central, and last three centroids as well as the average values for each criteria.

Table 4.5 : Measured values for each criterion of sample centroid; 1, 2, 3, 499, 500, 501, 985, 986, 987 and average.

Centroid			*1*	*2*	*3*	*499*	*500*	*501*	*985*	*986*	*987*	*average*
Dist. To Urban Centers	S1	m	14008	13554	13103	6118	6754	7102	2833	3299	5223	13595
Dist. To Settlements	S2	m	3238	2849	2499	1680	2309	2677	2218	1953	901	1814
Dist. To Main Transport Net.	S3	m	5922	6407	6740	7057	6576	6357	3396	3035	1435	4998
Dist. To any Road	S4	m	43	31	74	1022	668	658	160	26	41	271
Dist. To Agricultural Lands	S5	m	2555	2841	2483	1206	2114	2403	798	818	698	1825
Solar radiation	E1	w/m^2	205	204	203	202	201	201	197	196	197	197
Precipitation	E2	mm	38	38	39	58	63	61	50	50	50	55
Temperature	E3	ºC	20	20	20	18	16	17	26	26	26	20
Relative Humidity	E4	%	65	65	64	63	66	63	50	50	50	60
Wind direction	E5	º	122	122	116	104	114	111	89	89	89	101
Wind speed	E6	m/s	1.90	1.90	2.00	2.03	2.20	2.10	2.53	2.53	2.53	2.33
Slope	P1	º	10	19	3	39	36	36	0	21	1	26
Orientation	P2	º	38	11	112	318	83	44	-1	136	135	185
Dist. To Water Sources	P3	m	1855	2022	22`87	3790	3656	````	77	108	101	2267

4.3.2 Data clustering via Jenks Natural Breaks classification

The measured values are relatively diverse in character for each criteria due to not only the unit variety but also the diversity in the range of values, making the calculation based on absolute measured values irrelevant. Thus, a relative data clustering method is crucial. In this study we have decided to utilize the Jenks natural break data clustering method provided as a classification tool within ArcGIS 10.2.2 package. The Jenks natural breaks classification, also called the Jenks optimization, is a data classification method considered to determine the best arrangement of diverse values into different classes by minimizing the deviation within the classes and maximizing the standard deviation among them[13] (McMaster and McMaster, 2002).

[13] By that it is achieved to define sets of values which are the most similar within the group and the most different between the sets.

Table 4.6 : Jenks classification of each criterion measurements according to WIPI (α) and WSCI (β) equations.

Jenks classes		**distance to urban centers (m)**	**distance to rural settlements**	**distance to main transport**	**distance to any road**	**distance to agricultural lands**	**global horizontal irradiation**	**precipitation**	**maximum temperature**	**relative humidity**	**slope**	**aspect**
		S1	S2	S3	S4	S5	E1	E2	E3	E4	P1	P2
(α)		0.081	0.158	0.029	0.179	0.297	0.037	0.045	0.064	0.064	0.030	0.017
		m	m	m	m	m	w/m^2	mm	ºC	%	º	º
1	>	19411	3477	8559	912	3651	0	75	0	73.33	0	<13 / >343
2	>	16745	2775	6986	628	2774	191.67	66.67	27.03	68	10.93	<43 / >313
3	>	14638	2204	5627	441	2095	194.33	62.67	28.93	64.67	17.85	<73 / >283
4	>	12628	1706	4339	295	1560	197	58.67	30.43	62.33	23.75	<103 / >253
5	>	10254	1246	2999	181	1056	199.33	54.67	31.9	59.33	29.77	<133 / >223
6	>	6836	745	1562	86	540	201.67	51.67	33.23	56.33	36.52	<163 / >193
7	>	0	0	0	0	0	205.33	46.33	35.17	52.33	45.04	>163 / <193

Jenks classes		**distance to urban centers**	**distance to rural settlements**	**distance to main transport**	**global horizontal irradiation**	**precipitation**	**temperature**	**relative humidity**	**wind direction to aspect**	**wind speed**	**slope**	**aspect**	**distance to water**
		S1	S2	S3	E1	E2	E3	E4	E5	E6	P1	P2	P3
(β)		0.019	0.012	0.051	0.047	0.117	0.060	0.088	0.053	0.217	0.160	0.059	0.118
unit		m	m	m	w/m^2	mm	ºC	%	º	m/s	º	º	m
1	>	0	0	0	0	75	0	73.33	0		0	<13 / >343	0
2	>	6836	745	1562	191.67	66.67	15.13	68	21	2.03	10.93	<43 / >313	1452
3	>	10254	1246	2999	194.33	62.67	17.07	64.67	46	2.13	17.85	<73 / >283	2784
4	>	12628	1706	4339	197	58.67	18.5	62.33	71	2.27	23.75	<103 / >253	4107
5	>	14638	2204	5627	199.33	54.67	20.03	59.33	96	2.4	29.77	<133 / >223	5640
6	>	16745	2775	6986	201.67	51.67	21.47	56.33	126	2.53	36.52	<163 / >193	7333
7	>	19411	3477	8559	205.33	46.33	23.7	52.33	160	2.63	45.04	>163 / <193	9143

For the ease of calculation all measurements within each criteria have been classified into 7 classes or degrees. For example the closest distance to urbanized centers (S1) is classified as 7^{th} degree due to its high impact in wildfire ignition. Whereas, the farthest ones are classified as 1^{st} degree due to its low impact on the ignition phase of the wildfire. However, classifying the same criteria (S1) according to the spread capacities of each point, the distance of the closest urbanized areas is classified as 1^{st} degree since the presence of an urban area enhances the wildfire mitigation, thus reducing the spread capacities of the forest at that specific location.

Table 4.6 represents the reclassification procedure of each criteria for WIPI (Table 4.6a) and WSCI (Table 4.6b) indexes. Based of Jenks natural breaks classification it is set the minimum measurement value per each class. It is important to highlight that the classification of the same criteria separately under WIPI and WSCI calculation is based on the same breaking points since the reclassified values belong to the same measured values for 988 centroids. But due to the reversal relation of certain criteria to WIPI and WSCI result in a reverse Jenks classification values, as shown in the case of distance to urban centers (S1). The classification of sample criteria into 7 classes is visually represented in Figure 4.3.

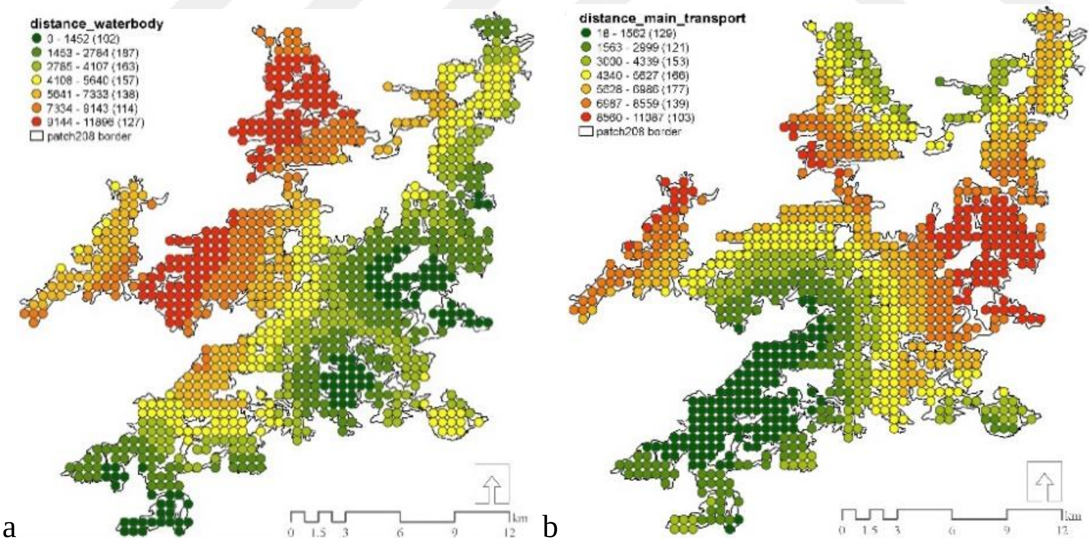

Figure 4.3 : Spatial distribution of landscape units according to Jenks natural breaks classification method into 7 classes for each criterion; distance to (a) water resources (P3), (b) main transportation network (S3), (c) any road (S4), (d) agricultural lands (S5), (e) urban centers (S1), (f) settlements (S2).

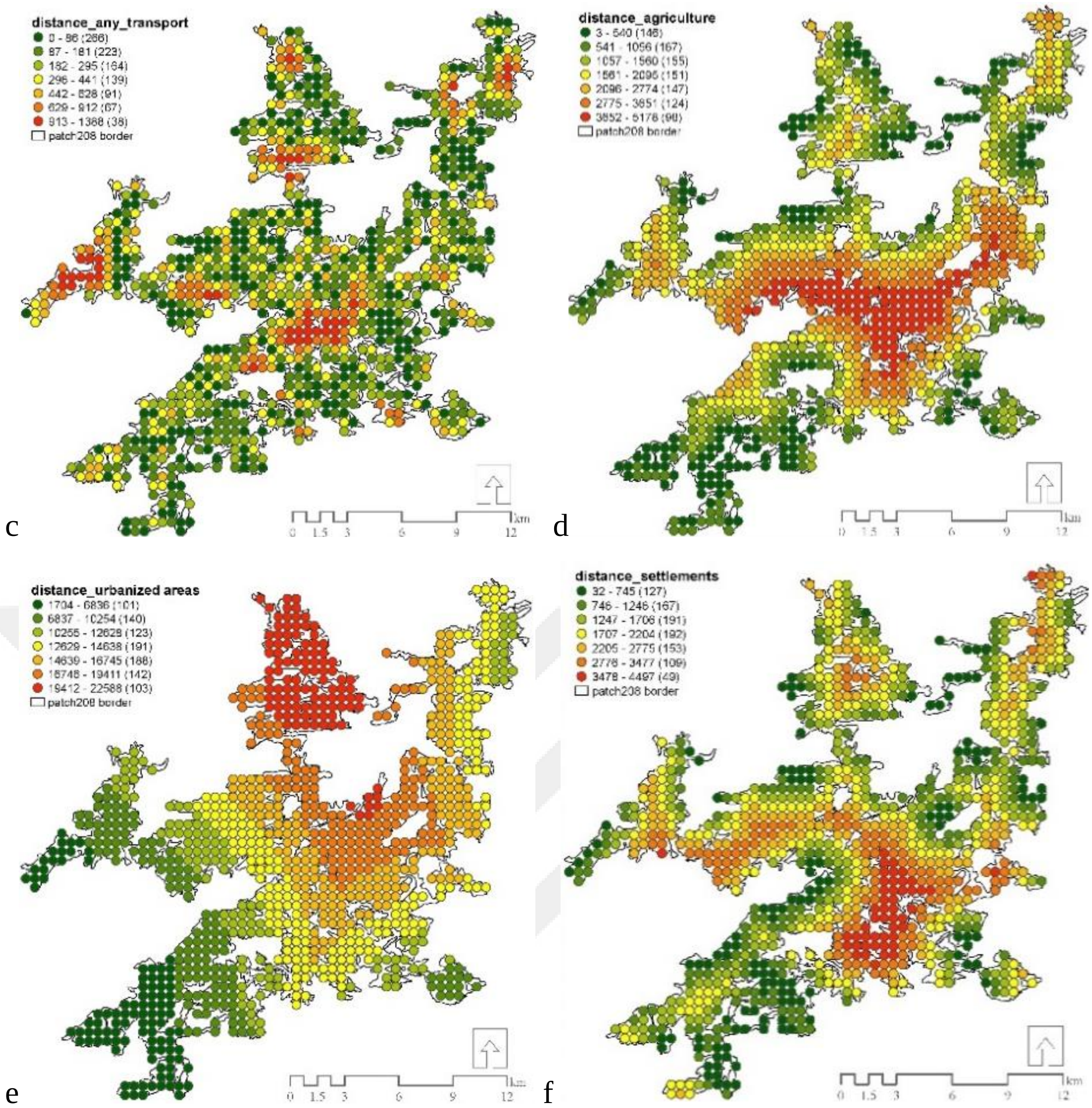

Figure 4.3 (continued) : Spatial distribution of landscape units according to Jenks natural breaks classification method into 7 classes for each criterion; distance to (a) water resources (P3), (b) main transportation network (S3), (c) any road (S4), (d) agricultural lands (S5), (e) urban centers (S1), (f) settlements (S2).

4.3.3 WIPI and WSCI indexing of broad-leaved forest patch AL-725

The reclassified values of each criteria into seven Jenks classes, are introduced in the equation 4.1 for calculating WIPI per each centroid. WIPI value is the sum of the product of each criteria Jenks class (according to classification in Table 4.6a) and the coefficient α, as calculated in Table 4.2. Similarly, the WSCI value is calculated as the sum of the product between Jenks class and the coefficient (β) of each criteria (as generated respectively in Table 4.3 and Table 4.6b). In this way there are generated the WIPI and WSCI values of all 988 centroids. The scatter plot of both values per each point is showing a concentration of values between 3 and 4 as shown in Figure 4.4.

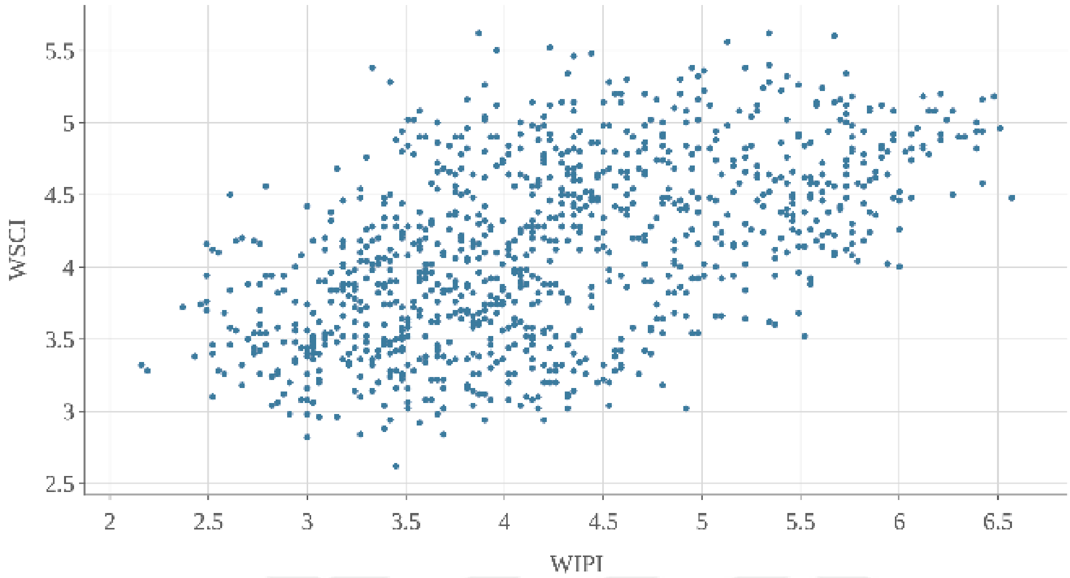

Figure 4.4 : The scatter plot (a) and histogram heat-map (b) of cross- distribution of WIPI to WSCI values.

According to histogram heat-map in Figure 4.5 the highest concentration happens between 3.5 to 4.0 range of both WIPI and WSCI values, making home for more than 60 locations.

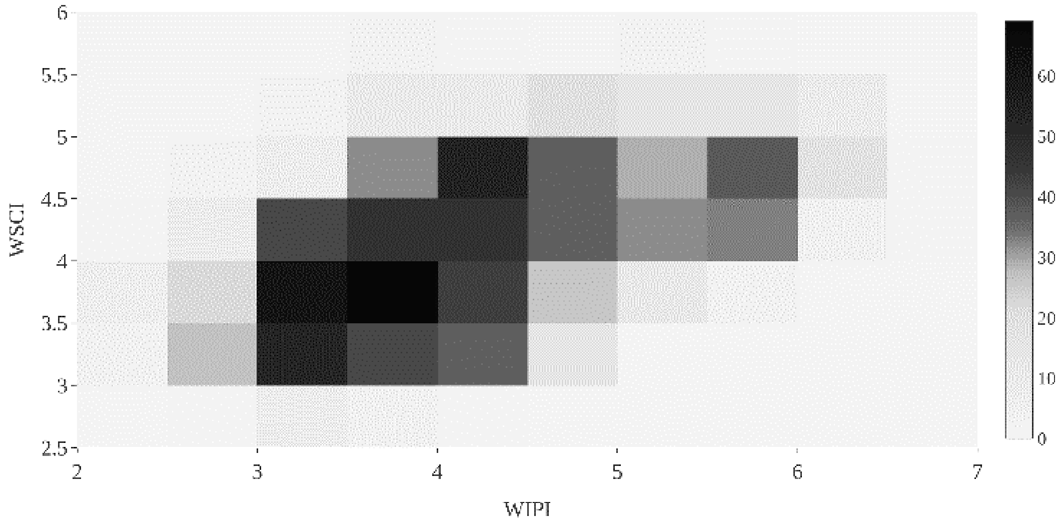

Figure 4.5 : The scatter plot (a) and histogram heat-map (b) of cross- distribution of WIPI to WSCI values.

Focusing more in detail, according to Table 4.7 the WIPI values ranges from 1.83 to 6.70, whereas the range of WSCI values is relatively narrower between 2.72 and 5.76. This difference is in the same line with the standard deviation values being higher in the case of WIPI (1.04) compared to WSCI (0.72). Within the objective of visual mapping of the WIPI and WSCI values, they are reclassified via the Jenks normal distribution method into 7 classes.

Table 4.7 : Jenks classification of WIPI and WSCI values in reference to the mean, maximum, minimum, and standard deviation values of all records.

Jenks class		1	2	3	4	5	6	7	mean	max	min	st dv
WIPI	>	1.83	2.79	3.44	4.00	4.51	5.11	5.75	4.35	6.70	1.83	1.04
WSCI	>	2.72	3.26	3.61	3.97	4.35	4.72	5.10	4.12	5.76	2.72	0.72

The values of the breaking points of each class are presented in Table 4.7. Mapped reclassification in Figure 4.6, is showing the number of points per each class (numbers in brackets). There are more than 100 units categorized as the most vulnerable locations in term of both fire ignition probability and fire spreading capacity.

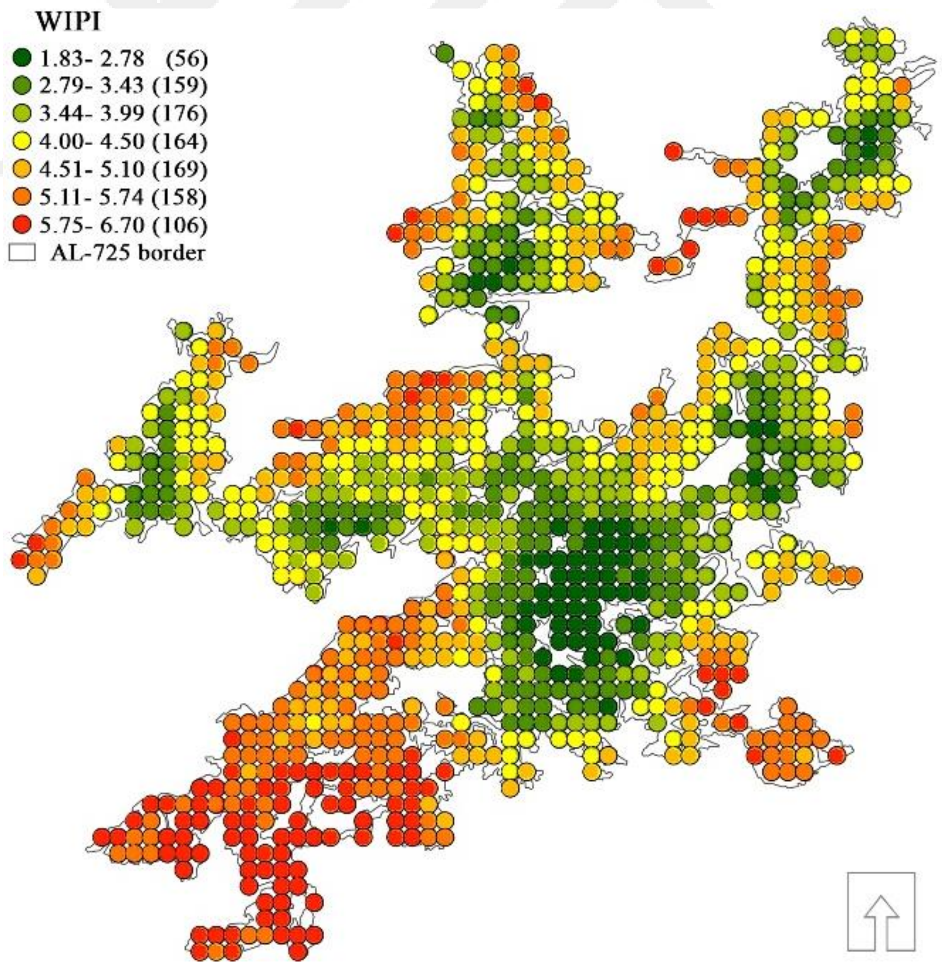

Figure 4.6 : Wildfire Ignition Probability Index (WIPI) map of broad-leaved forest surface patch AL-725 of Albanian CLC data.

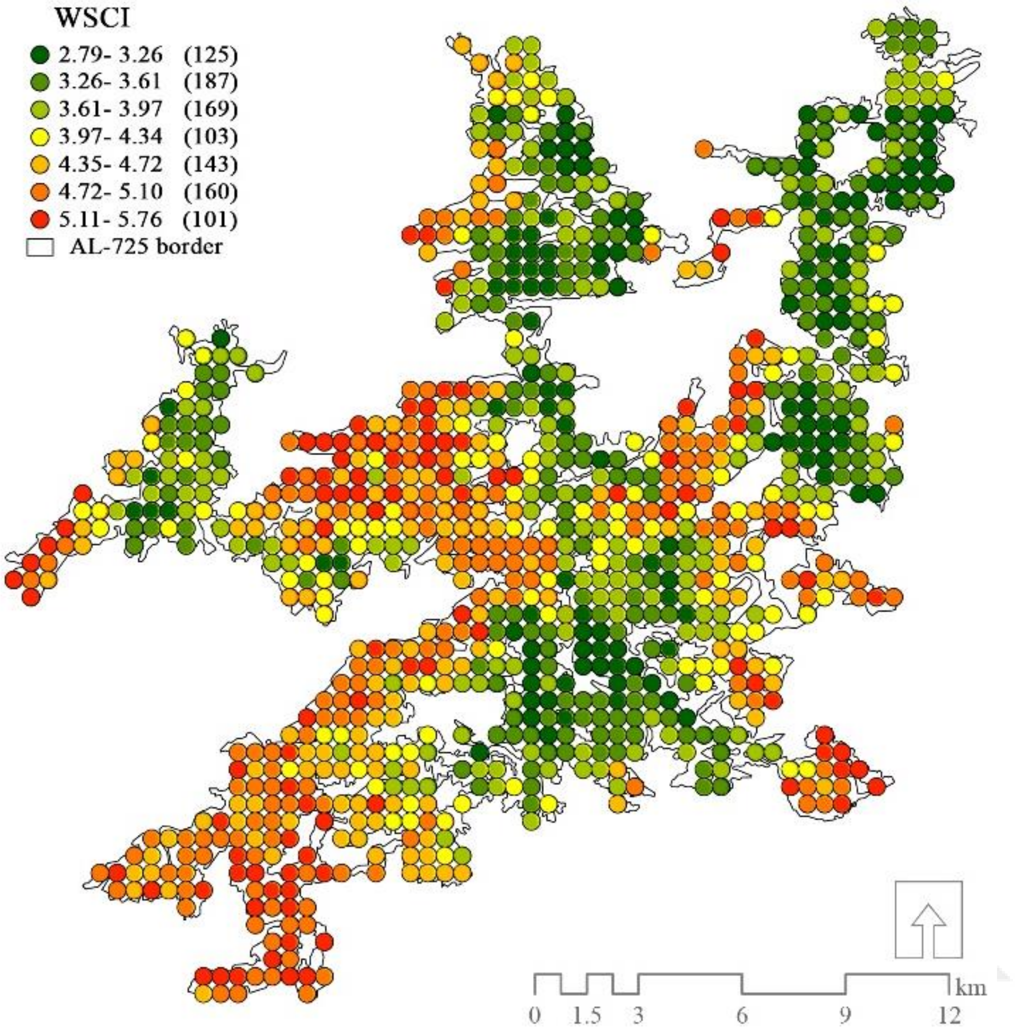

Figure 4.7 : Spread Capacity Index (WSCI) map of broad-leaved forest surface patch AL-725 of Albanian CLC data.

4.4 Validation

In order to validate the method, the results of the study can be checked with respect to the already burned surfaces within the forest patch under investigation. Up to this stage the results of the study rely on the CLC data of 2006. However, according to CLC data of 2012, there are two patches of burned areas (CLC-334) within the patch under investigation (AL-725). This bring an opportunity to discuss the specific results of pivot points falling within the burned areas. In principle, if these specific values belongs to the set of the highest WIPI and WSCI values, it indicates for a reliability of the proposed model.

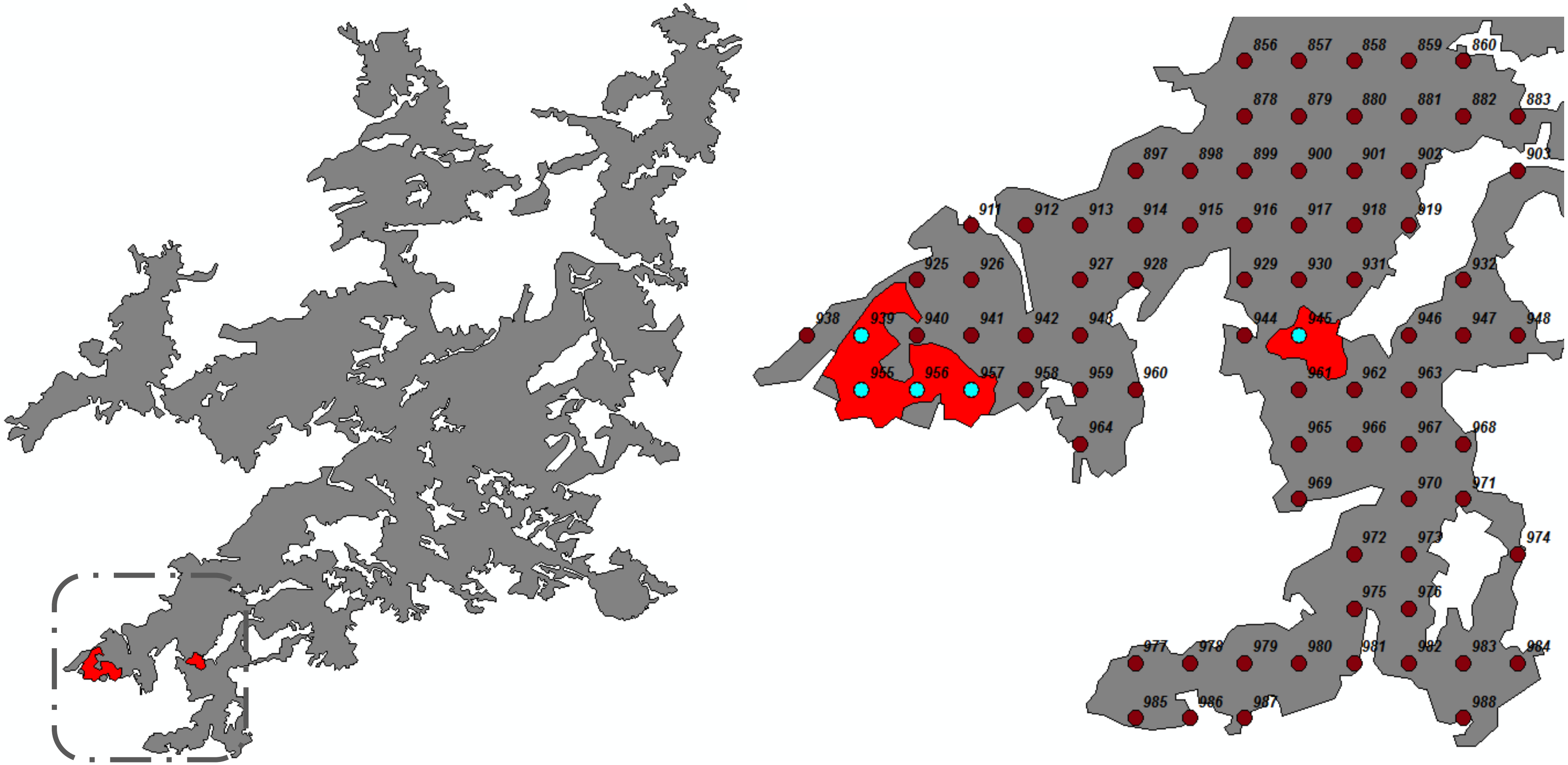

Figure 4.8 : The location of five pivot points (939, 945, 955, 956, 957) inside burned areas within patch AL-725.

According to the map in Figure 4.8, there are five pivot points that are located inside the burned surfaces as reported in 2012. Table 4.8 presents the WIPI and WSCI values of these points comparable with basic statistical data of the full set of 988 pivot points. The highest WIPI value among five points in focus, belongs to point “945”, scoring at 6.37. It is the only point within the smallest burned surface as shown in Figure 4.8. It stand to be far above (2.02) the average WIPI value (4.35), and slightly below (0.33) the maximal one (6.70). Regarding the second burned surface it is larger in surface area and consist of four pivot points within it. According to values in Table 4.8, the point with the highest WIPI value is “957” scoring 6.12. According to Table 4.7 based on Jenks natural break data clustering method, both points “945” and “957” are classified under the 7th category. This fact is indicating high risk values of fire ignition justifying the wildfire occurrence within the burned surfaces reported via CLC data of 2012.

Table 4.8 : WIPI and WSCI values distribution for 5 locations inside burned areas within patch AL-725 compared with statistical information of the total set of pivot points analyzed in this study.

	939	**945**	**955**	**956**	**957**	**mean**	**max**	**min**	**st dv**
WIPI	5.30	6.37	5.18	5.62	6.12	4.35	6.70	1.83	1.04
WSCI	4.52	5.25	4.61	5.16	4.68	4.12	5.76	2.79	0.72

Diverting the discussion focusing on WSCI values, the highest value belongs to point “945”, scoring 5.25. This values is 1.13 above the average WSCI value and 0.51 below the maximum. According to Table 4.7 based on Jenks natural break data clustering method, two of five points belongs to the 7th category and the remaining are very close to the 6th one. The WSCI value of point “945” is classified under the 7th class, similarly with the WIPI value for the same location. Both values stress on the high risk of wildfire ignition and spread in the specific area of pivot point “945”. This provision is validated by the fact this area is burned between 2006-2012 periods. The common tendency of high risk of fire ignition probability and fire spread capacity for five location points within the burned surfaces is shown in the charts presented in Figure 4.9. As a conclusion, the matching of the high risk values of WIPI and WSCI as proposed in this study relying on CLC 2006 data and the burned surfaces identified based on CLC data of 2012, can be considered as a validation of our method.

Figure 4.9 : Charts presenting the WIPI (a) and WSCI (b) values among five points within the burned surfaces.

4.5 Conclusions

This study presents a GIS-based model for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spreading capacity. The method is dedicated to case studies lacking long-term inventory data about forest fire regimes, such as Albania. The workflow consist of three steps; (i) multi-criteria inventory, (ii) analysis- data clustering (Jenks natural breaks classification), and (iii) indexing (WIPI-WSCI). At this stage the set of criteria consist of 14 variables belonging to social, environmental and physical character. Depending on the data availability for each case study the number of criteria may vary. First, the criteria is filtered based on their relevancy to either the ignition probability or spreading capacity of wildfire. Then, each criteria is assigned a weighted factor calculated via AHP pairwise comparison method.

The results of the study relies on CLC data of 2006, which are tested via the CLC data of 2012. The concurrence of the identified hotspots via the presented method with the burned surfaces of CLC data of 2012, imply for a considerable level of reliability and validity of the developed model. The method is aimed to act in assistance of initial phases of decision making and management processes under disaster risk management and fire safety agendas. Since it relies on data of a coarse spatial scale such as CLC, it is helpful in performing rapid analysis to identify hotspots of high risk within broad-leaved surfaces at landscape scale. The highlighted areas should be considered as urgent cases to be further analyzed at finer spatial scales.

5. REVEALING THE TRANSVERSAL CONTINUUM OF NATURAL LANDSCAPES IN COASTAL ZONES- CASE OF THE TURKISH MEDITERRANEAN COAST[14]

The study presents an analytical framework for examining the transversal structure, rather than the longitudinal pattern of the landscape in coastal zones. Our methodology introduces the concept of the ‘band’ as an alternative to the ‘buffer zone’. The Band is a dynamic notion which is rooted in the organic structure of landscape patterns and which relies on the order of adjacency/connectivity between land cover patches and the coastline. The study utilizes CORINE Land Cover data to produce 10 bands that stretch along the Turkish Mediterranean coast. By introducing two extra attributes: ‘band level’ and ‘transversal continuum depth’, this method is useful for the identification of; (i) transversally connected coastal natural landscape mosaics, (ii) endangered natural landscape patches to be conserved, and (iii) potential artificial surfaces to be restored. The workflow is formalized via Model Builder (ArcGIS), and is applicable to any coastal context in support of diverse decision making processes such as those of Integrated Coastal Zone Management (ICZM).

5.1 Introduction

Mediterranean coasts have been extensively studied and investigated due to their unique and complex social, economic, and, particularly environmental systems (Di Castri and Mooney, 1973; Blondel and Aronson, 1999). Historically, they have acted as a common pool resource (CPR) for numbers of communities, resulting in a diversity of cultural and natural landscape patterns within its surrounding areas (Duarte et al, 1999; Ostrom, 2010). Closer to our purpose, there have been several studies which have assessed the landscape structure of the Mediterranean region, both in terms of their spatial distribution and their time-dependent alterations of the land cover (Hepcan, 2012). With reference to the literature, the land surface properties of

[14] This chapter is based on the paper: Hysa, A., & Türer Başkaya, F. A. (2018). Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean Coast. *Ocean & Coastal Management, 158,* 103-115.

Mediterranean coasts generally are studied according to their longitudinal structure (Ivanov et al, 2013; Pons and Rullan, 2014), and with a focus on the linear configuration of the landscape running along the coastline. This is mainly related to the perception of the coastline as a boundary edge more than a transitional zone between the marine and terrestrial environments (van der Weide, 1993).

The motivation for thinking about coastal zones in a more comprehensive manner is not new. One of the main principles put forward by Kelleher and Kenchington (1991) is a holistic approach, which highlights a wider framework for the connection between the marine and terrestrial elements of coastal zones. The importance of a holistic approach is also strongly targeted in Agenda 21, which advocates that a wider view of the coastal zone is necessary since 75 % of global population is expected to settle within 60 km of a shoreline by 2020 (UN, 1992). In particular, the Chapter 17 of Agenda 21 is generally accepted as having paved the way for the delineation of significant areas of critical habitat to be protected (Barcena, 1992). A broad, holistic approach for coastal zone management is also highlighted as one of the seven principles of Integrated Coastal Zone Management (ICZM), which stresses on the inclusion of the offshore and upland environments, such as land-sea interlinks, as a part of the broader geographical context (Ballinger et al, 2010).

Our study aims to contribute to analysis methods of the transversal structure of landscapes in the coastal zone, rather than their longitudinal patterns. Specifically, the research focuses on the coastal-inland transition spatial gradient of natural landscapes. The core focus is the cross section rather than the front line of the coastal area. Indeed, the idea of the transversal gradient of landscape structure in coastal regions has been highlighted in previous ecological studies (Crossland et al, 2005; Newton and Icely, 2007). The common objective of these studies has been to measure the permeability of coastal areas in terms of species accessibility from continental lands to the coastal front line (Nord and Forslund, 2015) and vice-versa. This approach is proposed as a crucial condition for preserving the richness of the coastal habitat (Theobald et al, 2012). In this context, the proposed method presented in this article can be claimed to contribute to the spatial mapping of wildlife permeability across the coastal-inland gradient.

The issue of permeability or the physical accessibility is dependent upon the uninterrupted condition of the habitat, and this guides the discussion towards the concept of “landscape continuum”. At the same time, depicted as landscape connectivity, it is crucial in providing a habitat for wildlife (landscape patches) and allowing movement (ecological corridors) throughout a territory comprised of an uninterrupted ecological network (matrix) (Forman, 1991). Landscape dis-connectivity or fragmentation is a highly sensitive condition which is a crucial assessment goal in sustainable planning practices (EEA, 2011). Consequently, the transversal natural landscape continuum along the coastal-inland gradient is of great importance to investigate.

The coarser study area of this research consists of the zones along the Turkish Mediterranean coast. The study excludes the islands, since the de-naturalizing process occurring in these areas is considered to be much more modest when it is compared to that of the continental coastal zones (Pons and Rullan, 2014). Moreover, due to their size, the Turkish Mediterranean islands lack the required transversal depth within of coastal-inland gradient, and are therefore irrelevant to the proposed method. Excluding the islands, the 4181 km of the Turkish Mediterranean coast is one of the longest national coastlines bordering the Mediterranean Sea (Gunay, 1987). This geography has been the motivation for several studies which focus on regional (Berberoglu, 2003) as well as local scales (Esbah et al, 2010; Cinar, 2015).

The Turkish Mediterranean coast is considered to have an important and unique geography due to its eco-environmental features. The eastern part of the Turkish Mediterranean coast, in particular, has an exceptionally rich biodiversity (Yilmaz, 1999). According to the German Federal Agency for Nature Conservation, and based on IUCN statistics, the Turkish Mediterranean coast is home to 9383 species, 2682 of which are endemic. This fact makes the region the richest habitat in the Mediterranean area (GFANC, 2012). Additionally, it serves as a transitory habitat for several species of migrating bird as stop-over or breeding sites (van der Have and van den Berk, 1988). This is a factor of great interest, as it is essential to consider the transversal continuity of natural areas in coastal zones when studying the flight corridors and the route selection criteria of migrating birds.

On the other hand, the Turkish Mediterranean coast has been caught between touristic development agendas and natural conservation goals. Touristic services and their associated infrastructures have resulted in significant changes in the natural and cultural landscapes of the Mediterranean area with a dominant effect in the frontal line of the coastal zone (Antrop, 1993). The spatial spread of this concentration from the coastline towards the inland areas is advocated as a sustainable development strategy for tourism (Markovic et al, 2009) being highlighted within ICZM protocol as well (UNEP, 2008). While, this attempt diversifies and enriches coastal tourism by easing the pressure on the coast itself, it may cause extensive landscape fragmentation among natural areas further inland. Therefore, it is important to develop an analytical framework to assess the existing transversal continuum of natural landscapes in the coastal zone.

In response to these pressures, the buffer concept is one of the most effective environmental protection strategies in landscape planning practices for both coastal zones and watercourse areas (Fischer et al, 2000). The most important debate regarding the buffer concept is related to the width of the buffer strip. Although there is no universally accepted standard of coastal zone boundaries, certain sets can be derived from the case-based management issues that arise (Clark, 1997). In the literature, there are two main approaches towards this issue; which differ in having a fixed or varying width for the buffer strip. Being single parameter dependent, fixed-width buffer strips are easier to define and manage, but they are often insufficient when attempting to explain several ecological functions (Castelle et al, 1994). On the other hand, buffer strips with variable widths are based on a range of functions. They are typically dependent on context-specific circumstances including contiguous land use, and stream and site conditions such as; vegetation, topography, and hydrology (Castelle et al, 1994). This approach has been applied in previous studies (Başkaya and Tekeli, 2016).

This article is intended to challenge the buffer zoning approach widely theorized and practiced in landscape research (Fischer et al, 2000), by introducing the concept of the band. In this study, the band is defined as the level of spatial relationship that a specific landscape patch has with the coastline. This approach is dependent on the unique properties of a given landscape pattern, rather than the artificial (man-made) zoning found within the concept of buffer zones (BZ). It utilizes the land surface structure as derived from Land Cover/Land Use (LULC) maps. Thus, the findings of the proposed model are dependent upon the properties of the LULC map being used, as this is the fundamental input to the analytical process.

The raw material and the main analytical parameter of this study is the CORINE Land Cover (CLC) data of 2012, which is available as an open source via the European Environment Agency (EEA). Initially, it is used to generate the coastline feature to be utilized as the second parameter of the analysis. Both variables are introduced to a structured/designed process of spatial analysis utilizing GIS technologies. The analytical process is then developed into a model by using the Model Builder utility of ArcGIS, thereby making it applicable for other coastal areas. Using the model and two sets of input data from any coastal zone, it is possible to perform the analysis in a very short period of time. The time efficiency of the analysis provided via the proposed model makes it a useful tool for rapid connectivity analysis of a given landscape at a coarse scale, during the decision making processes of ICZM.

Through four workflow stages, the study produces several results and findings. First, by introducing two extra attributes to landscape patches indicating the level of band and the transversal continuum depth (TCD) value, the study reveals the transversally connected natural landscape mosaics along the Turkish Mediterranean coastal zone. Further analyzing the highlighted agglomerations of interconnected natural lands allows the identification of a set of endangered landscape patches to be preserved. In other words, if the landscape units belonging to the 'red list' of coastal natural land surfaces are de-naturalized, this may lead to extensive transversal fragmentation of natural lands in coastal zones. Similarly, it is determined that a set of artificial land surfaces are located in the front line of the coast to act as a barrier between the coastline and existing transversally connected natural landscape mosaics. In other words, if these potential patches were recovered/restored, they would enhance the transversal continuum of the natural landscapes in coastal zones.

As a conclusion, the article presents a framework for analyzing the landscape pattern in coastal zones. The main goal is to reveal the existing and potential transversal continuum of the natural landscapes within them. The formalized model is applicable to other cases which have similar contexts. It is intended to be a supporting tool in diverse decision making processes of coastal management and planning. The study of the transversal structure of natural landscapes in coastal zones can offer a comprehensive response to both ecological concern and sustainable tourism planning. In particular, the delineation of areas which are remarkable due to the existence of critical habitats they contain, is a crucial contribution to the objectives of Agenda 21

(Forst, 2009). Overall, the multifaceted implications of the presented framework brings it closer to the goals and objectives of ICZM agendas.

5.2 Materials and Methods

The most significant contribution of the study regarding the methodical approach is the conceptual shift from longitudinal towards the transversal study of the coastal landscapes.

5.2.1 Analytical approach; the concept of bands

Preceding studies have shown that coastal zones generally are studied according to fixed-width buffer strips of 1-10-50 km (Ivanov et al, 2013) or 1-2-10 km (Pons and Rullan, 2014). In these works, the buffer area is simply generated by an offset operation of the coastline against the inland areas (Figure 5.1b). In contrast, this article introduces the concept of dynamic bands rather than fixed buffer strips (Figure 5.1c). Basically, it relies on the investigation of the adjacency condition of landscape patches from the coast to areas further inland. The land cover patches that are in contact with the coastline are placed within band 1. The remaining patches that have direct connection with the patches of the first band are placed within band 2. Similarly, the process is run for each band in consecutive steps. This approach differs from the former, since the notion of fixed-width BZ is an artificial zoning to coastal territories. This new proposal more accurately reflects the basic properties of the land cover morphology of the territory (Figure 5.1a).

The method introduces two extra attributes for land cover features. First, the patches are assigned their ‘band level’ by considering their adjacency to both the coastline and other neighbor patches. The initial tests of the study were based on 5 bands, which turned out to be insufficient to represent comparative cases of transversal continuum of the natural landscapes in coastal areas. A band level beyond 7 performed better. For the ease of explanation, this article presents a model based on 10 bands. A second value being introduced is TCD. This is added to each natural landscape patch by indicating the maximum band level a particular natural patch is providing transversal connectivity for. By further analyzing both variables, the study identifies and highlights two important sets of landscape patches. First, it defines a red list of endangered patches, the de-naturalization of which may drastically contribute to the transversal landscape fragmentation in coastal areas. Second, it identifies a set of artificial surfaces belonging to the first band (adjacent with the coastline), the reclamation/naturalization of which may provide an extensive transversal continuity of the natural land surfaces along a given coastal zone.

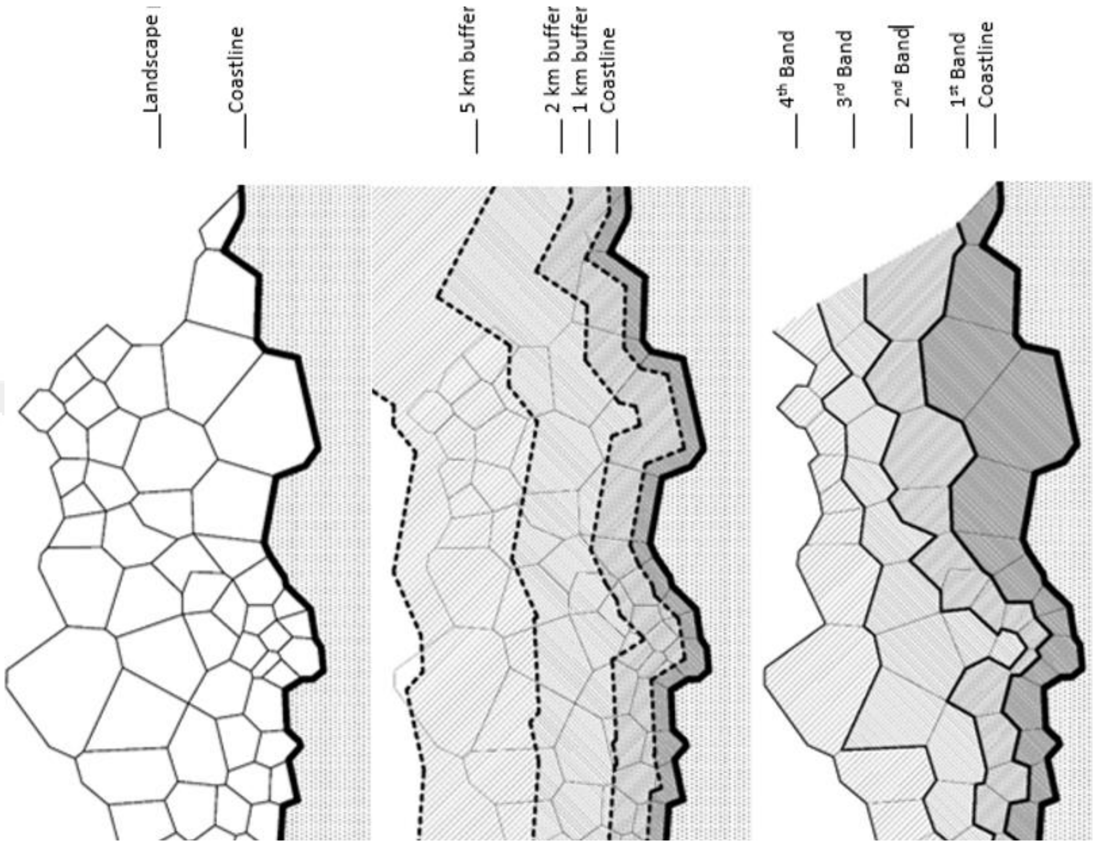

Figure 5.1 : The concept of fixed-width buffer (b) vs. varying-width band (c) in a coastal landscape pattern (a).

5.2.2 Utilizing CLC data

The workflow of the proposed method utilizes the LULC data of the inland areas within the coastal zones. The accuracy level and the rate of error are considered to be indicators of the overall reliability of a LULC map, this is also being widely studied due to the progressive increase of GIS usage (Edwards et al, 1998). However, the evaluation is usually an integral part of the production process (Goodchild and Gopal, 1989; Chust et al, 2004) rather than its utilization in a model. As there is a variety of LULC mapping techniques, the correct selection criteria are necessary in order to allow the use of the most appropriate. According to Bach et al. (2006) the selection criteria are dependent on a range of aspects, such as; thematic content, scale, spatial resolution, classification system, aerial coverage, topicality, availability, costs of acquisition, and the data format of the LULC map.

Consequently, within the scope of this study CLC data was utilized for the following advantages: it is open source via European Environment Information and Observation Network (EIONET) of EEA- thereby nullifying the acquisition costs; it has a spatial resolution appropriate for the eco-regional scale of the study area; it has a clear thematic content; it provides a detailed classification system; and it is available in the shapefile format, making it appropriate for analytical processes via GIS technology. More precisely, the study relies on the CLC data from 2012, which provides structured spatial data of land cover under certain typologies. The CLC nomenclature is structured in three hierarchical levels of surface cover types. The first divides the land surfaces into five main categories; artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and waterbodies (Bossard et al, 2000). The subcategories which follow are separated into two further hierarchical levels of typological sets, concluding with 44 land cover classes in the third level. The CLC data is initially utilized to define the borders of the study area and later as the main input for the analytical process in the following four steps. The study makes a clear division between man-made (artificial surfaces, agricultural areas) and natural (forests and semi-natural areas, wetlands, and waterbodies) surfaces with only a few specific exceptions, as explained in the following sections.

5.2.2.1 Generating the coastline and the study area border via CLC data

First, the CLC data are utilized to generate the coastline feature. This is achieved by merging all the land cover patches into a single polygonal feature to be converted into a polyline. The polyline feature is split at the start and end points of the Turkish Mediterranean coast. The final coastline shape is identical with the front line of the first band of the land cover patches. It serves as the first parameter of the analysis process. Following the steps of the stage 1 of the workflow, the first 11 bands of the land cover pattern of the Turkish Mediterranean coast are identified. The border line between band 10 and band 11 is accepted as the second boundary of the study area. Thus, the study area is spatially defined as the lands between the coastline and the upper-border of band 10 (Figure 5.2)

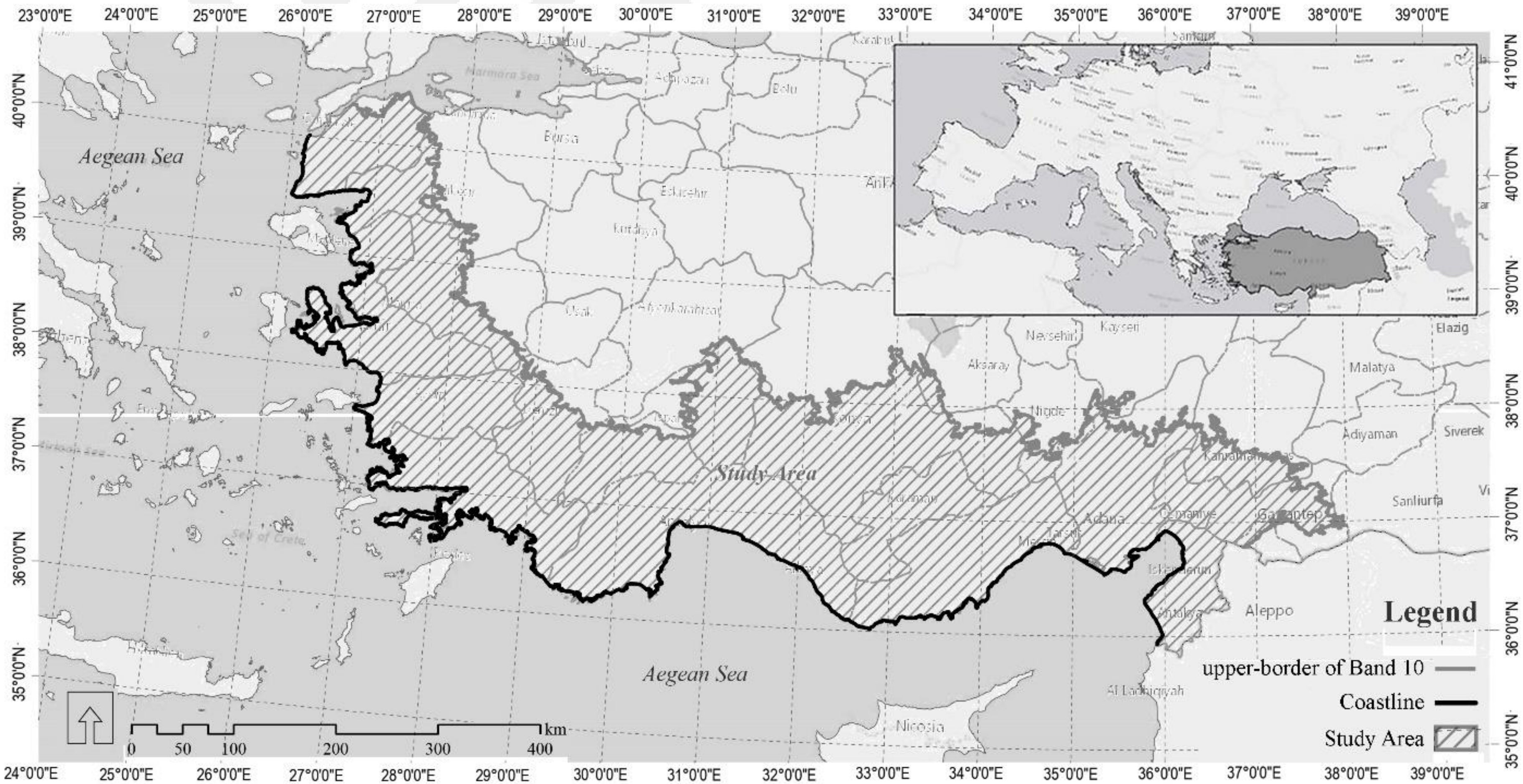

Figure 5.2 : The Study Area as defined between the upper-border of Band 10 and the Turkish Mediterranean Coastline.

5.2.2.2 Defining the set of natural lands within CLC

After defining the main bands of the study using the full CLC data, a filtering operation is performed to subtract the set of natural lands to be analyzed in further stages of the workflow within the scope of the objectives of the study. First, watercourse surfaces (CLC-511) are excluded from the set of natural lands to be put under further investigation. This is mainly due to the linear shape of their patches and the physical connectivity they have with other types of land surfaces. Watercourses (as a water coverage patch), generally start from the coastline (classified within the band 1) and continue further inland for tens of kilometers, by defining dominant transversal natural lands continuum without necessarily being accompanied with other natural land surfaces. This can result in false cases of transversal continuity of natural landscapes (Figure 5.3). Watercourses are crucial components of transversal networks of natural lands in coastal zones (Cantasano and Pellicone, 2014), but they (as water surfaces under CLC classification; CLC-511) are part of river systems which include many other spatial sub-components such as; riparian zones vegetation, floodplain, wetlands, and deltas. All these elements of river systems remain within the focus of this study under certain CLC classes, such as natural grassland (CLC-321); beaches, dunes, and sand plains (CLC-331); inland marshes (CLC-411); and peat bogs (CLC-412).

A further exemption is related to the reclassification of olive groves (CLC-223) and agro-forestry surfaces (CLC-244) from the agricultural lands category (original CLC classification) and into the set of natural landscape patches to be investigated at further stages of the workflow. This decision is based on several factors. First, olive vegetation is fundamentally contextual and unique to the Mediterranean region, a fact observed at a very early stage by different researchers (Turrill, 1929). Moreover, in the cultural context, olive trees and their plantations occupy a significant place in the collective memory of the Mediterranean area (Loumou and Giourga, 2003). This is because they are considered to be complementary with the idea of a genius loci and the naturalness of this land cover type. Finally, the olive groves occur to provide a living habitat for small terrestrial species and are vital locations along the migration corridors for several Mediterranean birds (Assandri et al, 2017).

Figure 5.3 : An example of false transversal continuum in the southern Turkish Mediterranean coast.

Similarly, agro-forestry lands (CLC-244) are significant due to their part in maintaining a rich biodiversity (Rosalino et al, 2011). Even the widely supported forest transition processes, though occurring against the agro-forestry surfaces, surprisingly enough, have resulted in reduction of biodiversity capacity of Mediterranean coastal zone (Marull et al, 2015). Olive groves and agro-forestry land cover classes are therefore included in the natural surfaces set to be further analyzed.

5.2.3 Utilizing GIS technology to model the workflow

A crucial challenge of this study is the development of a workflow model that can be applied to any coastal area that has two predefined parameters. The land cover data and coastline feature are designed to be the input stage of the analytical workflow. For this purpose, the study utilizes the Model Builder application of the ArcGIS 10.2.2 package. Model Builder has a broad range of uses, but in this study, it has been helpful in developing a model as a customized tool which is unique to the goals of the research (Allen, 2011).

After preparing the polyline feature of the coast and the CLC shapefile, the process then proceeds in four stages (Figure 5.4). The workflow of stage 1 is built upon two fundamental inputs; the CLC data and the coastline shapefile. Mainly via Boolean operations such as the ‘selection by attributes’ and ‘selection by location’ tools, it is possible to prepare the required 10 bands. At this stage, each land cover patch is assigned a unique value indicating the band to which it belongs. The output of stage 1 is then used as the main input for stage 2. The objective of the second stage is to generate the map of transversally interconnected natural land surface mosaics along the coast. The set of natural land surfaces is derived from the same CLC data, but with minor exceptions as previously explained. The operation of this stage is built on further Boolean operations which are used to search for adjacent natural surfaces. These start at the coast and proceed into bands further inland.

Stage 3 is crucial since a new value of classification is introduced. TCD represents a value between 1 and 10 which is assigned to each land cover patch of the mosaic generated at the end of stage 2. More precisely, this value indicates the highest band level of the mosaic to which a given patch belongs. The assignment of the TCD value highlights the existing transversal natural corridors from inland areas to the coast. The process of this stage has a top-down flow, from band 10 to band 1 (Figure 5.4).

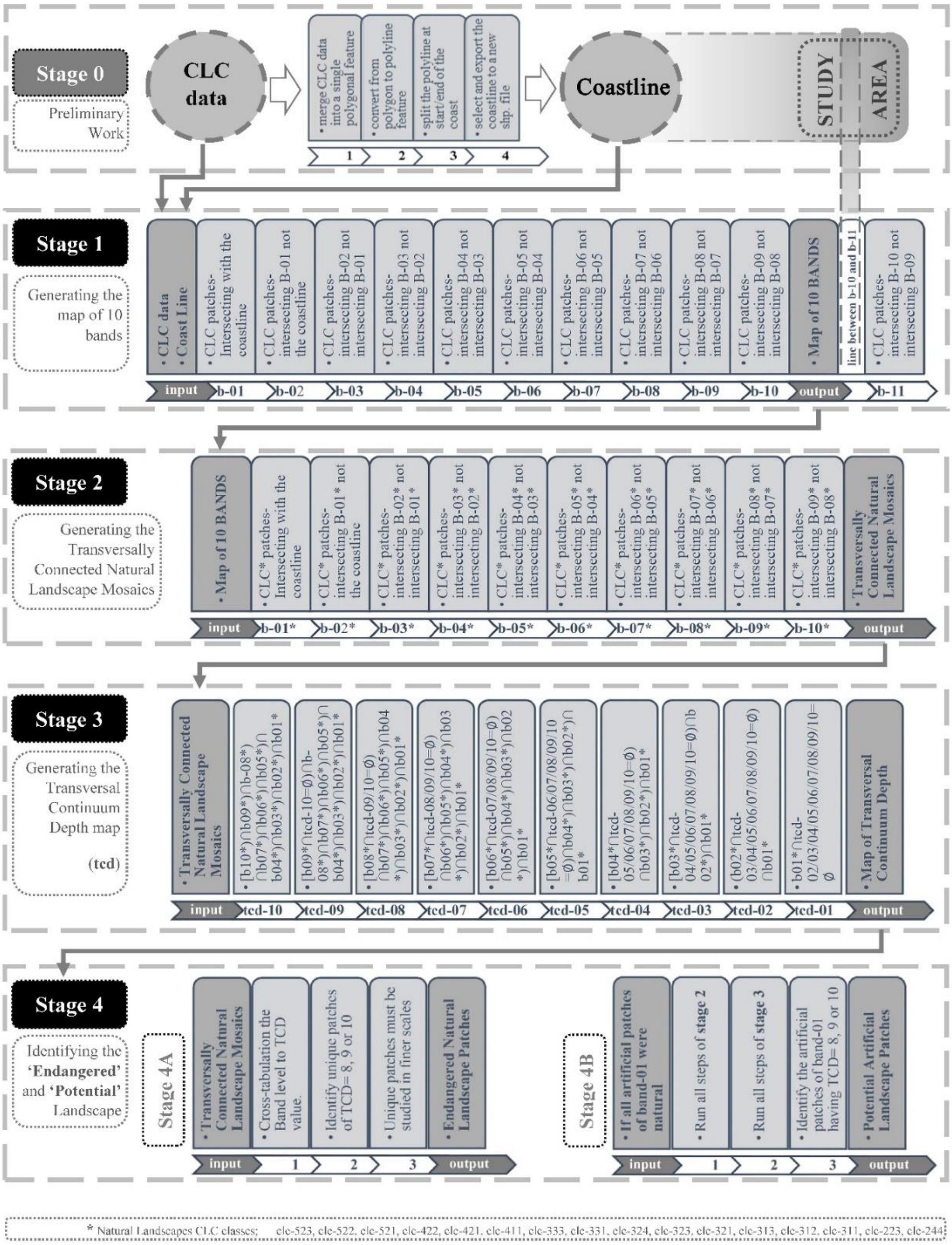

Figure 5.4 : The workflow of the analytical process as proposed in the study.

Stage 4 aims toward the identification of endangered natural landscape patches and potential artificial surfaces. The former are defined as unique patches that enable the transversally connected landscape mosaics with a TCD value of 8, 9, or 10. This is realized by cross-tabulating the values of the band level per TCD. Further, the identification process of potential artificial land cover patches is based on the assumption that all the existing artificial surfaces on the coastline are natural. By rerunning the same process of stage 2 and stage 3, existing transversally connected natural landscape mosaics that start with band 2 can then be mapped. Consequently, the artificial land cover patches on the front line of the coast can be considered as potential surfaces to be highlighted, as they act as barriers between the coastline and TCNLM.

5.3 Results

At each stage of the workflow (Figure 5.4) the study reveals significant results about the landscape formation within the Turkish Mediterranean coastal zone.

5.3.1 Stage 1: Generating 10 bands of land cover surfaces along the Turkish Mediterranean coast

Following the workflow of stage 1, the reclassification map of CLC patches in 10 bands is generated. The map shown in Figure 5.6 gives clues concerning the morphology of the first 10 bands along the Turkish Mediterranean coast. For instance, the distance between the coast and the reddish areas (bands 8-9-10) indicates the transversal depth variation of the landscape patches (Figure 5.6). In other words, a shorter distance between the coast and band 10 suggests a relatively more altered landscape patches per area, as indicated in the circled areas on the map.

Apart from the visual information delivered via the generated maps, statistical data based on certain attributes of patches per band (Table 5.1 and Table 5.2) assist further studies aiming at landscape metrics analysis. Table 1 provides ground for comparative statistical analysis to be made between the 10 bands, based on the number of patches, surface area, perimeter, and band width. Furthermore, with respect to landscape transversal depth alteration, according to Table 5.1, the distance of the patches within band 10 to the coastline varies from 24 km to 189 km (an average of 102 km). Subsequently, it can be inferred that the average depth of patches between the coastline and the closest patch within band 10 is 2.6 km, approximately 8 times shorter than the mean depth of patches between the coastline and the farthest patches of band 10.

At first, it may seem unnecessary and irrelevant to investigate landscapes almost 200 km away from the coastline. This is mainly because we are accustomed to considering a coastline according to its longitudinal dominance. However, the aim of this study is to scrutinize the transversal properties and potentials of the coastal zones by focusing on a wider gradient between the coastline and areas further inland. As pointed out before, the uplands in the coastal zones are getting more attention in the scope of holistic management agendas such as ICZM. Yet, the transversal depth distance may vary according to the patchiness of the land cover mosaic, and this variance should be further discussed.

Table 5.2 and the charts presented in Figure 5.5 provide comparative information on the natural and artificial landscape patch distribution along the 10 bands of the study area. According to Table 5.2a and Figure 5.5a, natural surfaces count for 53 % of the total landscape patches within the study area. This ranges between 49.3% at band 10 and 58.5% at band 6. Furthermore, Table 5.2a and the chart in Figure 5.5b show that the total area of natural surfaces cover 55% of the territory and ranges from 45.1 % at band 8 to 70.5% at band 4. However, according to Table 5.2b and Figure 5.5c, the perimeter values of the natural patches account for 58% of the total perimeter inside the study area. This ranges from 50.9% at band 9 to 66% at band 5. Similar statistical data on the distribution of the land cover patches throughout the 10 bands of the study area can be further studied under landscape metrics methodology.

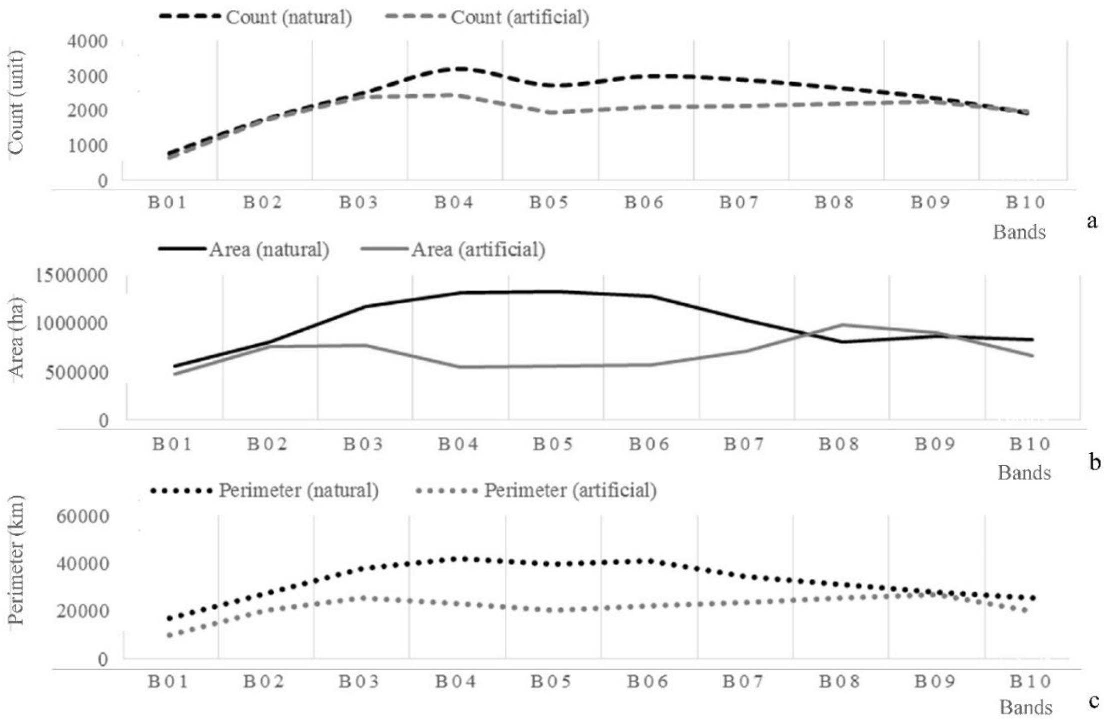

Figure 5.5 : Natural vs. artificial surfaces distribution within the 10 bands of the study based on (a) count, (b) area, and (c) perimeter criteria.

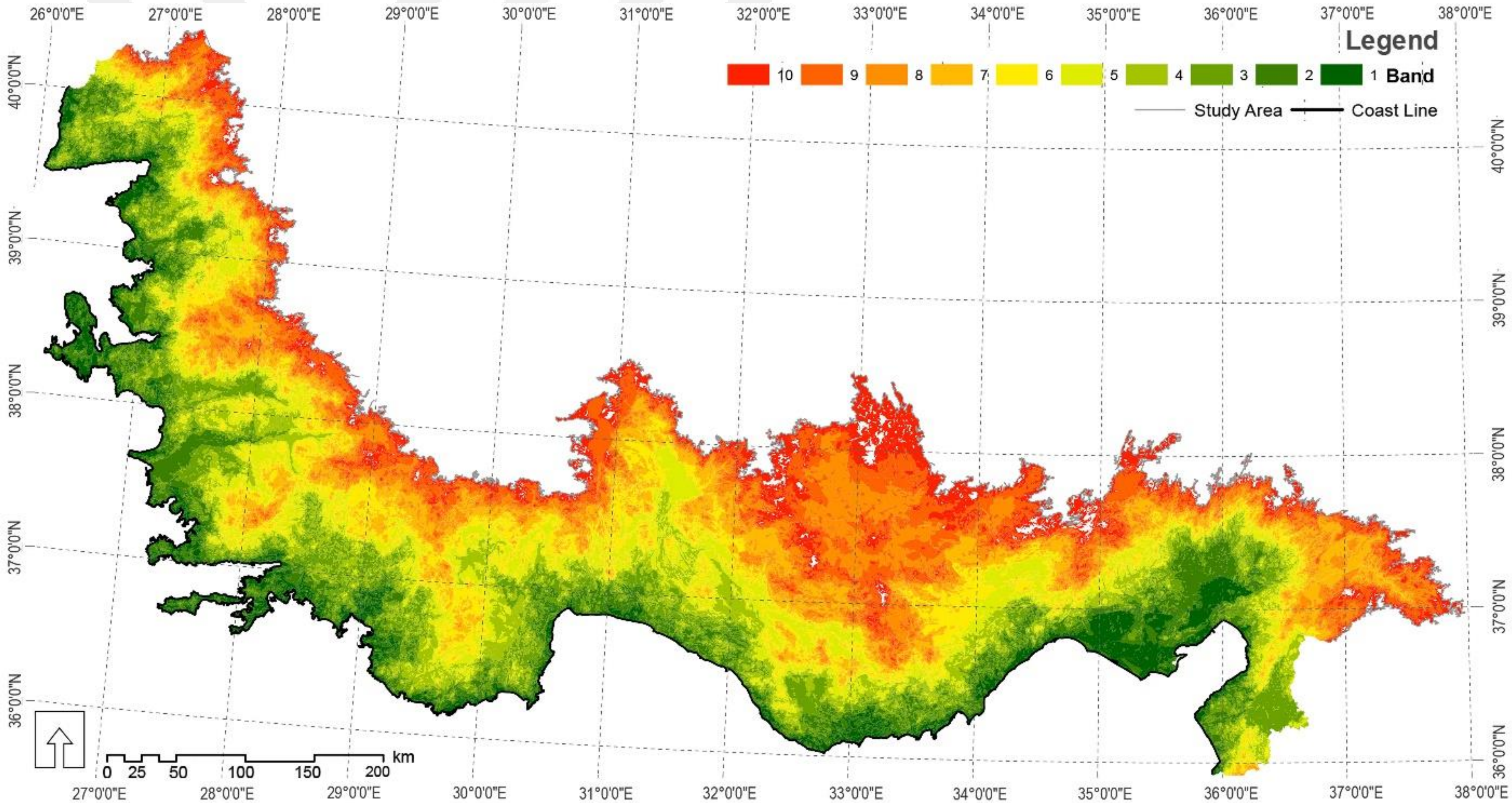

Figure 5.6 : The map of 10 bands within the study area along the Turkish Mediterranean coast.

Table 5.1 : Statistical data on 10 bands along the landscapes of the Turkish Mediterranean coast.

Terms of ANALYSIS	b01	b02	b03	b04	b05	b06	b07	b08	b09	b10	Mean	St.Dev
Count of Patches	1416	3443	4860	5638	4657	5087	5017	4831	4600	3898	4345	1199
Total Area [ha]	1035229	1578012	1938586	1871489	1883963	1853224	1740444	1791490	1771494	1486325	1695026	271002
Mean Area	731	458	399	332	405	364	347	371	385	381	417	116
StdDev of Area	4256	2949	2939	1788	2790	1768	1901	5151	1570	2792	2790	1159
Max of Area	94736	117116	132945	57897	116778	67837	62984	349625	35509	153219	118865	89200
Total Perimeter [km]	26948	47884	63408	65135	60277	63328	58131	56348	54788	45494	54174	11563
Mean of Perimeter	19	14	13	12	13	12	12	12	12	12	13	2
StdDev of Perimeter	53	43	57	32	42	31	29	40	25	31	38	11
Max of Perimeter	999	885	3264	1399	1529	1187	797	2357	668	1286	1437	801
Mean of Band Width [m]	5329	5909	5335	4281	4283	4213	4109	5664	3090	4603	4682	864
StdDev of Band Width	7223	7476	7343	6927	5460	7578	5190	10961	3773	6732	6866	1897

5.3.2 Stage 2: Mapping the transversally connected natural landscape mosaics

In stage 2, the study focuses on defining the transversally connected natural landscape mosaics of the Turkish Mediterranean coastal zone. The main input of stage 2 is the map of 10 bands derived as the output of stage 1. The first step consists of a filtering process through which all artificial landscape patches, as defined in the workflow, are omitted (Figure 5.4). The remaining patches, demarcated as natural landscape surfaces, are then analyzed. This analysis is initiated by assessing the adjacent natural land surfaces within each band in relation to their preceding sibling band, and by including the coastline as the starting reference. As a result, the map in Figure 5.7 represents the natural land cover patches that are in contact with the natural landscape patches of their preceding band. In this case, all remaining patches, regardless of the band level they belong to, are ignored as being fragmented from the transversally connected natural landscape mosaics that have direct access to the coastline.

Table 5.2 : Statistical data contrasting natural vs. artificial surfaces within 10 bands based on the surface areas (a) and perimeters (b) of the patches.

Area [ha]	**Count**	**%**	**Sum**	**%**	**Av**	**Min**	**Max**	**St.Dv**
Natural	23308	53	9512409	55	408	25	132945	2124
Artificial	20390	47	7656190	45	375	25	349625	3551
total	43698		17168599		393	25	349625	

a

Peri. [km]	**p/a sum**	**Sum**	**%**	**Av**	**Min**	**p/a max**	**Max**	**St.Dv**
Natural	3.34	317864	58	14	2	2.46	3264	43
Artificial	2.99	228859	42	11	2	0.67	2357	32
total		546723			25		3264	

b

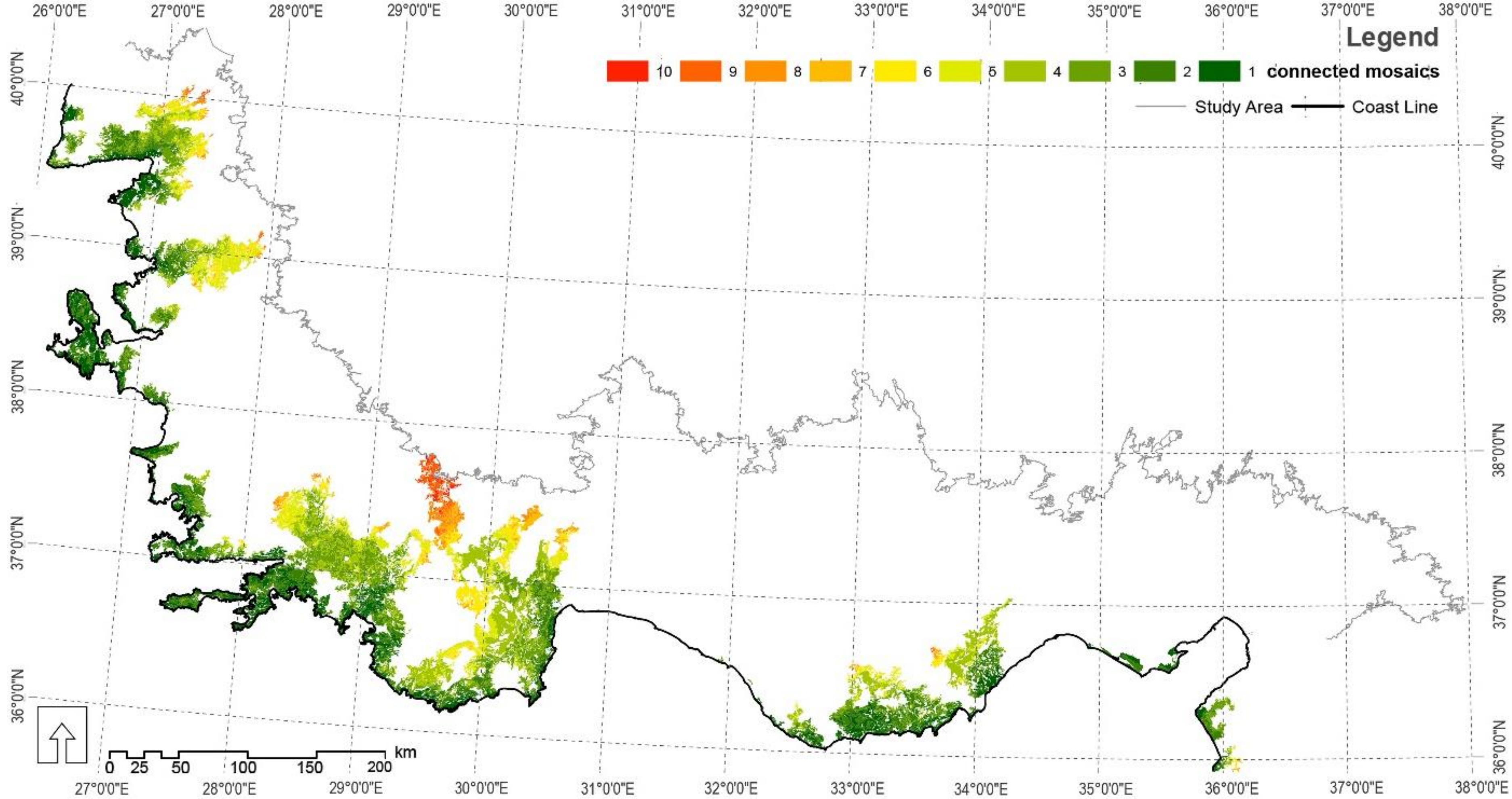

Figure 5.7 : Connected natural landscape mosaics up to 10 bands along the Turkish Mediterranean coast.

5.3.3 Stage 3: Measuring the TCD value

In stage 3, the study focuses on measuring the TCD value of each natural landscape patch within the transversally connected natural landscape mosaics. To allow the mapping of the transversal landscape continuum level as shown in stage 2, the composition of the adjacent natural landscape patches (CLC features) from the coastline to the inner continental areas required an extension to the concept of bands. Referring to Figure 5.7, it is obvious that the transversal natural landscape mosaics are different in their composition, and only rarely do they contain any patches of band 10. For this reason, the mosaics containing band 10 patches are considered to be more valuable since they provide deeper transversal continuity. Thus, the TCD value indicates the highest band level to which a given landscape patch can provide transversal connectivity.

The map in Figure 5.8 represents the distribution of patches according to their TCD value. The map assists in the identification of the corridors that provide the highest transversal continuum of natural coastal lands. These areas can be evaluated as future zones of primary environmental and ecological concern. The information generated by this map also allows the reclassification of the natural landscape patches of the band 1 according to their TCD value. Obviously, a landscape patch in the front line of the coast with a TCD value of 8, 9, or 10, is much more valuable than a band 1 patch with a TCD value of 1, 2, or, 3. According to Figure 5.8 and Table 5.3, the former cases are not frequent, accounting respectively for 3, 4, and 4 patches. These patches can be considered as endangered landscape units, the land-use alteration of which would contribute to transversal natural landscape fragmentation in the coastal zone.

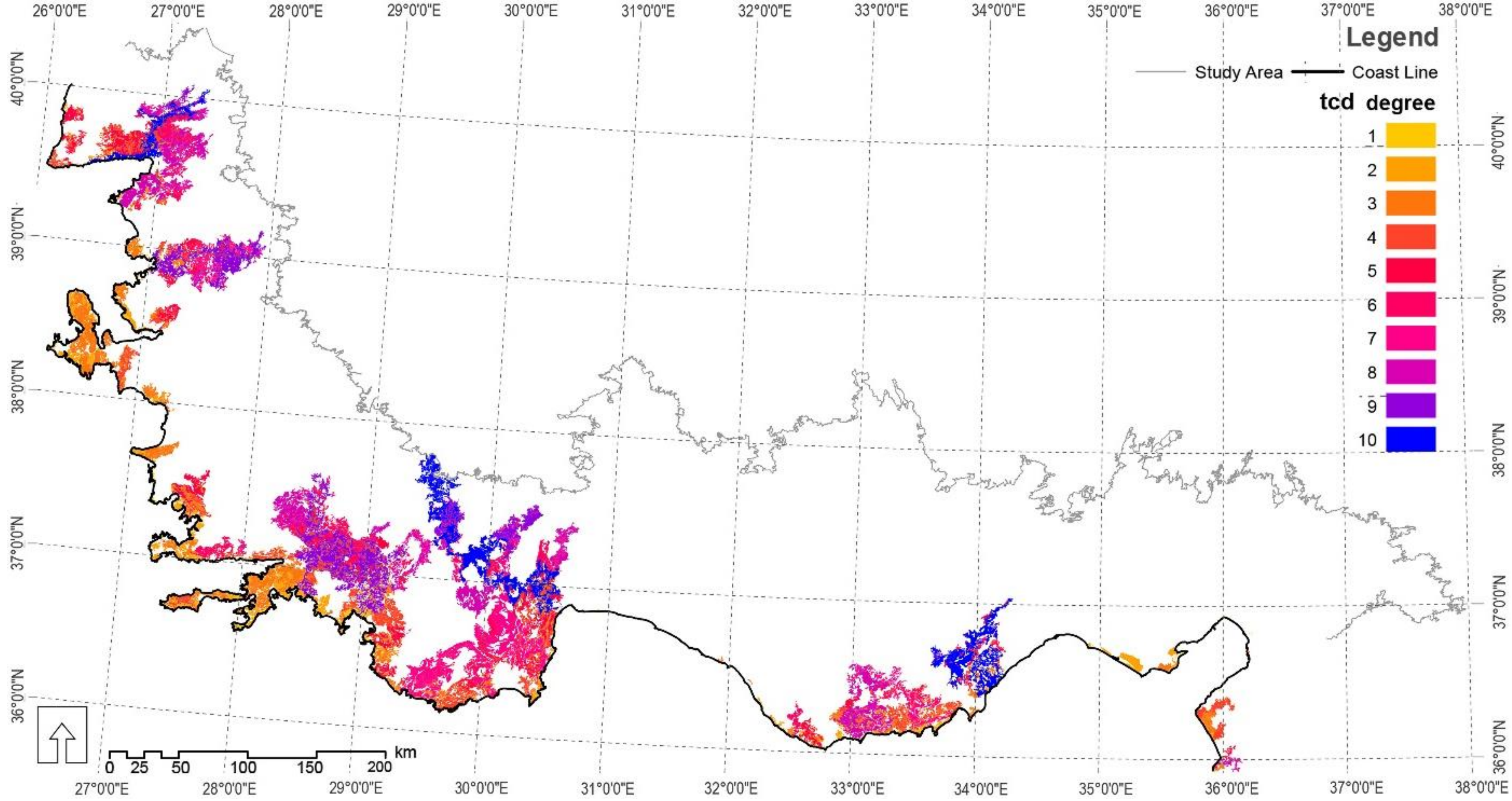

Figure 5.8 : The map of 10 bands along the Turkish Mediterranean coast according to their TDC value.

The map in Figure 5.8 represents the distribution of patches according to their TCD value. The map assists in the identification of the corridors that provide the highest transversal continuum of natural coastal lands. These areas can be evaluated as future zones of primary environmental and ecological concern. The information generated by this map also allows the reclassification of the natural landscape patches of the band 1 according to their TCD value. Obviously, a landscape patch in the front line of the coast with a TCD value of 8, 9, or 10, is much more valuable than a band 1 patch with a TCD value of 1, 2, or, 3. According to Figure 5.8 and Table 5.3, the former cases are not frequent, accounting respectively for 3, 4, and 4 patches. These patches can be considered as endangered landscape units, the land-use alteration of which would contribute to transversal natural landscape fragmentation in the coastal zone.

5.3.4 Stage 4A: Identifying the endangered natural landscape units

A cross-tabulation matrix can be generated according to the attribute table of the TCD map. Table 5.3 includes the number of patches of each TCD degree per each band. By focusing on the row values, it can be understood that there is a progressive decline in the number of patches as the TCD value increases. The progressive decrease is most evident in the case of natural patches within band 1; 55% of the patches (418 patches) by the coast have no connection with the natural inland areas of upper bands. In other words, it indicates the small number of natural landscape units in the front line of the Turkish Mediterranean coast with direct coastal access to the transversally connected natural patches of the following 9 bands. In addition, the data presented in the first row shows the number of transversally connected natural landscape mosaics from the coast to inland areas by their TCD degree.

By referring to the same table, it can be concluded that along the Turkish Mediterranean coastal zones there are only 2 sets of 9th and 3 sets of 10th TCD value of natural landscape mosaics. This is in-line with the visual information given in Figure 5.8. Furthermore, it can be stated that the largest number of landscape patches belongs to band 2 of the 2nd TCD value, accounting for 935 units. The high ratio (4.92) of the amount of patches within band 2- 2nd TCD (935) to the number of patches within band 1- 2nd TCD (190) indicates the existence of higher de-naturalization rates of the landscape surfaces at the front line of the coast.

Table 5.3 : Amount of patches per band to degree classes of the Turkish Mediterranean coast, highlighting the endangered patches.

Patches	**TCD**										
Bands	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**total**
1	418	190	74	38	14	4	11	3	4	4	760
2		935	210	58	22	4	9	8	5	4	1255
3			807	142	64	10	8	14	**2**	4	1051
4				813	155	43	14	15	**2**	**3**	1045
5					485	88	20	19	6	5	623
6						310	64	22	7	**3**	406
7							179	50	7	**3**	239
8								102	21	5	128
9									43	10	53
10										50	50
total	418	1125	1091	1051	740	459	305	233	97	91	5610

The column values and the distribution of patches inside a 9th or 10th degree mosaic, reveal that in both 9th degree (TCD) mosaics there is only 1 patch per band 3 and band 4. Similarly, there exists only 1 landscape unit per band 4, band 6, and band 7 within each 10th degree (TCD) mosaic. These numbers indicate for the structurally critical parts of the transversally connected natural land mosaic where the connectivity condition is most fragile (Figure 5.9). These landscape patches, can be considered as endangered units, the artificializing processes of which may drastically contribute to the transversal natural landscape fragmentation in coastal zones. Even though this study does not focus on the level of threat these highlighted patches face, it shares certain goals with the Red Data Book of the Biotopes project. Furthermore, the identified units should be further studied at finer scales. This is crucial to better understand the level of the natural landscape continuum within their patch boundaries. By this way it follows the logic of hierarchical structure of spatial units in ecosystems scheme as proposed in the same study (Blab et al, 1995).

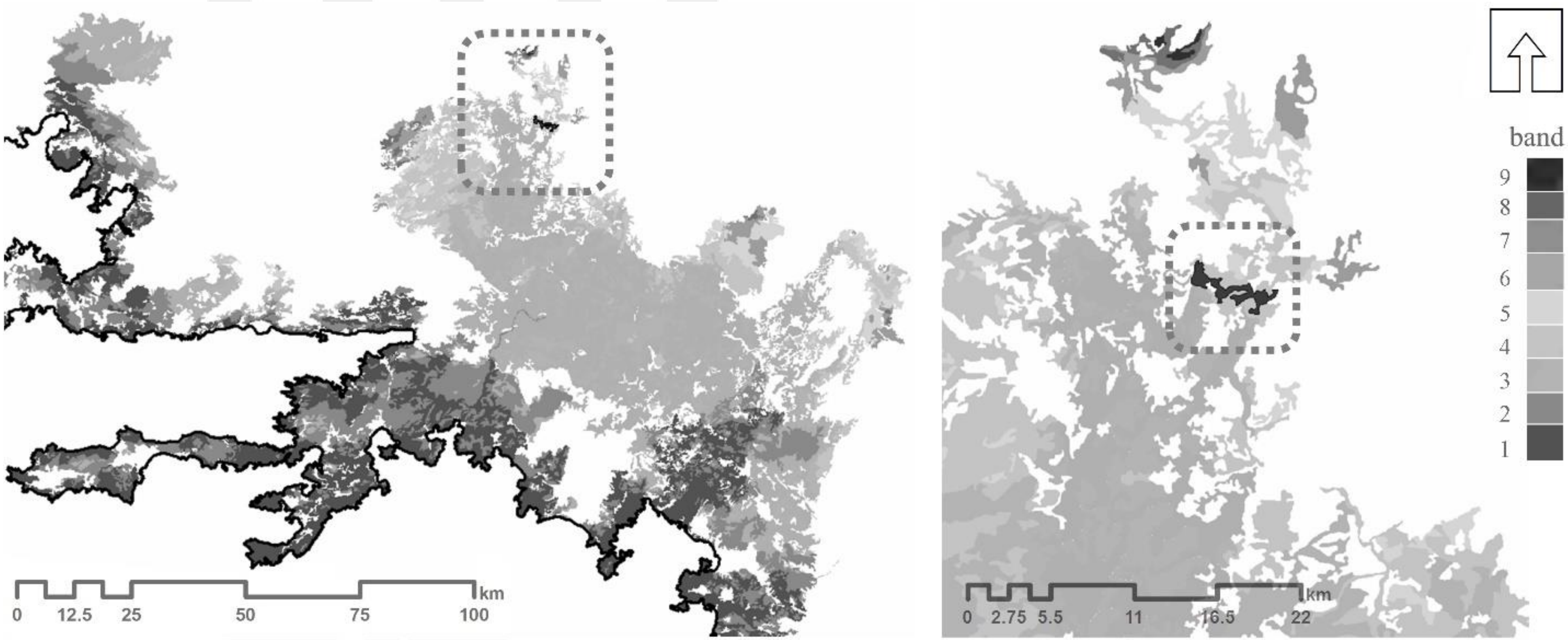

Figure 5.9 : Identification of an endangered feature of band 4 - TCD 9 on the Turkish Mediterranean coast.[15]

[15] A trial on further analyzing the identified endangered natural landscape patch within the transversally connected natural landscape mosaic at a finer spatial scale is included in Figure A.3, in the Appendixes section of this thesis.

Figure 5.9 shows the case of the single landscape unit belonging to band 4 within a transversally connected natural landscape mosaic of a TCD value of 9. It is obvious that the highlighted patch serves as a hinge between the natural landscape units of the lower (band 3) and upper (band 5) bands within the 9th degree mosaic. These land cover units can be easily identified via the proposed method. Yet, the findings belong to a coarse spatial scale, revealing the need for further studies at finer scales since landscape fragmentation is a phenomenon which is particularly sensitive to man-made infrastructure, such as transportation (Trombulak and Frissell, 2000; Marcantonio et al, 2013). Consequently, this study proposes a top-down cross-scalar hierarchical approach, as opposed to the previous bottom-up frameworks (Lechner et al, 2015).

5.3.5 Stage 4B: Generating the set of promising artificial landscape patches

In addition to the identification of endangered natural landscape patches, the proposed method is also useful in identifying a set of potential or promising artificial landscape patches at the front line of the coast. In other words, this can be a label for those units of artificial land cover classes of band 1, the 'naturalization' process of which may provide transversal continuity for the natural landscapes in coastal zones. The basic aim is to identify the artificial patches of band 1 that separate the coastline from the transversally well connected natural landscape mosaics starting at band 2.

The process of stage 4B relies on the assumption "if all artificial patches of band 1 were natural areas". By rerunning stages 2 and 3 of the workflow, a new set of transversally connected mosaics can be identified (see Figure 5.10). The artificial patches of band 1 that enable transversally interconnected mosaics with TCD values of 8-9-10 are considered as potential patches to be highlighted. These units can be further studied at finer scales to develop recovery/restoration strategies and transforming them from causes of fragmentation to landscape connectivity mediators.

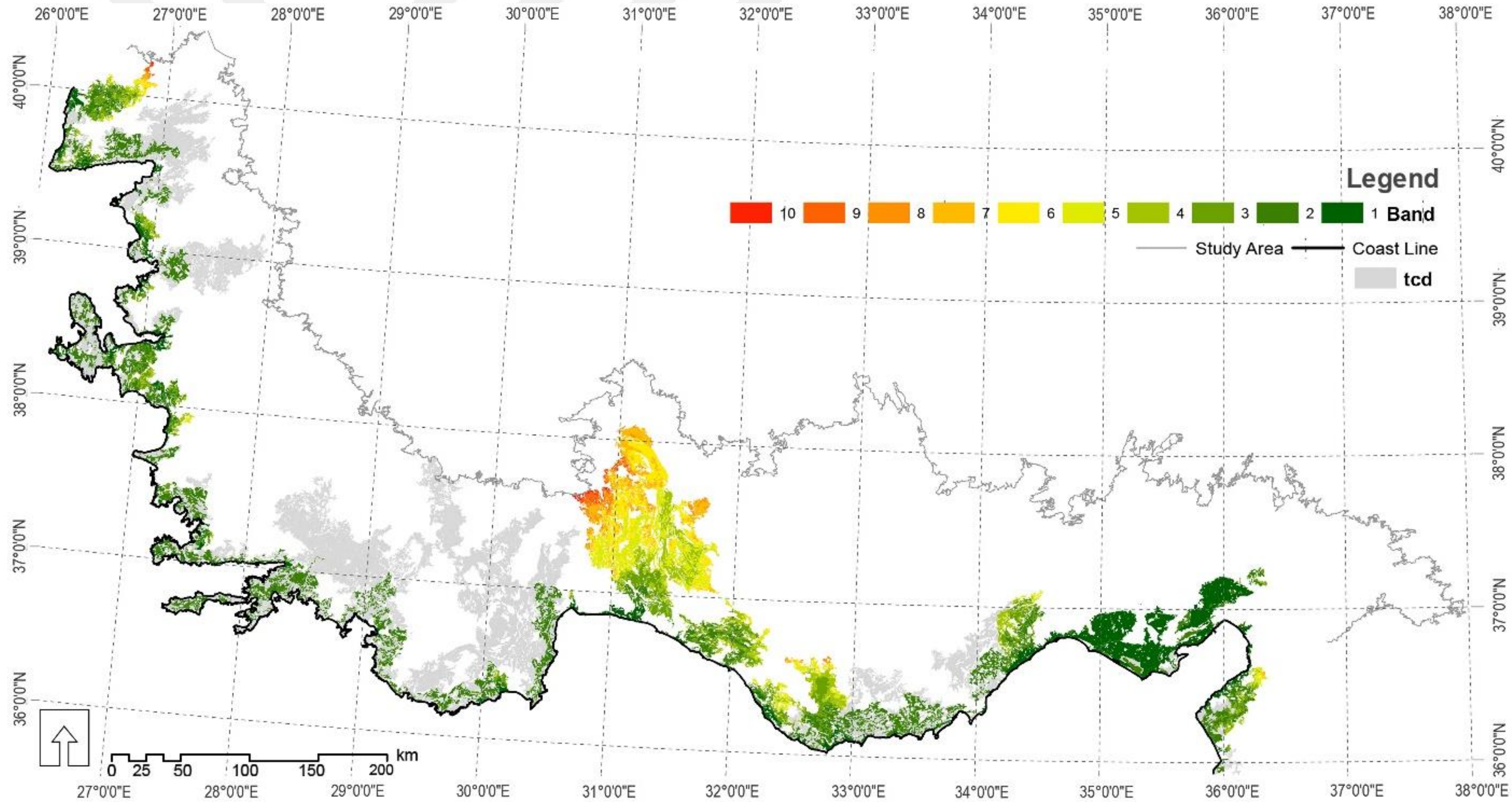

Figure 5.10 : Potential transversally connected natural landscape mosaics.

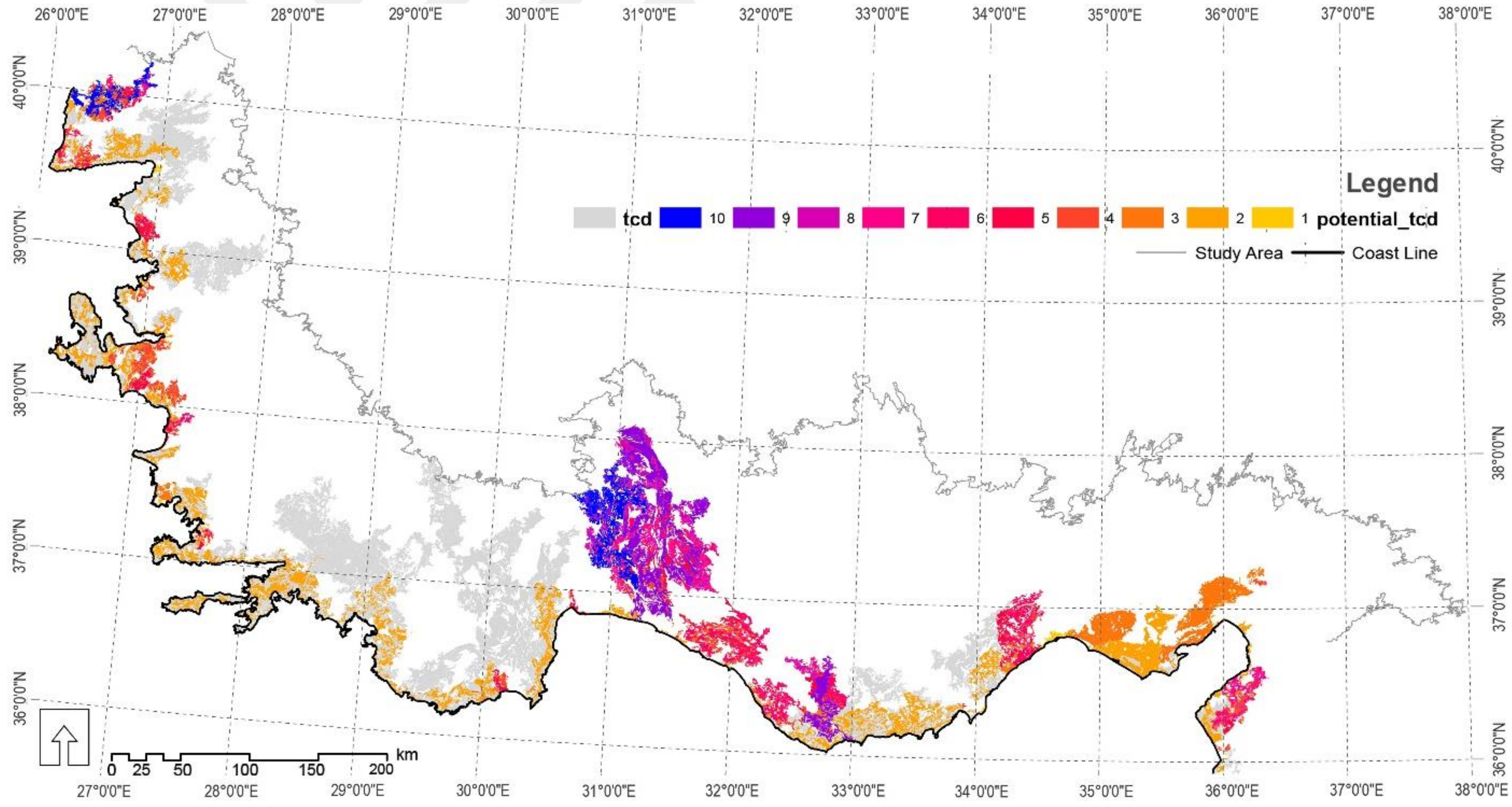

Figure 5.11 : Potential transversally connected natural landscape mosaics by their TCD values.

5.4 Discussion and Implications

The results of the study orient the discussion to highlight certain achievements/credits, implications, and potential pitfalls of the presented methodology. Initially, there are certain merits of the proposed method, especially while developing an unusual analytical approach for analyzing the landscape structure in coastal zones. The accomplishments of the study provide certain implications of the method for a diversity of decision making and management processes. However, there are some critical issues or potential pitfalls of the methodology that need to be highlighted. The possible drawbacks should be tested and evaluated through certain methods targeted as future works and further improvements of our methodology.

First, the proposed concept of "bands" turn out to be a useful analytical approach in investigating the landscape structure in coastal zones in relation to the coastline. At the same time, the workflow of the proposed method is successful in identifying the existing transversally connected natural landscape mosaics in the coastal zones and the endangered natural landscape patches within them. Furthermore, it makes possible the identification of a set of artificial surfaces in the front line of the coast as potential landscape patches, the reclamation of which may extensively enhance the transversal continuum of natural landscapes in coastal areas. A further achievement of the study is related to the applicability of the proposed method. In this article, the method is tested on the Turkish Mediterranean coast, but since the workflow is modeled in Model Builder/ArcGIS, it is available to be applied in other cases of coastal zones.

The achievements of our model align it with certain decision making and management agendas which are intended to handle coastal zones through the use of a holistic approach. One of the chief concerns of coastal zone managers is the threat of upland development activity (Clark, 1997). This becomes even more important when considering the goals of sustainable tourism agendas for coastal zones, which promotes a transversal spread of the concentrated development interest on the shoreline deep into the upland areas (Markovic et al, 2009). Sustainable coastal tourism which preserves coastal ecosystems, natural resources, cultural heritage and landscapes is highlighted as a crucial objective within the ICZM protocol (UNEP, 2008). A further stress on upland areas particularly on protected landscapes is hidden behind the phenomenon of sea level rise (SLR) as a consequence of the global warming (Epanchin-Niell et al, 2017). Spatially thinking, it indicates a shrinkage of continental borders indicating a transversal shift of the coastline, having a significant effect on uplands in the coastal zone. Consequently, the concept of a transversal analytical approach to coastal zones, as opposed to one which is longitudinal, is seen to be much more relevant and consequential.

Furthermore, the identification of the transversally connected natural landscape mosaics in the coastal zone is a contribution to the bioregional zoning schemes that fall within the scope of bioregional planning for coastal zones. Fundamentally, bioregional planning is an end result of the ICZM model that adopts the ecosystems approach to management systems (Kelleher, 1999). According to Forst (2009), a more widespread application of zoning schemes with a basis in bioregional planning can be formulated for coastal zones and, by extension, for upland ecosystems. Land cover evidence is a key biophysical property of coastal zones, which can be considered as a long-term indicator to be monitored in support of their ecological planning (Laffoley et al, 2004). Consequently, our study contributes by utilizing CORINE land cover data as a mean for investigating the transversal bioregional corridors in support to ICZM goals.

Furthermore, the identification of endangered natural landscape patches within the transversally connected natural landscape mosaics, is a direct contribution to the Red Book of the Biotopes (RBB) project. The main goal of RBB is to identify, categorize and monitor threatened biotopes as core habitat areas (Blab et al, 1995). However, in our study it comes with an emphasis on the red list specifically for coastal zones. The presented method of identifying the endangered natural landscape patches is in support of Article 8 under ICZM protocol. More precisely, point 3.a within Article 8 highlight the duty of all Parties to provide ground for identifying and delimiting, apart from protected areas, open areas in which urban development and other activities are restricted or, where necessary, forbidden (UNEP, 2008).

In addition to achievements and implications of the method presented here, certain potential pitfalls are worth identifying as areas of further improvement. Since the detection of landscape pattern and discontinuities depend on grain size (Strayer et al, 2003), extent (Wu, 2004) and measurement type of the data (Blaschke, 2006), the proposal at this stage is dependable only at the landscape scale (Lavers and Haines-

Young, 1993). This is because the methodology applied during the CLC data preparation is based on a minimum mapping unit of 25 ha for patches and 100 m for linear features (JRC-EEA, 2005), thereby providing reliable information at a much coarser scale (1:100,000) compared to other land cover monitoring methods such as LUCAS (Gallego and Bamps, 2008). This may involve a possible conflict between the scale of information and the assessment goals set for the continuum of natural landscapes – as a phenomenon taking place within a range of spatial scales (Hysa and Başkaya, 2017). However, the work presented in this paper should be considered as the initial step of a cross-scale landscape continuity assessment process. It is intended to be useful in highlighting the core transversally connected natural landscape mosaics at the eco-regional scale. The method presented in this study has the potential to be applied at different spatial scales by using a variety of LULC maps in support of bioregional planning, which treats the land and sea as one integral system (Kelleher, 1999). This can motivate future works to comparatively utilize a variety of LULC data.

5.5 Conclusion

This study presents a method of investigating the transversal structure of landscapes in the coastal zones, which are generally studied according to their longitudinal configuration. This transversally oriented approach leads to the concept of bands, which here are proposed as an alternative to the BZ concept widely used in coastal zone studies. The workflow consists of four analytical stages; (i) generation of a 10-band map, (ii) mapping transversally connected natural surfaces, (iii) assigning transversal connectivity depth (TCD) values and (iv) identifying the endangered and potential landscape patches. Both endangered and potential patches should be further studied at finer scales since the boundary and adjacency condition between patches is sensitive to grain size of the data utilized. This is vital for the development of recovery or restoration strategies, thus contributing to the transversal continuum of natural landscapes in coastal zones.

Utilizing the Model Builder extension of the ArcGIS software, all the stages are structured into a model which can be applied to any coastal geography relying on two fundamental predefined parameters; the coastline and the Land Use/Land Cover data. At this phase, the study utilizes CLC data, focusing on the natural land surfaces. In addition to CLC data, the methodology is sufficiently robust to be applied utilizing other LULC maps or landscape character data. Its short application time makes the proposed model a useful tool for rapid transversal connectivity analysis at the landscape scale during the decision making processes of landscape conservation planning and transfrontier landscape studies.

In conclusion, the proposed method is intended to serve as an analytical tool to support decision making and management processes for coastal zones. An analysis of the land cover properties of any coastal area under investigation is considered to be a crucial step in the framework of ICZM. Furthermore, the assessment of landscape structure in terms of its LULC properties is becoming progressively crucial in sustainable development agendas such as Sustainable Coastal Tourism (SCT) via the United Nations Environmental Programme. According to the objectives of SCT, the diversification of tourism with off-shore activities, especially those based on the eco-environmental properties of the coastal areas, and the spatial spreading of sites of touristic interest are highlighted as goals to be challenged by the ICZM agendas. Within this context, the proposed method is vital for the assessment and analysis of the transversal properties of the natural landscapes of coastal zones.

6. A GIS-BASED METHOD FOR REVEALING THE TRANSVERSAL CONTINUUM OF NATURAL LANDSCAPES IN THE COASTAL ZONE[16]

The method presented in this article is helpful for analyzing the landscape properties and unfolding the transversal continuity of natural landscapes in the coastal zone. The novel conceptual approach to analyze the landscape structure in the transversal direction with reference to coastline is different from the classical one which focuses on the longitudinal analysis of landscape properties in the coastal areas. The procedure is relying on the fundamental questioning of the spatial relation of each landscape patch with the coastline. The raw material is LULC geospatial data. At this stage the method is tested successfully utilizing CORINE Land Cover (CLC) data acquired as an open source via EIONET (EEA). The method is structured in four sequential stages, and formalized via ModelBuilder/ ArcGIS software into a model applicable to any coastal zone. The output of each phase is used as the raw material of the following stage. The presented method is useful in identifying a set of endangered natural landscape patches located as a hinge in between two transversally connected natural landscape mosaics (TCNLM). A second set is highlighted as potential artificial surfaces located as barriers between the coastline and TCNLM.

- The presented procedure focuses on the transversal landscape structure in coastal zone rather that the classical longitudinal landscape analysis.
- The procedure brings a new way of CORINE Land Cover data utilization beyond its basic monitoring objective, useful for a variety of decision making and management such as; ICZM, Sustainable Coastal Tourism, Environmental protection, Landscape connectivity, etc.
- The method builds a novel tool set customized via ModelBuilder in ArcGIS, being applicable to any coastal zone.

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[16] This chapter is based on the paper: Hysa, A., & Türer Başkaya, F. A. (2018). A GIS-based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone. *MethodsX*, *5*, 514-523.

Table 6.1 : Specifications Table.

Subject area	• ***Earth and Planetary Sciences***
More specific subject area	*Coastal Zone Management, Environmental Protection, Landscape Connectivity*
Method name	*ModelBuilder, Transversal Continuity Depth (TCD)*
Name and reference of original method	*Hysa, A., and Türer Başkaya, F. A. (2018). Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean Coast. Ocean & Coastal Management, 158, 103-115.*
Resource availability	*CLC data source:* http://rod.eionet.europa.eu/obligations/572/deliveries *Model Builder Diagrams are shared with this article. The customized tools will be available up to request.*

6.1 Method Details

This section includes the detailed explanation about the methodical procedures of each stage of the workflow. Each stage is explained explicitly as it is modeled in ModelBuilder interface.

6.1.1 Conceptual approach: the concept of band

The method presented in this article originates from an unusual conceptual approach to the analysis of landscapes in the coastal zone (Figure 6.1a) as developed in our previous research (Hysa and Türer Başkaya, 2018). Generally, the coastal landscapes are investigated in their longitudinal structure along the coastline, leading to the widely used approach of fixed buffer strips (Figure 6.1b) (Castelle et al, 1994). In contrast, our approach is focusing on the transversal formation of landscapes along the coastal zone. Investigating the landscape structure from the coastline further inland, leads to the novel concept of bands (Figure 6.1c). More precisely the band level refers to the adjacency order a certain landscape patch has with the coastline considering it as the initial spatial reference. This new approach is profoundly settled on the organic structure of landscape patches in the territory (Figure 6.1c), much different from the fixed buffer strips being an inorganic zoning (Figure 6.1b).

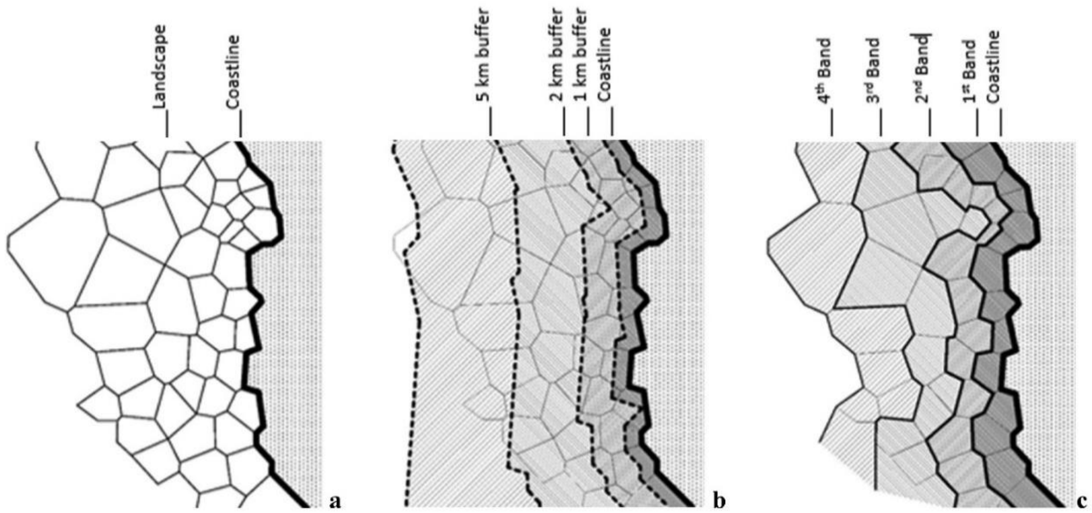


Figure 6.1 : The comparison between the fixed BZ approach (b) and the concept of bands (c) in coastal landscapes (a) (adapted from Hysa and Türer Başkaya, (2018)).

The procedure is formalized into a model/ toolset via ModelBuilder in ArcGIS 10.2.2 software. ModelBuilder is accepted as a visual programming language useful in constructing reprocessing workflows in the form of models. The formalized models consist of stringed sequences of geo-processing tools by providing the output of the previous operation as the input of the next one (ArcGIS, 2018). The usage purposes of Model Builder is of a very wide range but in this experiment it can be considered to help in developing a model as a customized tool unique to the goals of the study (Allen, 2011).

The workflow consist of 1 preparatory and 4 analytical stages (Figure 6.2). First, the input parameters (CLC data and the Coastline feature) of the process are derived from CLC geospatial data as the raw material of this study. Both inputs are introduced into the process of stage 1 generating the set of 10 bands (Figure 6.2). The output of stage 1 is the main input of stage 2 which results in the set of transversally connected natural landscape mosaics (hereafter TCNLM). The main goal of stage 3 is the reclassification of each landscape patch of TCNLM by the maximum band level they provide transversal connectivity for, by assigning the transversal continuity depth (hereafter TCD) value. Last, at stage 4 there are defined a set of endangered natural landscape patches and a further set of potential artificial land cover surfaces.

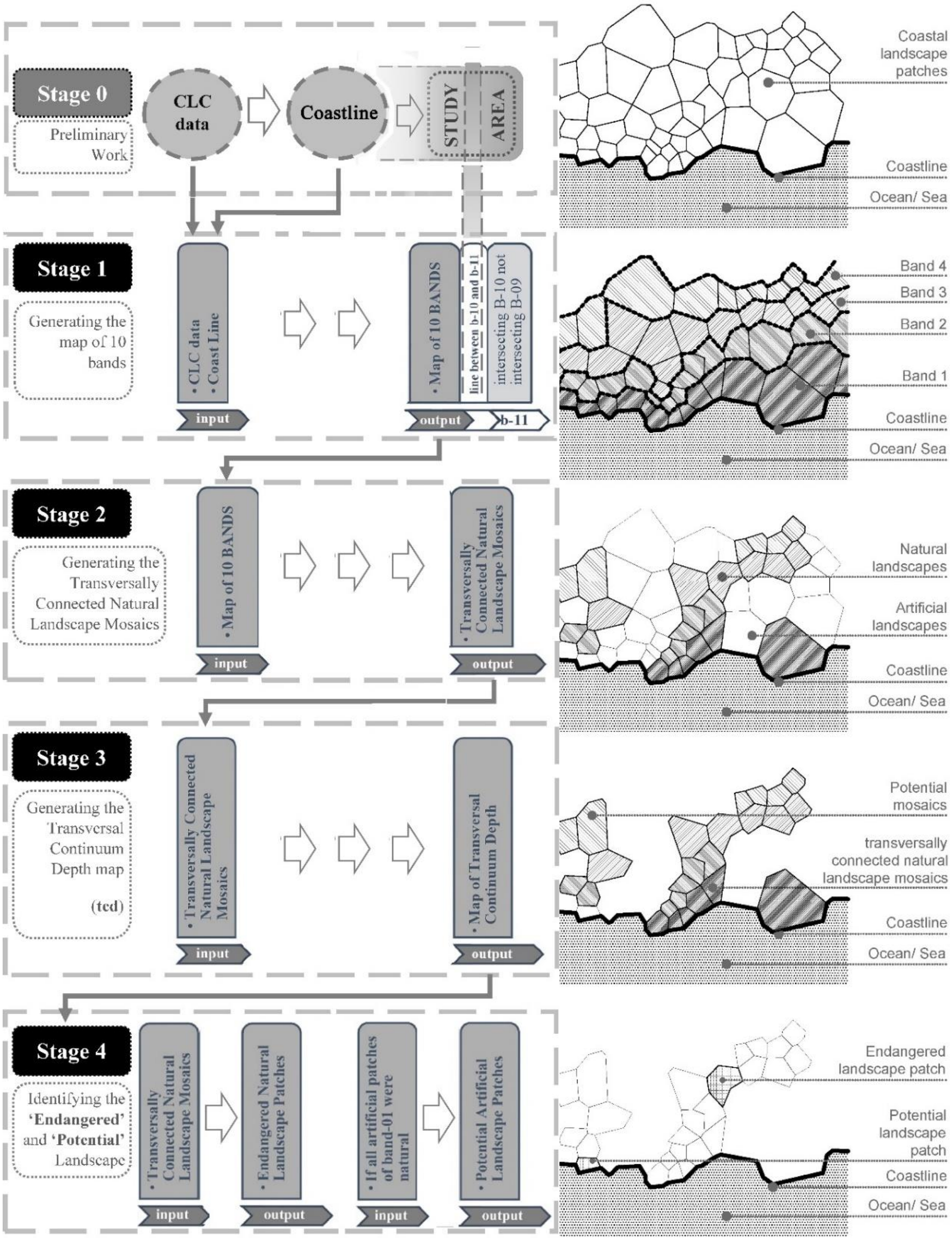


Figure 6.2 : The workflow of the method and the conceptual graphics per each stage.

6.1.2 Stage 1 in detail

Stage 1 of the procedure is preceded by a preliminary stage (Stage 0 in Figure 6.3) aiming the derivation of the geospatial polyline feature of the coastline. First, CLC data in the coastal zone is merged into a single polygon shapefile which is converted into a polyline geometry. The polyline feature is split at the start and ending points of the coastline generating the geospatial shapefile of the coastline being the second input data for the stage 1. The main goal of the stage 1 is to reclassify all CLC patches by their adjacency order in spatial relation with the coastline. As a result, each land cover patch is assigned a new unique value of band level. The workflow of stage 1 is formalized via ModelBuilder (Figure 6.4).

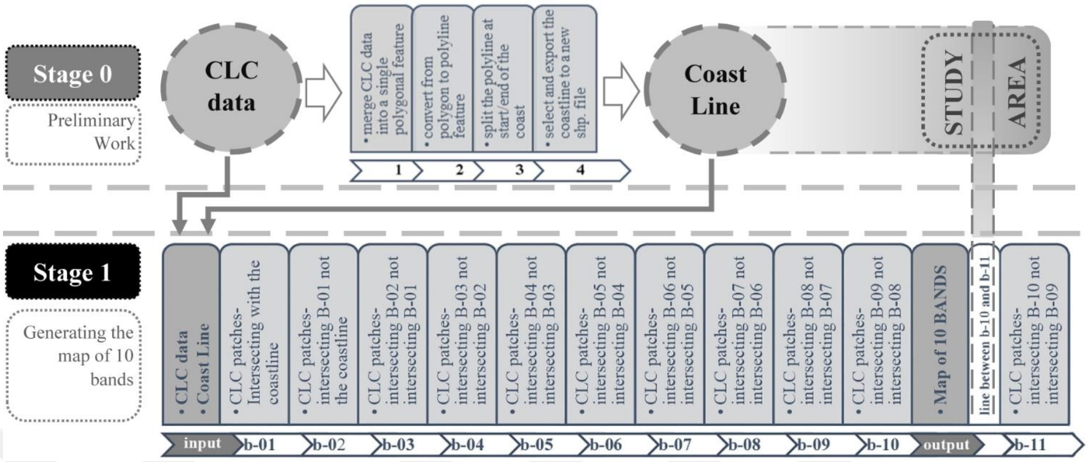


Figure 6.3 : The detailed sequences of preparatory stage and stage 1 of the workflow (adapted from Hysa and Türer Başkaya (2018)).

Referring to Figure 6.4 and Table 6.2 the workflow consist of three core subsequences. First, the raw CLC data is tested for the adjacency with the coastline (S1-a1). The selected CLC patches in touch with the coastline (S1-a2) are exported as the patches of the band 1 (S1-a3). The raw CLC data is re-tested for the adjacency with the formerly defined patches of the band 1 (S1-b1). The selected patches excluding the band 1 patches (S1-b2) are categorized as the band 2 (S1-b3). The subsequence B is repeated for defining all further bands. Finally, the set of patches of each band is added a new attribute value (S1-c1) of band level (S1-c2), and further merged (S1-c3) into a single geospatial file (.shp) to be utilized as the input in stage 2.

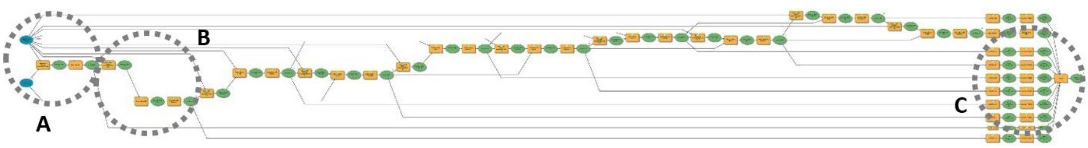
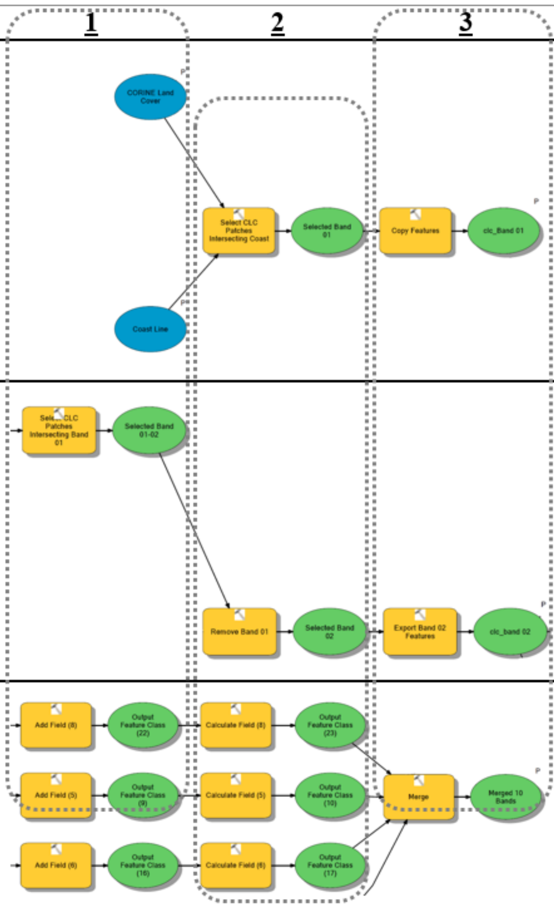


Figure 6.4 : The full workflow sequences of stage 1 as modeled in ModelBuilder.

Table 6.2 : Key ModelBuilder sub-sequences of the workflow of stage 1.



S1		Tool / *Aim*
A	a1	**Set Parameter**
		Coastline and CLC data as parameters of the model
	a2	**Select by Location**
		Select CLC patches intersecting Coastline
	a3	**Copy Feature**
		Exporting selected patches as Band 01
B	b1	**Select by Location**
		Select CLC patches intersecting Band 01
	b2	**Remove Selection**
		Deselecting patches identical with Band 01
	b3	**Copy Feature**
		Exporting selected patches as Band 02
C	c1	**Add Field**
		Adding new field as "Band"
	c2	**Calculate Field**
		Band= 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
	c3	**Merge**
		Merging all patches of 10 bands into a one (.shp) file

6.1.3 Stage 2 in detail

The map of 10 bands derived as the output of the stage 1 is the raw material for the stage 2 (see Figure 6.5) (S2-a1) aiming to reveal the TCNLM along the coastal zone. The procedure of stage 2 initiates with a filtering operation of natural CLC patches of each band (S2-a3). The natural surfaces consist of the following CLC classes; clc-523, clc-522, clc-521, clc-422, clc-421, clc-411, clc-333, clc-331, clc-324, clc-323, clc-321, clc-313, clc-312, clc-311. In other words, the artificial surfaces (clc-100) and the agricultural areas (clc-200) are excluded at this stage.

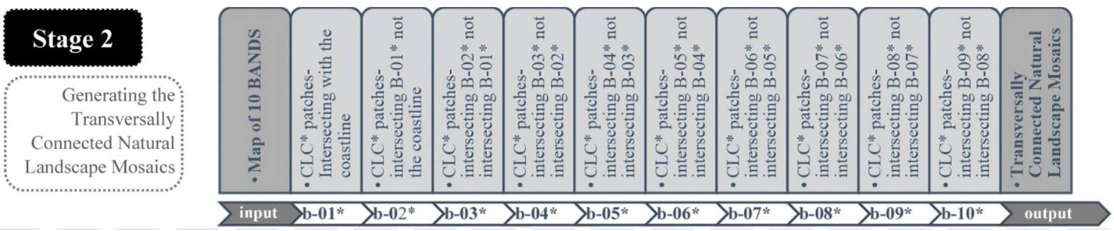


Figure 6.5 : The detailed sequences of stage 2 of the workflow (adapted from Hysa and Türer Başkaya (2018)).

The set of natural land cover classes may tolerate some exceptions due to the specifics of the context of the study area. For example, in the Mediterranean context the olive groves (clc-223) and agro-forestry (clc-244) areas are considered part of the natural environment (Assandri et al, 2017; Rosalino et al, 2011), and are included in shown in the case of Turkish Mediterranean coastal zone by Hysa and Türer Başkaya (2018). The process of stage 2 runs similar to stage 1, searching for natural landscape patches within each band, that is sharing borders with any natural land cover patch belonging to the preceding band.

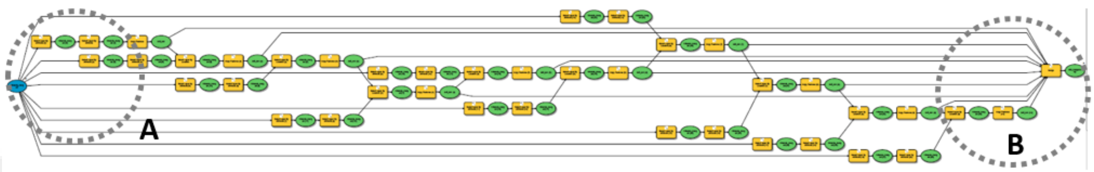
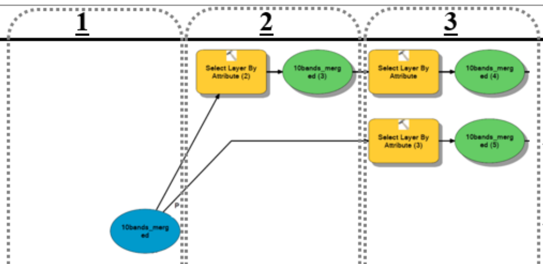
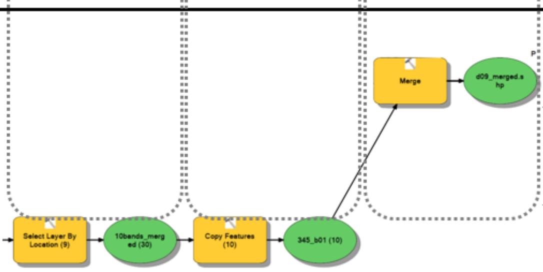


Figure 6.6 : The full workflow sequences of stage 2 as modeled in ModelBuilder.

As shown in the full workflow of stage 2 in Figure 6.6 and further in detail in Table 6.3, the sequence starts with setting the 10 band data as the main parameter (input) of the process (S2-a1). First, selecting by attributes there are filtered the patches of the band 1 (S2-a2). A further filter is performed to them aiming the exclusion of artificial and agricultural surfaces (S2-a3).

Table 6.3 : Key ModelBuilder sub-sequences of the workflow of stage 2.

S2	1 2 3		Tool / *Aim*
A		a 1	**Set Parameter** *Merged 10 bands of CLC data from Stage 1*
		a 2	**Select by Attribute** *Selecting Band 1 patches*
		a 3	**Select by Attributes** *Select Natural Landscape patches of Band 1*
B		b 1	**Select by Location** *Select natural CLC patches intersecting the preceding bands*
		b 2	**Copy Feature** *Exporting selected patches as Band 02*
		b 3	**Merge** Merging all patches into a one (.shp) file of TCNLM

The remaining natural landscape surfaces are exported as the set of natural surfaces in the frontline of the coast (S2-b2). The sub-sequence (S2-A) is run again for the band

2. The natural landscape patches of the band 2 that intersects with the natural surfaces of the band 1 (S2-b1) are exported as transversally connected natural landscapes of the band 2 (S2-b2). The remaining natural surfaces of the band 2 that are not connected with natural surfaces of the band 1 are excluded from the further steps of the workflow. The same sub-sequence repeats for all remaining bands resulting in a set of natural landscape patches that are interconnected. The merged data consist of the TCNLM along the coastal zone.

6.1.4 Stage 3 in detail

The stage 3 (see Figure 6.7) consists of a reclassification procedure for each patch of the TCNLM derived from the stage 2. The patches are classified by their maximum band level they provide transversal connectivity for. For example, a patch belonging to the band 2 and being part of a TCNLM that stretches further inland to the band 8, is assigned a TCD value of 8. In this context, the patches having a low band level (1, 2, 3, and 4) and a high TCD value (7, 8, 9, and 10) can be considered crucial components of TCNLM structure. In other words, those are natural landscape patches closer to the ocean but providing deeper natural landscape continuity further inland.

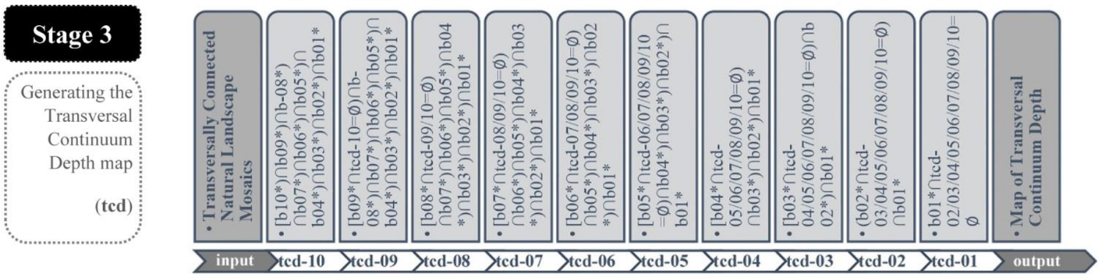


Figure 6.7 : The detailed sequences of the stage 3 of the workflow (adapted from (Hysa and Türer Başkaya, 2018)).

The workflow of stage 3 as represented in Figure 6.7 is flowing in the reverse order compared with the flow of the stage 1 and the stage 2. It tests the transversal adjacency condition staring from the band 10 rather than the coastline. This is because the aim is to assign to each TCNLM patches the maximum band level further inland they provide connectivity for. Referring to Figure 6.7 the first step is the most complex one, checking for interconnection among all bands in a descending order. In each consecutive step the string becomes shorter due to the reduction of bands under investigation. The visual information in Figure 6.8 is in the same line with this fact. The full ModelBuilder workflow sequences in Fig.8 are representing the complexity of each sequential string, resulting in one merged geospatial data of TCNLM reclassified by their TCD values.

First, the reclassification initiates by setting TCD value of 10 to all patches of band 10 (hereafter b10t10). Next, TCD value of 10 is assigned to the patches of the band 9 that are adjacent with b10t10 resulting in b9t10. Similarly, TCD value of 10 is assigned to all patches of further lower bands that are transversally connected to the preceding ones in descending order. After finalizing the sequential string defining TCD=10, in the next step the reclassification operates on the un-classified patches only. Thus, TCD value of 9 is initially assigned to all patches of the band 9 that have not been assigned a TCD value of 10 in the preceding sequence. Similarly, the procedure continues with the following bands in descending order as in the first sequence. The same logic is repeated for the remaining TCD values going less in complexity. Finally, TCD value of 1 is assigned to natural landscape patches that are adjacent to the coastline only and are not transversally connected to any patch of the band 2.

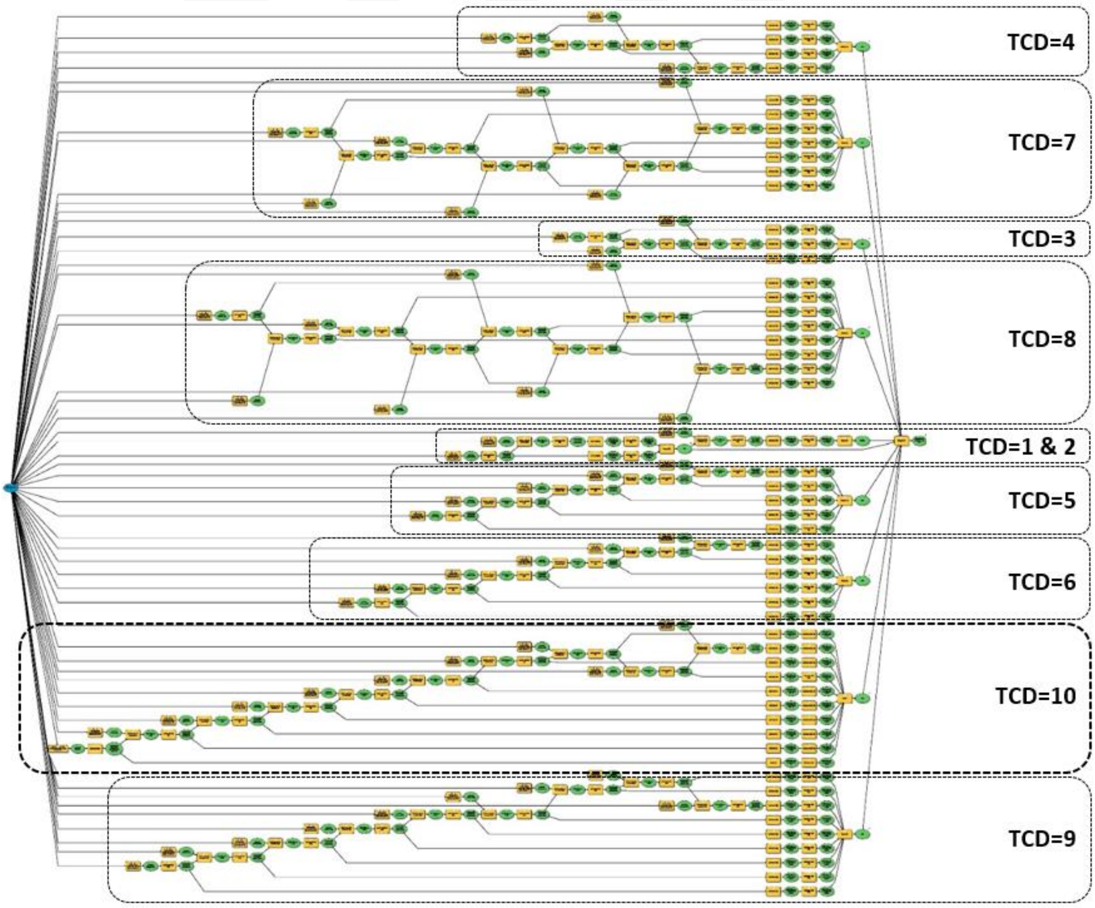


Figure 6.8 : The full workflow for classifying TCNLM patches by their TCD values structured in ModelBuilder.

Further in detail, Figure 6.9 and Table 6.4 brings a closer look to the sequential string of TCD=10. First, the TCNLM data is set as the main parameter (S3-a1). Then, the patches of the band 10 are selected based on their attributes (S3-a2), and further are exported (S3-a3) as patches to be assigned a new value (S3-c1) of TCD=10 (S3-c2). The sequence continue by filtering TCNLM data highlighting patches of the band 9 (S3-b1) not assigned any TCD value yet (S3-b2). The defined patches (S3-b3) are assigned the TCD value of 9.

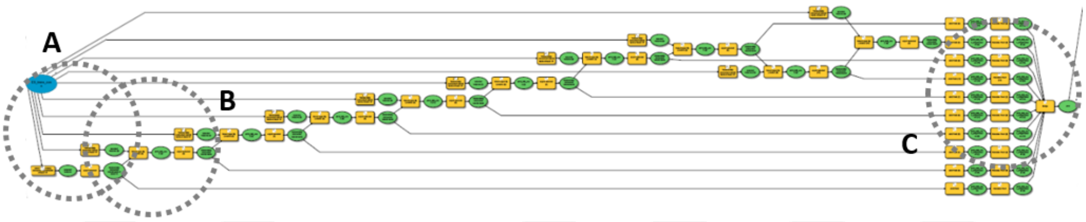
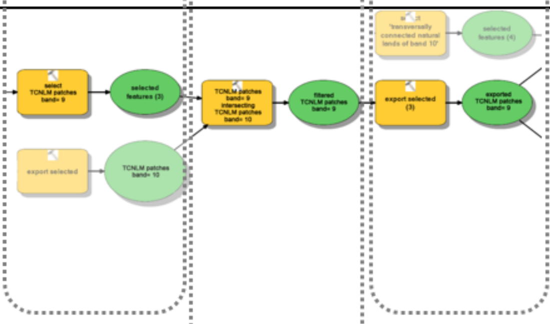
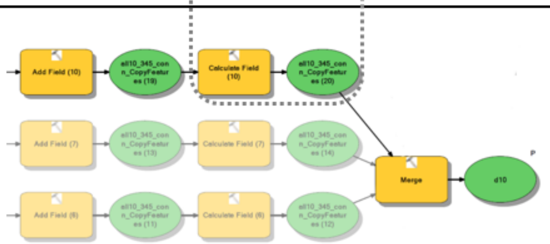


Figure 6.9 : The workflow sequences of stage 3 as modeled in ModelBuilder for assigning TCD value of 10.

Table 6.4 : Key ModelBuilder sub-sequences of the workflow of stage 3 for assigning TCD value of 10.

S3	1	2	3		Tool / *Aim*
A				a1	**Set Parameter**
					TCNLM data as parameter of the model
				a2	**Select by Attributes**
					Select TCNLM patches of the band 10
				a3	**Copy Feature**
					Exporting selected as patches of TCD=10
B				b1	**Select by Attributes**
					Select TCNLM patches of the band 9
				b2	**Select by Location**
					Select patches of the band 9 intersecting with patches of the TCD=10 value
				b3	**Copy Feature**
					Exporting selected as patches of TCD=9
C				c1	**Add Field**
					Adding new field as "TCD"
				c2	**Calculate Field**
					Attributing to all patches TCD= 10
				c3	**Merge**
					Merging all patches of TCD=10 value

The process runs the same with the following bands in a descending order, resulting in the merged set of patches belonging to various bands but sharing a TCD value of 10 (S3-c3). Regarding the reclassification of the remaining TCD values the process runs in a similar way according to the procedure explained in Figure 6.7 and Figure 6.8.

6.1.5 Stage 4 in detail

The presented three stages consist of data analysis procedures based on the existing attributes of CLC datasets. Whereas the stage 4 stands on two interpretive evaluation of the results of the previous stages (see Figure 6.10).

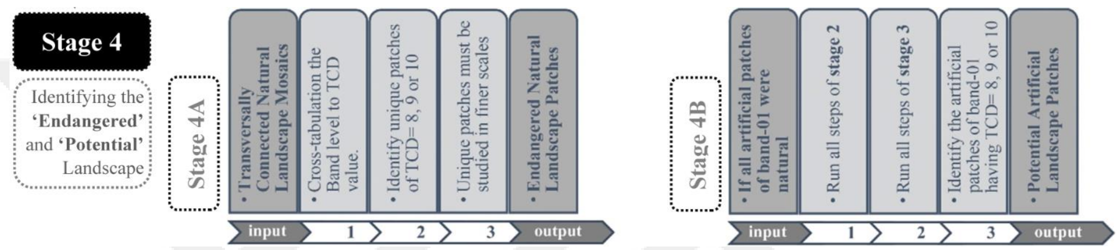


Figure 6.10 : The sequences of the stage 4A and stage 4B of the workflow (adapted from Hysa and Türer Başkaya (2018)).

For example, stage 4A relies on the cross-tabulation (see Table 6.5) of band level to TCD value for each TCNLM patch. As previously stated, the patches attributed by lower band level and high TCD value can be considered as crucial components of TCNLM. Moreover, if these patches are unique within the TCNLM they belong to, they can be highlighted as engendered natural landscape patches as illustrated in previous studies (Hysa and Türer Başkaya, 2018).

Table 6.5 : The cross-tabulation of band level to TCD value for each TCNLM patch.

	TCD	*TCD*	*TCD*	*TCD*	*TCD*	*TCD*	*TCD*	*TCD*	*TCD*	*TCD*
band 1	*b1t1*	*b1t2*	*b1t3*	*b1t4*	*b1t5*	*b1t6*	*b1t7*	*b1t8*	*b1t9*	*b1t10*
band 2		*b2t2*	*b2t3*	*b2t4*	*b2t5*	*b2t6*	*b2t7*	*b2t8*	*b2t9*	*b2t10*
band 3			*b3t3*	*b3t4*	*b3t5*	*b3t6*	*b3t7*	*b3t8*	*b3t9*	*b3t10*
band 4				*b4t4*	*b4t5*	*b4t6*	*b4t7*	*b4t8*	*b4t9*	*b4t10*
band 5					*b5t5*	*b5t6*	*b5t7*	*b5t8*	*b5t9*	*b5t10*
band 6						*b6t6*	*b6t7*	*b6t8*	*b6t9*	*b6t10*
band 7							*b7t7*	*b7t8*	*b7t9*	*b7t10*
band 8								*b8t8*	*b8t9*	*b8t10*
band 9									*b9t9*	*b9t10*
band										*b10t10*

A second interpretive analysis relies on the assumption if all artificial patches belonging to the band 1 were natural landscape surfaces. The assumption is introduced in the process at the initial steps of the stage 2. During the filtering process (S2-a3), there are filtered the artificial surfaces instead of the natural ones. The rest of the process runs identical with the remaining workflow sequences of the stage 2 in order to identify TCNLM that connects to the coastline through an artificial land cover patch. The aim of the stage 4B is to identify artificial patches belonging to the band 1 that separate the coastline and TCNLM which starts at the band 2. The highlighted artificial surfaces if restored/ reclaimed can provide extensive connectivity to TCNLM to the coastline.

7. CONLUSIONS AND RECOMMENDATIONS

This thesis is a collection of articles, each of which makes a specific case of CLC data utilization in decision making processes of landscape planning and management. Each paper is included as a separate chapter within the thesis in accordance with the rules and regulations set by the Graduate School of Science, Engineering, and Technology at Istanbul Technical University on the preparation of doctoral thesis out of at least three published scientific papers. According to the current regulation "Instructions on the Preparation of the doctoral thesis out of published scientific articles" dated on 28 March of 2018, each article should be included as a separate main chapter of the thesis (FBE, 2018). A detailed table giving detailed bibliographic information about the conformity of each paper with the above-mentioned regulation is given in the appendixes section (Table A.3).

Consequently, the main chapters (Chapter 2 to Chapter 6) include dedicated sections regarding discussions and conclusions. In other words, the results and findings of each article are discussed in detail within the respective chapter. Besides the individual concluding remarks of each article (chapter), there are a couple of common conclusions and recommendations that can be stated in the final chapter of this thesis. Furthermore, a comparison between the findings of each article helps in better understanding the most appropriate research problem/case study, that CLC data can successfully be utilized for. Furthermore, certain difficulties and limitations faced during the research process are reported in this chapter. Finally, it concludes with a list of recommendations dedicated to highlighting further improvement and future steps of the research presented in this thesis.

7.1 General Overview

In the information age that we are living in, the advancements in information technologies are continuously expanding. Especially the storage capacities and computation capabilities of the machine are progressively increasing. On one hand, this fact is accepted a great opportunity in dealing with big data of tremendously complex real-life problems, while on the other, it brings about many questions on when/where and how these achievement should reasonably be utilized. It is exactly here where the human intellect becomes a vital ally in achieving holistic decision making processes.

The main objective of the research work presented in this thesis is to find answers to the abovementioned question. The main focus stands on the advancements in territorial satellite monitoring technologies, and how they can be utilized in spatial decision making and management processes. More precisely, the thesis reports the research process focused on the possibilities of CLC data utilization in diverse decision making processes. Following a problem oriented research methodology, a set of case problems have been defined as the ground where the utility of CLC data is tested. As the fundamental raw material, CLC data is derived as an open source via EIONET (EEA) portal in shapefile format (.shp). ArcGIS software has been the main interface in the visualization and the analysis stages of the research.

First, CLC data is utilized in the assessment of landscape fragmentation among broad-leaved forested surfaces (CLC-311), being tested in the national territory of Albania. In this study, Matrix Green toolbox extension has been used besides the core ArcGIS software. MG generates direct links between each pair of disconnected landscape patches. Thus, the landscape fragmentation assessment in this proposal relies on measuring the potential/missing connectivity among patches. . The results of the study show that CLC data provide good evidence to measure landscape fragmentation at the landscape scale. Even though landscape fragmentation is also a phenomenon happening and perceivable at much finer spatial scales than that enabled by CLC data, the presented method bears the potential to be utilized simultaneously at a gradient of spatial scales. Thus, it should be considered as the initial phase of a multi-scale landscape fragmentation methodology. The method proposed in this work may assist decision making processes of landscape planning and conservation by measuring the existing landscape fragmentation among natural landscapes. This is a direct contribution since landscape fragmentation assessment is highlighted by EU as a crucial analysis during sustainable territorial management initiatives in Europe. More specifically, several governmental bodies in Albania (Ministry of Agriculture and Rural Development, National Agency of Environment or National Agency of Protected Areas), can benefit from the presented methodology as well as the results of this study.

Landscape fragmentation assessment has been among the goals of the second case problem as well (Chapter 3). However, in this study different from the previous one, landscape fragmentation is meant for the functional rather than the physical one. The main focus is not on the disconnected natural landscape surfaces already being physically fragmented, but on the cross-border condition of natural landscape patches. Landscape surfaces that are divided via local administrative boundaries are considered functionally fragmented. As a result, in this study, CLC data is tested as a useful input in decision making processes of territorial and administrative reform (TAR) under which the new spatial division of the territory into local administrative units is performed.

The study initiates by criticizing recent administrative-territorial division in Albania, by focusing on cross-border fragmented landscapes caused by the current local administrative borderlines. Later it puts forward a method of CLC data utilization as an environmental friendly mean in local border definition stage of TAR process, experimented for the case of Tirana. The border lines of natural landscape patches as derived via CLC data are proposed as the main lines that the new administrative borders should track along. CLC data utilization here is proposed within a multi-criteria framework including social, economic, and environmental properties of the territory.

The findings of this study show that a territorial and administrative reform not considering environmental criteria results in functionally disconnected landscapes, which in the long run may lead to physically fragmented landscapes patches. CLC data figures out to provide enough spatial information to support TAR decision making processes, especially during the border definition phase. The methodology developed and presented in this article may provide a holistic framework if considered by the decision making bodies responsible for the TAR process. The multi-criteria character of the framework urges for the collaboration of many expertizes delivering reliable information about the social, economic, and environmental properties of the territory facing TAR.

A third case problem dealing with landscape fragmentation phenomena is focused on the coastal zone. The paper entitled "Revealing the transversal continuum of natural landscapes in coastal zones - Case of the Turkish Mediterranean coast" (Chapter 5) aims to render the transversal structure of coastal landscapes and reveal the transversal continuity/fragmentation condition among natural landscapes in the coastal zone. At this stage, the study presents the case of the Turkish Mediterranean coast, but at the same time, the proposed method is applicable to any coastal region. The main contribution of this study is the novel approach of focusing on the transversal direction instead of the classical one which considers coastal landscapes in the longitudinal direction along the coastline. It brings an alternative conceptual approach to the analysis of landscape in the coastal zone by shifting from the 'fixed BZ' to the concept of 'Bands'. The band value refers to the spatial connectivity order a landscape patch has with the coastline. A further achievement of this study is the utilization of GIS technology in the assessment of landscape connectivity based on CLC data.

The proposed method leads to the following findings: (i) a novel classification procedure for CLC data in the coastal zone based on their band value, (ii) discovering of a set transversally connected natural landscape mosaics (TCNLM), (iii) identification of a set of endangered natural landscape patches to be conserved, and (iv) defining a set of potential artificial landscape patches in the frontline of the coast to be restored. This study presents a method that can contribute to and can be integrated with holistic management initiative for coastal areas such as ICZM and Sustainable Coastal Tourism (SCT). Both initiatives highlight their objectives as the importance of considering the coastal zone transversally wider in space, and considering the landscapes further inland.

At this stage, the study is successfully tested in the Turkish Mediterranean coastal zone, the findings of which already are material that can be of use by relevant Turkish ministries or local governmental bodies. For example, the Ministry of Energy and Natural Resources, Ministry of Environment and Urban Planning, and Ministry of Agriculture and Forest are among the central governmental bodies that can consider the identified TCNLMs along the Turkish Mediterranean coast during their decision making on development and management plans in the region. Similarly, the local governments and metropolitan municipalities can develop a further detailed analysis about the identified TCNLMs that fall within the territory they are responsible for. Furthermore, the local governments that are sharing cross-border TCNLMs can develop joint management initiatives for these natural assets.

The methodical framework and the procedural workflow of the previous study are developed into a model via ModelBuilder extension in ArcGIS. The detailed stages and steps of the workflow are reported in a further article entitled “A GIS-based method for revealing the transversal continuum of natural landscapes in the coastal zone” being published in MethodsX journal. The proposed atomized model is applicable to any coastal zone having two raw materials: (i) the coastline shapefile, and (ii) CLC data. Even though it depends on the size of the study area (size of CLC data file) and the performance of the machine, the procedure is useful for rapid analysis of the transversal landscape structure in the coastal zone. Besides the direct contribution to ICZM and SCT agendas, this article presents a concise and straightforward method of sharing the development phases of a model via ModelBuilder in ArcGIS.

The remaining article (Chapter 4) makes a case of CLC data utilization in the processes of disaster risk management and fire safety engineering. The study entitled “A GIS-based Method for Indexing the Broad-leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity” puts forward a novel method of risk assessment for forest fire events based on a multi-criteria approach (social, physical, and environmental). Each subunit of forest surface is assigned relative values of risk for each criterion. The method suggests a differentiation between the ignition and spread stages of a wildfire by proposing a distinctive calculation procedure for ignition probability and spread capacity of the forest surfaces. Even though in this study the methodical purpose of CLC data utilization is less central compared with the previous research articles, it is of great assistance in spatially identifying the forested surfaces to be studied further.

As a result, certain hotspots of wildfire risky areas are identified within the broad-leaved forest surface. The method of the study is validated by comparing the risk assessment results (based on 2006 data) with the burned areas from CLC data of 2012. The points located within the burned areas result to have the greatest risk values of wildfire ignition probability and wildfire spreading capacity. At this stage, the study is successfully tested for a forested patch in the northern Albania. Yet, the study has the potential to be adapted to other similar cases that are in lack of reliable detailed information about their territory. The results of the study can be used by several Albanian authorities such as the Ministry of Environment and Tourism, the

Department of Civil Emergencies Planning and Response, or the Regional directorate for Civil Emergencies, as well as the local authorities responsible for the study area. The method presented in this paper is useful in preparing rapid, unexpensive, and reliable risk assessment maps for forested surfaces at the landscape scale, in support of disaster risk management and fire safety planning by other parties and for other study areas.

7.2 Comparative Common Discussion

At the first look the articles presented in this thesis can be considered as separate and independent studies. However, tabulating their attributes in a comparative table can help in understanding both the differences and similarities among them. Table 7.1 presents detailed information on the following attributes per each paper: the title, keywords, objective & scope, methods & materials, results & findings, contribution, and bibliographic information about the publication.

According to Table 7.1, all articles include CLC data among the keywords. Similarly, referring to the methods & materials column in Table 7.1, CLC data is the common material utilized in all cases. As stated before, CLC data utilization is much more central and methodically related with the proposed methods in the articles presented in Chapter 2, Chapter 3, Chapter 5, and Chapter 6. Whereas, in Chapter 4 CLC data is crucial in providing reliable spatial information about the forest landscape surfaces which are further used within the objective and scope of the specific study. Yet, even though all articles can be grouped under the common objective of CLC data utilization, each of them has specific sub-goals as presented in the column of objectives & scope as explained before in detail.

Landscape fragmentation is another keyword being used in the majority of the papers presented in this thesis. Moreover, referring to the objective & scope column, landscape fragmentation or connectivity is a common goal for the majority of the studies. Yet, there are some minor but worth to be mentioned differences in dealing with the topic of landscape fragmentation in each paper. For example, in the article 1 (Chapter 2) landscape fragmentation is set as an assessment goal based on the disconnected forested landscape patches, while in the article 2 (Chapter 3)) it is meant for the functional fragmentation happening within natural landscape patches (cross-border) being split by administrative borders. Here, physical landscape fragmentation is set as a possible result of functionally divided natural landscapes under a cross-border condition. Furthermore, in the paper 4 (Chapter 5) and paper 5 (Chapter 6) landscape fragmentation is aimed to be measured based on the connectivity continuum.

Additionally, since three studies (article 1, article 2, and article 3) focus on several case problems located within the Albanian territory, they include Albania among the keywords. Even though Albania has a considerable Mediterranean coastline (362 km), it is insufficient in length to enable a study area in which the method developed in article 4 (Chapter 5) and article 5 (Chapter 6) could be tested. Consequently, article 4 and article 5 make a case of Turkish Mediterranean Coast (with a coastline length of 4181 km) different from the first three articles. ModelBuilder and GIS are among the keywords mostly cited here, at the same time ArcGIS is among the common methods used in all of the studies. Besides ArcGIS, ModelBuilder extension is utilized in article 3, article 4, and article 5, for modeling the analytical workflows into models applicable in similar study areas. Another common method followed in all studies, is the problem oriented research approach. At the same time, it has been the main inspiration to define relevant spatial issues, in the decision making and management processes of which CLC data could be successfully assist.

According to Table 7.1, the main differences between the articles presented in this thesis belong to the results & findings as well as the contributions. Even though all studies have initiated with the main intention of utilizing the same raw material, due to the differences among the case problems, they have led to distinctive results and implications. For instance, while the results of paper 4 and paper 5 are useful in scanning the transversally connected natural landscape mosaics (TCNLM) in the coastal zone contributing to ICZM and SCT agendas, article 3 succeeds to develop a wildfire risk assessment method for the forested landscape surfaces contributing to disaster risk management and fire safety engineering practices.

Table 7.1 : Comparative information about five articles included in the thesis.

No	Title	Keywords	Objectives & Scope	Methods&Materials	Results & Findings	Contributions	Publication
1	**Landscape Fragmentation Assessment Utilizing the Matrix Green toolbox and CORINE Land Cover data**	○ Landscape fragmentation ○ CORINE Land cover ○ Matrix Green toolbox ○ ArcGIS ○ Albania	○ Utilizing CORINE Land Cover as a data to measure Landscape Fragmentation (LF) ○ Visually and Numerically Assessing LF among broad-leaved forests ○ Comparing the fragmentation among 3 different years	○ Matrix Green ○ ArcGIS ○ Kernel Density map ○ Problem Oriented Research ○ CORINE Land Cover	○ Fragmentation of broad-leaved forest has increased from 2000 to 2012 ○ 0-0,5 km links areas are potential areas for landscape connectivity recovery in a territory ○ The most fragmented areas are identified	○ By assessing LF policy making practices such as transportation and regional planning (EEA, 2011)	Hysa, A., & Başkaya T., F. A. (2017). Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data. *JoDLA-Journal of Digital Landscape Architecture*, *2*(1), 54-62.
2	**Land Cover Data as Environmentally Sensitive Decision making Mediator in Territorial and Administrative Reform**	○ cross border landscapes ○ landscape fragmentation ○ environmental conservation ○ environmental boundary ○ CLC ○ Albania	○ Criticize/evaluate the territorial/administrative reform (TAR) based on ○ Develop a multi-criteria method of spatial division to assist territorial reform ○ Utilizing CLC data as mediator during local administrative boundary definition phase of TAR	○ Multi-criteria analysis ○ ArcGIS ○ Problem Oriented Research ○ CORINE Land Cover	○ A TAR process not considering land cover evidences results in landscape fragmentation ○ CLC data figures out to be a successful indicator during local administrative border definition phase of TAR ○	○ Assisting decision making processes during territorial/administrative reforms and sustainable management processes for natural landscapes ○ A novel model for cross-boundary natural landscapes management in local scale.	Hysa, A., and Başkaya T., F. A. (2018). Land Cover Data as Environmentally Sensitive Decision-making Mediator in Terrıtorıal and Administrative Reform. *Cogent Environmental Science*, *4*(1), 1-17.
3	**A GIS Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity**	○ CORINE Land Cover ○ wildfire ignition ○ wildfire spread ○ GIS ○ disaster risk management	○ Developing a multi-criteria fire risk assessment method for broad-leaved forested surfaces based on CLC data. ○ Differentiating between the risk of ignition and spreading phase of a forest wildfire.	○ Analytical Hierarchy Process (AHP) ○ Multi-criteria inventory ○ ArcGIS ○ Meteonorm ○ Problem Oriented Research ○ CORINE Land Cover	○ The results show a good match between the modelled results and the already occurring wildfire cases. ○ Social factors are more affective in fire ignition probability	○ Developing a fire occurrence risk model by indexing forested surfaces by their Wildfire Ignition Probability Index (WIPI) values ○ Developing a fire spread risk model by indexing forested surfaces by their Wildfire Spread Capacity Index (WSCI)	Hysa, A., and Başkaya T., F. A. (2018). A GIS Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity. *Modelling Earth Systems and Environment*, *x*(x), xx-xx. (published in October the 1th, 2018)

Table 7.1 (continued) : Comparative information about five articles included in the thesis.

No	Title of the Article	Keywords	Objectives & Scope	Methods & Materials	Results & Findings	Contributions	Publication
4	**Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean Coast**	○ coast-continent gradient ○ landscape continuum ○ Mediterranean coast ○ CORINE Land Cover ○ Model Builder	○ Utilizing CLC data in Landscape continuum assessment in the coastal zone ○ Assessing the transversal natural landscape continuum in coastal zones. ○ Identifying the endangered natural landscape patches to be conserved ○ Identifying the potential natural landscape patches to be recovered ○ Developing a workflow applicable to similar cases of coastal zone	○ Transversal Continuity Depth (TCD) ○ Problem Oriented Research ○ CORINE Land Cover ○ ArcGIS	○ A novel method to analyze the transversal structure of natural landscapes in coastal zones. ○ Transversally connected natural landscape mosaics (TCNLM) along the Turkish Mediterranean coast are identified. ○ Within TCNLM's it is identified a 'red list' of endangered natural landscape patches to be conserved. ○ Within potential TCNLM's it is highlighted a set of potential artificial landscape patches to be restored.	○ A new classification procedure for land cover data based on relation to the coast. ○ Assisting Conservation Agendas and Decision making processes in Coastal areas such as ICZM and SCT ○ Providing useful thematic maps for Turkish governmental institutions dealing with the conservation and management of natural lands in the coastal zone.	Hysa, A., & Türer Başkaya, F. A. (2018). Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean Coast. *Ocean & Coastal Management, 158*, 103-115.
5	**A GIS-Based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone**	○ ModelBuilder ○ ArcGIS ○ CORINE Land Cover ○ ICZM ○ Sustainable Coastal Tourism	○ Transferring the workflow presented in the article 4 into a generative model applicable to any case of coastal zone	○ Model Builder ○ CORINE Land Cover ○ ArcGIS	○ A toolbox is generated via ModelBuilder in ArcGIS being applicable to any continental coast at coarse scale, using similar datasets.	○ A new way of CLC data utilization beyond its basic monitoring objective, useful for a variety of decision making and management processes such as; ICZM, Sustainable Coastal Tourism (SCT), Environmental protection, etc.	Hysa, A., & Türer Başkaya, F. A. (2018). A GIS-based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone. *MethodsX, 5*, 514-523.

Similarly, while paper 1 presents a rapid method to assess the time-based dynamics of landscape fragmentation among the disconnected forested landscape patches, article 2 results successfully in developing a novel method for defining local administrative borders by considering environmental attributes of the territory facing a territorial and administrative reform. Table 7.1 presents further detailed information about each article included in this thesis.

The articles included in this thesis can be further compared based on their cross relevancy with temporal and spatial scales. Figure 7.1 represents a hypothetical chart of this relation. For example, the wildfire ignition probability topic (WIPI, article 3) compared with other case articles belongs to the small temporal and spatial scale. In other words, it refers to an event (fire ignition) which can happen at a very small area and within a very short period of time. On the contrary, the spatial scale relevancy of the last article (TCNLM, article 4-5) belongs to the large spatial scale covering a large land surface and spread into a long period of time. Similarly, relative conclusions about their relevancy toward the spatial and temporal scales can be drawn for other articles. The hypothetical chart in Figure 7.1 presents all cases included in this thesis.

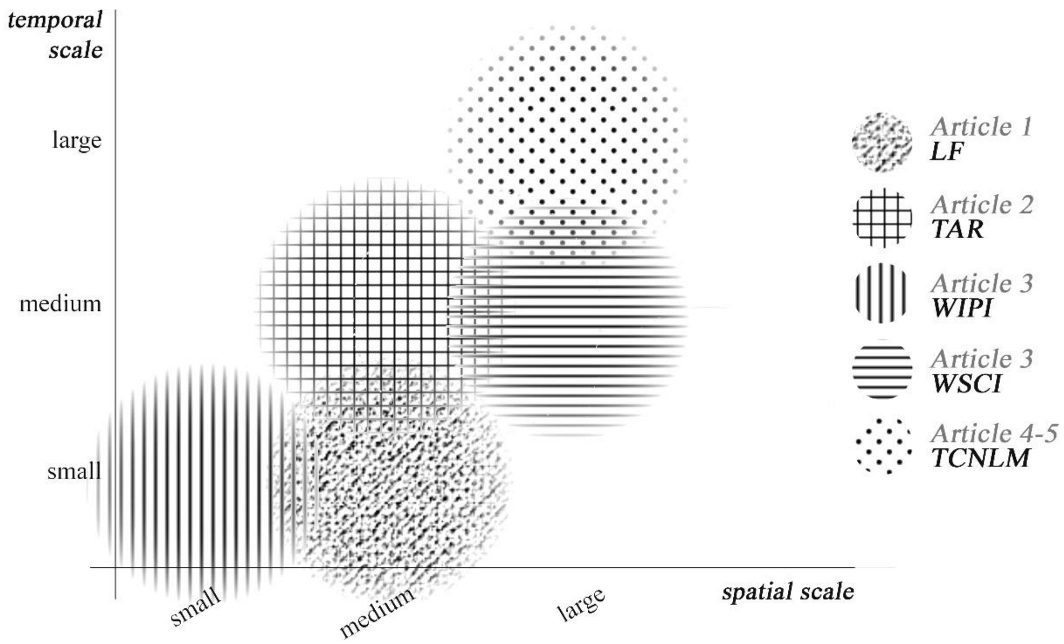


Figure 7.1 : Comparative chart between case problems based on their relevancies to temporal and spatial scales.

7.3 Final Conclusions, Limitations, and Recommendations

Even though this thesis presents a collection of distinctive research case studies having their specific results and conclusions, a set of common conclusions can be listed. Moreover, there are certain common limitations of the research process worth to be mentioned. Finally, a set of recommendations can be pushed forward, which targets further improvement and future steps of the methods presented in this thesis. The final conclusions, limitations and recommendations are included as follows;

Conclusions:

- CLC data provides relevant spatial information on land cover properties of a territory useful in a variety of spatial decision making and management processes.
- Problem Oriented Research (POR) is a successful research method in exploring the advantages that CLC data is providing beyond its territorial monitoring goals.
- POR resulted to be a motivating research methodology, keeping the research process and the interest of the researcher at the highest possible levels. By defining relevant problems to be solved, it boosts diversity and makes possible to avoid a monotonous process of a thesis research.
- Referring to the results of the research studies presented in this thesis, CLC data is appropriate for spatial analysis of landscape structure, especially at coarse spatial scale.
- CLC data results to be a useful raw material for landscape fragmentation assessment at landscape scale.
- CLC data availability in a periodical time basis (every six years) provides spatial information to track the evolution/dynamics of landscape fragmentation among forested surfaces in the territory.

- CLC data results to be a convenient environmental criteria for reducing natural landscapes fragmentation during the administrative border definition stage of the territorial and administrative reform (TAR).

- The example of Albanian TAR presented in Chapter 3 (article 2) has shown that a TAR process not considering the environmental criteria of the territory such as land cover, results in functionally fragmented landscapes.

- CLC data provides appropriate spatial information about landscape mosaics, to develop a reclassification method for landscape patches in the coastal zone based on their connectivity order with the coastline.

- As a consequence, the concept of "band" results much more successful than the fixed "buffer zone" for coastal zone landscape analysis, since it relies on the organic structure of landscape mosaic of the territory.

- The proposed reclassification method based on the adjacency condition of landscape patches with the coastline can assist landscape analysis processes within the scope and objectives of Integrated Coastal Zone Management and Sustainable Coastal Tourism.

- ArcGIS results to be an effective interface for exploring the utility of CLC data, beyond its fundamental monitoring purpose, in a variety of spatial decision making and management processes.

- Matrix Green toolbox (ArcGIS) is an effective tool in visually and statistically measure physical fragmentation among forested landscape patches as derived from CLC data.

- ModelBuilder is a very useful interface in modelling linear analytical workflows which can be available as automated models to be applied in other similar case studies. Thus, it enables a simple method to test the validity and reproducibility of the proposed method.

- The model developed within article 4 and 5 (Chapter 5 and 6), is already applicable to any coastal area which possesses a coastline and CLC data. Moreover, the method is adaptable to other cases of aqua-centered environments such as; watersheds, watercourses, lakes, etc. It is also adaptable to other land cover databases, different from CLC.

- The results of this study within article 4 and 5 (Chapter 5 and 6), can be of use by different Turkish institutions responsible of spatial management such as; the Ministry of Agriculture and Forest, Ministry of Environment and Urban Planning, Ministry of Culture and Tourism, Ministry of Energy and Natural Resources, etc.

- Similarly, the defined TCNLMs can indicate focal management areas of policy making for local/regional administrations they belong to.

- CLC data provides trustful spatial information to identify forested landscape surfaces to be further studied within fire risk assessment processes.

- Analytic Hierarchy Process (AHP) through pairwise comparison method, results useful in weighting diverse multiple criteria (social, environmental, and physical) according to their relative impact on wildfire ignition or spreading phenomena.

- Jenks natural break data clustering method, results a useful mean to classify relative set of values (very diverse in values) into absolute sub-classes. As it is shown in the Chapter 4 (article 3), 7 classes results successful for providing visually perceivable number of classes.

- WIPI and WSCI indexing methods developed within article 3 (Chapter 4) results successful in defining the landscape areas that are mostly under risk of wildfire events. The periodical CLC data (every 6 years) provide useful comparative spatial information in support of validation of the method.

Limitations:

- While CLC data results to deliver useful spatial information for landscape analysis at coarse spatial scale due to its accuracy level (85%), it remains insufficient in providing trustful evidences for landscape at finer spatial scales.

- MatricGreen toolbox at this stage is generating a redundancy of links between fragmented patches. It should be developed further to eliminate the extra links in order to end up with the most crucial ones and avoid redundant cases.

- Eventhough, article 3 (Chapter 4) presents a rapid and novel method for indexing forested areas according to their WIPI and WSCI multicrieteria values, due to its coarse spatial scape CLC data remains insufficient in providing appropriate spatial information for wildfire events. This is more evident considering especially, the sensitivity of wildfire ignition events towards the finer scales.

- More specifically, CLC data is not providing further detailed information on the tree type (fuel type) and their structure (density, height, age, moisture, surface vegetation, etc.) which are crucial attributes of the forest in wildfire risk assessment.

- The lack of available data of forest types in Albania[17], the electricity lines, and dump areas has been a limitation for the study in article 3 (Chapter 4).

- Another limitations has been the lack of field work analysis, which is accepted a crucial research methodology within landscape research practices. In this thesis is aimed a laboratory work on several cases aiming to define new research channels, each of which is suggested to be further supported by field work and qualitative evaluation methods.

- The moderate level performance of the machine (Table 1.4) utilized during the research process has been an obstacle slowing down the computation time of the spatial analysis.

- Publishing in four different publishing houses (Elsevier, Springer Nature, Taylor & Francis, and Wichmann) was difficult in becoming familiar with different submission requirements, standarts, formats, and procedures.

[17] At the moment there is no forest inventory for Albanian territory. National Forest Inventory project has been commissioned two times, but has not been finalized. Currently, the National Forest Inventory is under production within the Forest Resources Assessment program (FRA) by FAO.

- During the publishing process it has been faced the difficulty in remotely and anonymously communicating with the reviewers of each article.

Recommendations and future research:

- CLC data should be supported by other databases providing detailed information on the abovementioned attributes of the forest. For example High-Resolution Layers (HRLs) provide crucial information about forests by their tree cover density and forest type as briefly explained in section 1.2.3.

- The method presented in article 3 (Chapter 4) is tested in a standard forested landscape patch, but its impact could much higher if applied on territories having a specific profile of high importance such as, national parks, natural reserves, areas under protection, cross-border natural reserves, or wildland urban interface.

- Since Landscape fragmentation is a phenomenon present at finer spatial scales, the methods proposed within Chapter 2, Chapter 3, Chapter 5, and Chapter 6 can be further developed by utilizing other land cover data produced for finer scales (ex. Urban Atlas, HRLs, etc.). This objective can motivate cross-scale landscape fragmentation assessment methods.

- The method presented in Chapter 5 and Chapter 6, has the potential to be adapted to landscapes surrounding lakes, or along watercourses. The transversal continuum of natural landscapes in relation to fresh water resources is of great importance in supporting ecological and biodiversity studies.

- Furthermore, the method presented in Chapter 5 and Chapter 6, can be applied to a variety of Coastal zone study areas. This can motivate comparative cases between different coastal formations. For example, comparing the TCNLMs in European Atlantic and Mediterranean Coastal zones; case of Spain.

- Similarly, the method can be applied in order to map the evolution trends of TCNLMs within a specific coastal zone or a watershed. This can be done by revealing the transformation trends of TCNLMs of a specific coastal zone during a specific time span. The main material could be the CLC data of different years; 1990, 2000, 2006, 2012 (hopefully 2018). For example, the full northern Mediterranean coastal zone within 5 bands could be a proper case to be investigated.

- The procedure developed in ModelBuilder (article 5, Chapter 6) is easily adaptable to utilize other land cover data at various spatial scales. For example, Urban Atlas land cover data could be utilized in revealing the transversal structure of natural landscape mosaics in metropolitan coastal zones.

- Even though, CLC data is successfully tested as an environmentally friendly local administrative boundary defining tool (Chapter 3), the dynamics of land cover changes within a relatively short period of time is in conflict with the static character of administrative borders. Thus, the method presented in article 2 (Chapter 3) can be extended towards a futuristic concept such as “dynamic local administrative borders” or “landscape responsive local administrative borders”.

- In order to experience much faster and responsive analytical process, the presented methods should be applied utilizing a workstation computer machine possessing much better attributes than that presented in Table 1.4.

- ModelBuilder has resulted to be useful in atomizing the analytical workflows of the studies. Yet, it is recommended that the researcher using it be equipped with enough knowledge of programming language such as Python. In some cases, beyond the default tools of ArcGIS there mey be a need for modifications based on basic Python scripting.

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APPENDICES

Appendix A

Table A.1 : Participating states in the CLC projects.

Country	CLC 1990	Change 1990–2000	CLC 2000	Change 2000–2006	CLC 2006	Change 2006–2012	CLC 2012
Albania[c]	No	No	Yes	Yes	Yes	Yes	Yes
Austria[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Belgium[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bosnia/Hercegovina[c]	No	No	Yes	Yes	Yes	Yes	Yes
Bulgaria[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Croatia[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cyprus[a]	No	No	Yes	Yes	Yes	Yes	Yes
Czech Republic[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Denmark[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estonia[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Finland[a]	No	No	Yes	Yes	Yes	Yes	Yes
France[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Germany[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Greece[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hungary[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Iceland[b]	No	No	Yes	Yes	Yes	Yes	Yes
Ireland[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Italy[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kosovo[c]	No	No	Yes	Yes	Yes	Yes	Yes
Latvia[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Liechtenstein[b]	No	No	Yes	Yes	Yes	Yes	Yes
Lithuania[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Luxembourg[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macedonia FYR[c]	No	No	Yes	Yes	Yes	Yes	Yes
Malta[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Montenegro[c]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Netherlands[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Norway[b]	No	No	Yes	Yes	Yes	Yes	Yes
Poland[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Portugal[a,e]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Romania[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serbia[c]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slovakia[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slovenia[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spain[a,f]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sweden[a]	No	No	Yes	Yes	Yes	Yes	Yes
Switzerland[b]	No	No	Yes	Yes	Yes	Yes	Yes
Turkey[b]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
United Kingdom[a,d]	No	Yes	Yes	Yes	Yes	Yes	Yes
Total	**27**	**28**	**39**	**39**	**39**	**39**	**39**

[a] EU member country (member of EEA as well) = 28.
[b] EEA member country = 5 (All collected CLC characteristics concerning Turkey are contained in corresponding Tables 10.2, 11.1, 12.1, 13.1, 14.1, and 15.1. They were not included into the overall characteristics of the European landscape.)
[c] EEA cooperating country = 6.
[d] United Kingdom of Great Britain and Northern Ireland.
[e] Including Azores and Madeira.
[f] Including Canary Islands.

Table A.2 : CLC project nomenclature.

1 Artificial surfaces
11 Urban fabric
111 Continuous urban fabric
Most of the land is covered by structures and the transport network. Building, roads, and artificially surfaced areas cover more than 80% of the total surface. Nonlinear areas of vegetation and bare soil are exceptional.
112 Discontinuous urban fabric
Most of the land is covered by structures. Buildings, roads, and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces.
12 Industrial, commercial, and transport units
121 Industrial or commercial units
Artificially surfaced areas (with concrete, asphalt, tarmacadam, or stabilized, e.g., beaten earth) without vegetation occupy most of the area, which also contains buildings and/or vegetation.
122 Road and rail networks and associated land
Motorways and railways, including associated installations (stations, platforms, embankments, linear greenery narrower than 100 m). Minimum width for inclusion: 100 m.
123 Port areas
Infrastructure of port areas, including quays, dockyards, and marinas.
124 Airports
Airport installations: runways, buildings, and associated land.
13 Mine, dump, and constructions sites
131 Mineral extraction sites
Areas with open-pit extraction of construction material (sandpits, quarries) or other minerals (open-cast mines). Includes flooded gravel pits, except for river-bed extraction.
132 Dump sites
Public, industrial, or mine dump sites.
133 Construction sites
Spaces under construction development, soil or bedrock excavations, earthworks.
14 Artificial nonagricultural vegetated areas
141 Green urban areas
Areas with vegetation within urban fabric; includes parks and cemeteries with vegetation and mansions and their grounds.
142 Sport and leisure facilities
Camping grounds, sports grounds, leisure parks, golf courses, racecourses, etc. Includes formal parks not surrounded by urban areas.
2 Agricultural areas
21 Arable land
211 Nonirrigated arable land
Cereals, legumes, fodder crops, root crops, and fallow land. Includes flowers and fruit trees (nurseries cultivation) and vegetables, whether open field, under plastic or glass (include market gardening). Includes aromatic, medicinal, and culinary plants. Does not include permanent pastures.
212 Permanently irrigated arable land
Crops irrigated permanently or periodically, using a permanent infrastructure (irrigation channels, drainage network, and additional irrigation facilities). Most of these crops cannot be cultivated without an artificial water supply. Does not include sporadically irrigated land.
213 Rice fields
Land prepared for rice cultivation. Flat surfaces with irrigation channels. Surfaces periodically flooded.
22 Permanent crops
221 Vineyards
Areas planted with vines.
222 Fruit trees and berry plantations
Parcels planted with fruit trees or shrubs: single or mixed fruit species, fruit trees associated with permanently grassed surfaces. Includes chestnut and walnut groves and hop plantations.

(*Continued*)

Table A.2 (continued) : CLC project nomenclature.

223 Olive groves
Areas planted with olive trees, including mixed occurrence of olive trees and vines on the same parcel.
23 Pastures
231 Pastures
Dense grass cover, of floral composition, dominated by graminacea, not under a rotation system. Mainly for grazing, but the fodder may be harvested mechanically. Includes areas with hedges (bocage).
24 Heterogeneous agricultural areas
241 Annual crops associated with permanent crops
Nonpermanent crops (arable land) associated with permanent crops on the same parcel.
242 Complex cultivation patterns
Juxtaposition of small parcels of diverse annual crops, pasture, and/or permanent crops.
243 Land principally occupied by agriculture, with significant areas of natural vegetation
Areas principally occupied by agriculture, interspersed with significant natural areas.
244 Agroforestry areas
Annual crops or grazing land under the wooded cover of forestry species.
3 Forest and semi-natural areas
31 Forests
311 Broad-leaved forests
Vegetation formation composed principally of trees, including shrub and bush understoreys, where broad-leaved species predominate.
312 Coniferous forests
Vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate.
313 Mixed forests
Vegetation formation composed principally of trees, including shrub and bush understoreys, where neither broad-leaved nor coniferous species predominate.
32 Scrub and/or herbaceous vegetation associations
321 Natural grasslands
Low productivity grassland. Often situated in areas of rough, uneven ground. Frequently includes rocky areas, briars, and heathland.
322 Moors and heathland
Vegetation with low and closed cover, dominated by bushes, shrubs, and herbaceous plants (heather, briars, broom, gorse, laburnum, etc.).
323 Sclerophyllous vegetation
Bushy sclerophyllous vegetation includes maquies and garrigue. In the case of shrub vegetation areas composed of sclerophyllous species such as *Juniperus oxycedrus* and heathland species such as *Buxus* spp. or *Ostrya carpinifolia* with no visible dominance (each species occupy about 50% of the area), priority will be given to sclerophyllous vegetation and the whole area will be assigned class 323.
324 Transitional woodland/scrub
Bushy or herbaceous vegetation with scattered trees. Can represent either woodland degradation or forest regeneration/recolonization.
33 Open spaces with little or no vegetation
331 Beaches, dunes, sands
Beaches, dunes, and expanses of sand or pebbles in coastal or continental location, including beds of stream channels with torrential regime.
332 Bare rocks
Scree, cliffs, rock outcrops, including active erosion, rocks and reef flats situated above the high-water mark.
333 Sparsely vegetated areas
Includes steppes, tundra, and badlands. Scattered high-altitude vegetation.
334 Burnt areas
Areas affected by recent fires, still mainly black.

(*Continued*)

Table A.2 (continued) : CLC project nomenclature.

335 Glaciers and perpetual snow
Land covered by glaciers or permanent snowfields.
4 Wetlands
41 Inland wetlands
411 Inland marshes
Low-lying land usually flooded in winter, and more or less saturated by water all year round.
412 Peat bogs
Peatland consisting mainly of decomposed moss and vegetation matter. May or may not be exploited.
42 Maritime wetlands
421 Salt marshes
Vegetated low-laying areas, above the high-tide line, susceptible to flooding by seawater. Often in the process of filling in, gradually being colonized by halophilic plants.
422 Salines
Salt-pans, active or in process of abandonment. Sections of salt marsh exploited for the production of salt by evaporation. They are clearly distinguishable from the rest of the marsh by their parcelation and embankment systems.
423 Intertidal flats
Generally unvegetated expanses of mud, sand, or rock lying between high and low water marks. 0 m contour on maps.
5 Water bodies
51 Inland waters
511 Water courses
Natural or artificial water courses serving as water drainage channels. Includes canals. Minimum width for inclusion: 100 m.
512 Water bodies
Natural or artificial stretches of water.
52 Marine waters
521 Coastal lagoons
Stretches of salt or brackish water in coastal areas that are separated from the sea by a tongue of land or other similar topography. These water bodies can be connected to the sea at limited points, either permanently or for parts of the year only.
523 Estuaries
The mouth of a river within which the tide ebbs and flows.
523 Sea and ocean
Zone seaward of the lowest tide limit.

Source: Heymann, Y., Steenmans, Ch., Croissille, G., Bossard, M. et al. 1994. *CORINE land cover. Technical guide.* Luxembourg: Office for Official Publications European Communities; Bossard, M. Feranec, J., Otahel, J. 2000. *CORINE land cover. Technical guide.* Addendum 2000, Technical Report 40. Copenhagen: European Environment Agency. Available at http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-clc1990-250-m-version-06-1999/corine-land-cover-technical-guide-volume-2. With permission.

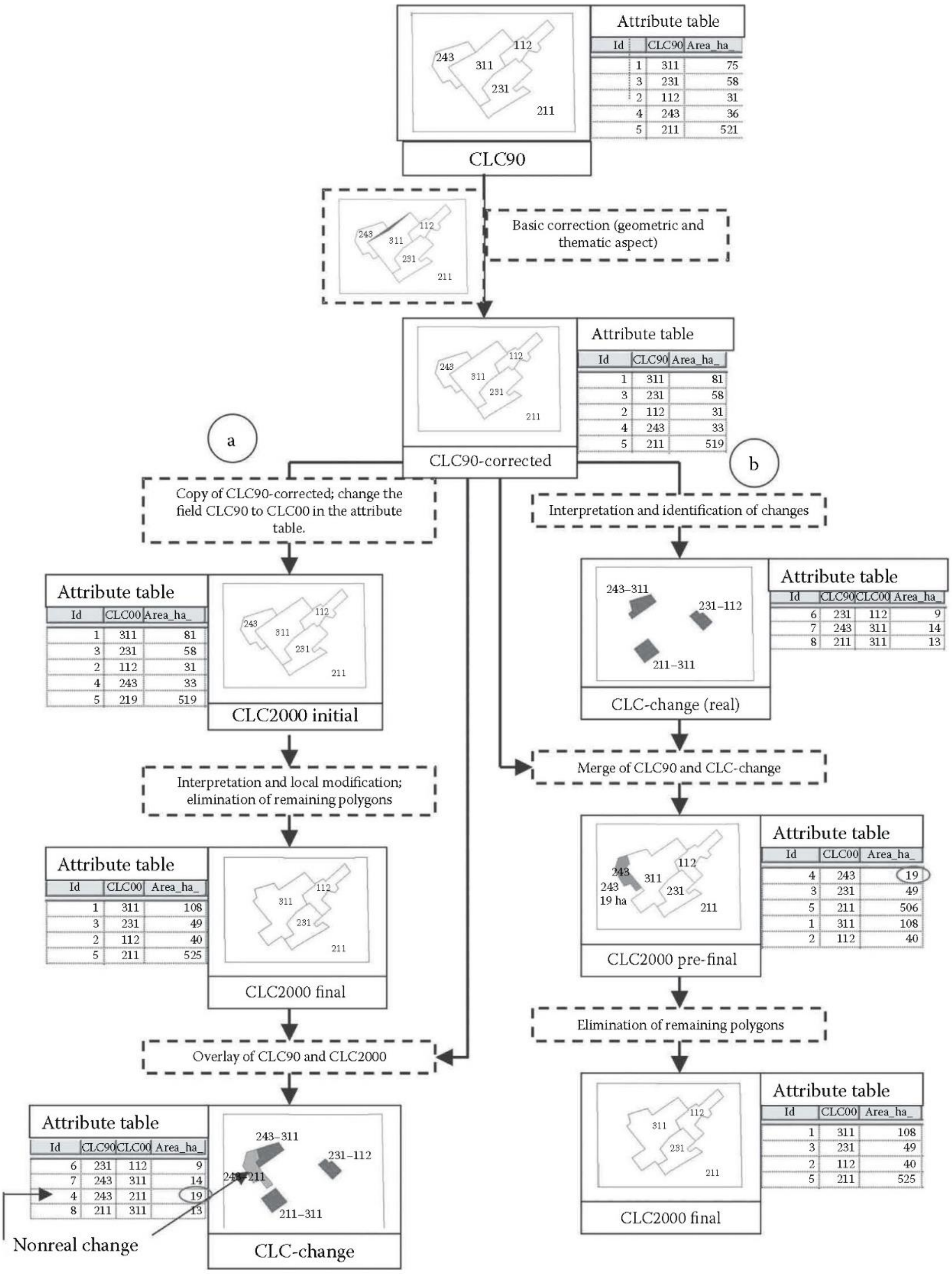


Figure A.1 : Generation of the CLC 2000 by the computer-assisted photointerpretation method: Two different approaches— (a), (b) (Feranec et al, 2007).

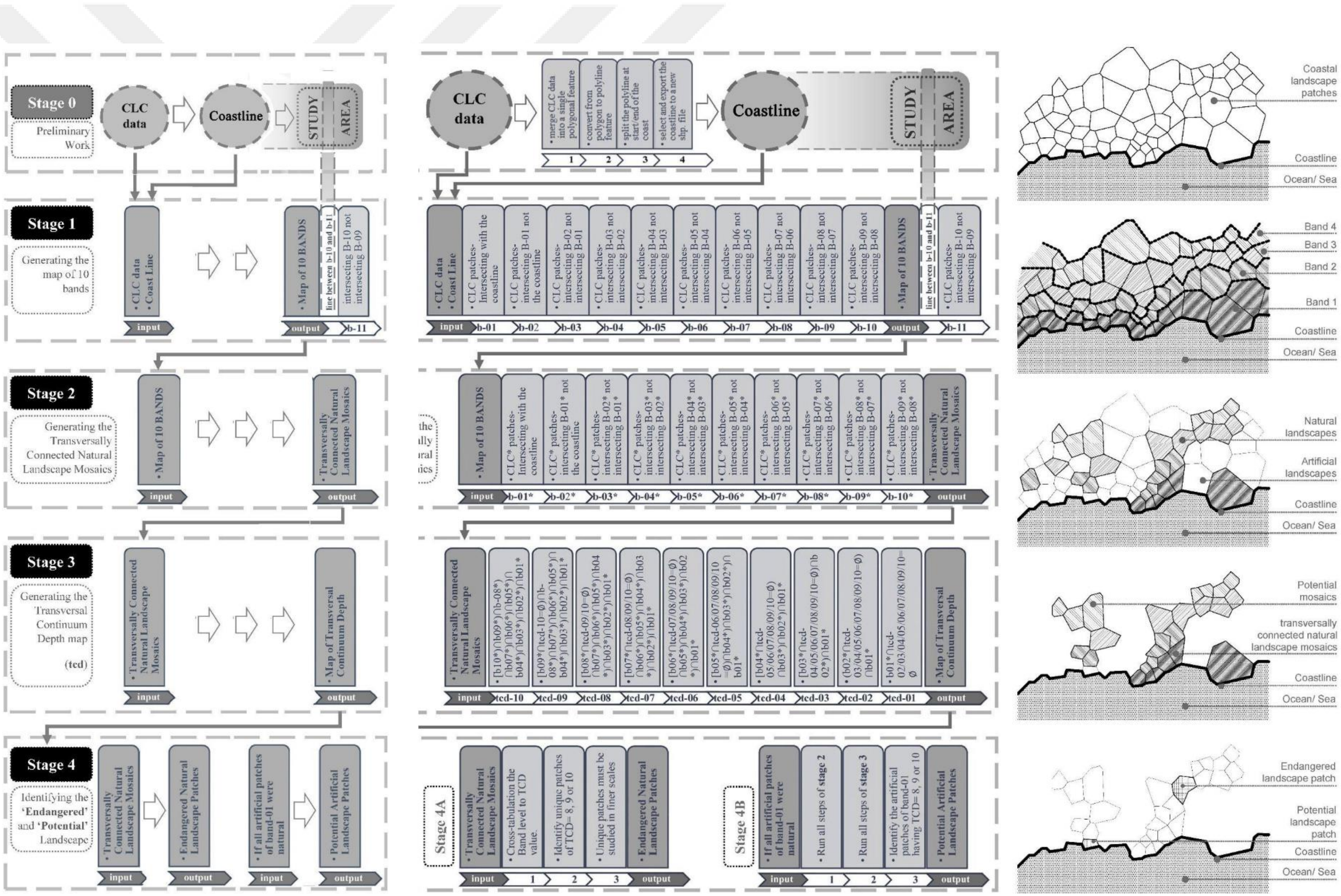


Figure A.2 : Full Workflow for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone.

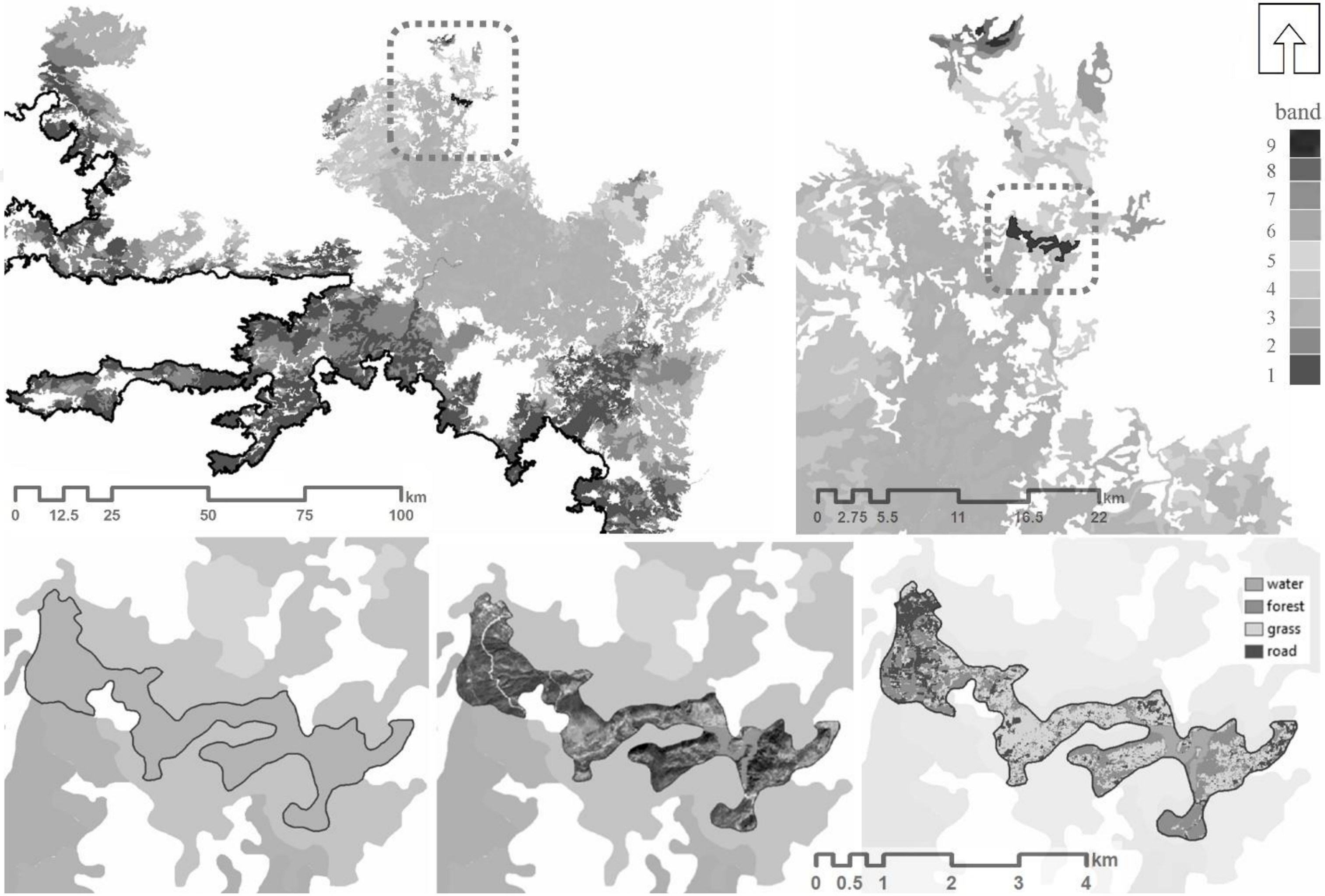
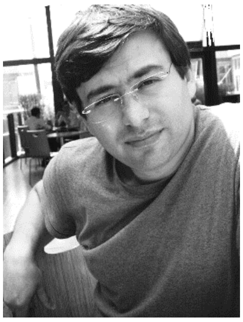


Figure A.3 : Identification of an engendered landscape patch and a trial for further analysis at finer scale.

Table A.3 : Detailed bibliographic information about the articles included in the thesis.

No	Title	Authors	Journal	Publisher	Indexing/ abstracting	Categ	Status	DOI	Bibliographic
1	**Landscape Fragmentation Assessment Utilizing the Matrix Green toolbox and CORINE Land Cover data**	Artan HYSA, Fatma Ayçim TÜRER BAŞKAYA	Journal of Digital Landscape Architecture	Wichmann / Germany			Published	10.14627/537629006	Hysa, A., & Başkaya T., F. A. (2017). Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data. *JoDLA-Journal of Digital Landscape Architecture*, *2*(1), 54-62.
2	**Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones-Case of the Turkish Mediterranean Coast**	Artan HYSA, Fatma Ayçim TÜRER BAŞKAYA	Ocean & Coastal Management	Elsevier/ Holland	•BIOSIS •International Civil Engineering Abstracts •Oceanic Abstracts •Scopus	A.1b (49.19)	Published	10.1016/j.ocecoaman.2018.03.011	Hysa, A., & Türer Başkaya, F. A. (2018). Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones-Case of the Turkish Mediterranean Coast. *Ocean & Coastal Management*, *158*, 103-115.
3	**Land Cover Data as Environmentally Sensitive Decision-making Mediator in Territorial and Administrative Reform**	Artan HYSA, Fatma Ayçim TÜRER BAŞKAYA	Cogent Environmental Science	Taylor & Francis / UK	•Directory of Open Access Journals (DOAJ)	A.2	Published	10.1080/23311843.2018.1505326	Hysa, A., and Başkaya T., F. A. (2018). Land Cover Data as Environmentally Sensitive Decision-making Mediator in Terrıtorıal and Administrative Reform. *Cogent Environmental Science*, *x*(x), xxx-xxx
4	**A GIS-Based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone**	Artan HYSA, Fatma Ayçim TÜRER BAŞKAYA	MethodsX	Elsevier/ Holland	•Directory of Open Access Journals (DOAJ) •Scopus •PubMed Central	A.2	Published	10.1016/j.mex.2018.05.012	Hysa, A., & Türer Başkaya, F. A. (2018). A GIS-based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone. *MethodsX*, *5*, 514-523.
5	**A GIS Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity**	Artan HYSA, Fatma Ayçim TÜRER BAŞKAYA	Modeling Earth Systems and Environment	Springer/ Holland	•Emerging Sources Citation Index, •GeoRef, •ProQuest Agricultural & Environmental Science Database,	A.2	Published	10.1007/s40808-018-0519-9	Hysa, A., & Türer Başkaya, F. A. (2018). A GIS based method for indexing the broad-leaved forest surfaces by their wildfire ignition probability and wildfire spreading capacity. *Modeling Earth Systems and Environment*, *x*(x), 1-14.



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PUBLICATIONS AND PRESENTATIONS ON THE THESIS:

- **Hysa, A.**, and Başkaya T., F. A. (2018). A GIS Based Method for Indexing the Broad-Leaved Forest Surfaces by their Wildfire Ignition Probability and Wildfire Spreading Capacity. *Modelling Earth Systems and Environment*, *x*(x), xxx-xxx. (published online in October the 11th, 2018)

- **Hysa, A.**, and Başkaya T., F. A. (2018). Land Cover Data as Environmentally Sensitive Decision-making Mediator in Terrıtorıal and Administrative Reform. *Cogent Environmental Science*, *4*(1), 1-17

- **Hysa, A.**, and Türer Başkaya, F. A. (2018). A GIS-based Method for Revealing the Transversal Continuum of Natural Landscapes in the Coastal Zone. *MethodsX*, *5*, 514-523.

- **Hysa, A.**, and Türer Başkaya, F. A. (2018). Revealing the Transversal Continuum of Natural Landscapes in Coastal Zones- Case of the Turkish Mediterranean, *Coast. Ocean & Coastal Management*, *158*, 103-115.

- **Hysa, A.**, and Başkaya T., F. A. (2017). Landscape Fragmentation Assessment Utilizing the Matrix Green Toolbox and CORINE Land Cover Data. JoDLA-*Journal of Digital Landscape Architecture*, *2*(1), 54-62.