KARADENIZ TECHNICAL UNIVERSITY
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FOREST ENGINEERING DEPARTMENT

INVESTIGATING THE SPATIOTEMPORAL CHANGES OF LAND USE / LAND COVER AND ECOSYSTEM SERVICES OVER THREE PERİODS IN YUVACIK

MASTER THESIS

Sauti RAYMOND

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THESIS STATEMENT

I declare that all of them the information included in this master thesis titled 'Exploring the spatiotemporal changes of forest and ecosystem services over three periods of Yuvacık planning unit' is as an outcome of my works under the supervision of Asst. Prof. Uzay KARAHALİL and with agreement of academic rules and ethical conduct. I also confirm that, as needed by these rules and conduct, I have completely recognized and refered to all the material and results that are not originating precisely from this work. 25/10/2019

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SUMMARY

INVESTIGATING THE SPATIOTEMPORAL CHANGES OF LAND USE / LAND COVER AND ECOSYSTEM SERVICES IN THREE PERIODS IN YUVACIK

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This study was carried out to map out to analyze the spatial and temporal change of forests ecosystem services in 1972, 2004 and 2015 of Yuvacık Planning Unit. GIS techniques and ArcGIS 10.3™ was used to determine the total area of stands to be analyzed for targeting spatiotemporal dynamics of field study. The spatial and temporal parameters of and forest ecosystem services such as land use/land cover change, crown closure, soil loss, water production, carbon storage, fire sensitivity index and biodiversity were analyzed over 43 years. The private and cadastral forests occurred as new types of land use while coppice forest, oak stands were disappeared and 99% of open lands were change into residential areas and the forest cover increased in Yuvacık PU and it has 12092.1 ha total area due to tree species maps. Degraded and mixed forests were progressively decreased and in additional Beech pure stands were remained strong among other pure stands. Forest in Yuvacık PU were in type of dense forest increased up to 42 % (5194.9 ha) from 1972 to 2015 and mature trees climbed delicately (2548 ha) due to development stage “cd” in the same period. The carbon storage in above and below ground of forest ecosystems was 1071.3 Gg in 1972, 1122.8 Gg in 2004 and 1090.6 Gg in 2015 with the carbon density rate 100 to 300 Mg/ha. Moreover, the soil loss declined from 1,1 billion ton y^{-1} to 108,549 ton y^{-1} and water produced decreased slightly from 1,8 billion to 272 million m^3 y^{-1} between 1972 and 2015. Afterward, Yuvacık forest management planning unit were classed in 2nd class of high wildfire vulnerability with respectively FSI of 6.13, 5.99 and 6.30. In addition, due to biodiversity index rate dedicate the well growth of Yuvacık forests.

Key Words: Spatiotemporal change, Ecosystem services, Fire sensitivity index, Carbon storage, Water production, Soil loss, Biodiversity

ÖZET

YUVACIK ORMANLARINDA ZAMANSAL, KONUMSAL VE EKOSİSTEM HİZMETLERİNDE MEYDAN GELEN DEĞİŞİMİN 3 FARKLI PERİYOT İÇİN ANALİZ EDİLMESİ

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Bu çalışma, 1972, 2004 in 2015 yıllarında Yuvacık planlama birimindeki ormanların zamansal ve konumsal değişimini ortaya koymak amacıyla yapılmıştır. Çalışma alanında belirlenen değişimleri izlemek ve meşcerelerin toplam alanını belirlemek için Coğrafi Bilgi Sistemleri (CBS) teknikleri ve ArcGIS 10.3^{TM} programı kullanılmıştır. Arazi kullanımı ve arazi örtüsü değişimi, gelişim çağı, toprak kaybı, su üretimi, karbon depolama, yangın duyarlılık indeksi, biyolojik çeşitlilik gibi orman dinamiklerinde 43 yıl boyunca meyda gelen değişimler zamansal ve konumsal olarak analiz edilmiştir. Toplam 12092.1 ha alana sahip olan Yuvacık planlama biriminde; arazi kullanımında özel ormanlar ve kadastro dışı alanlar oluşurken, baltalık ve saf Meşe alanları ortadan kalkmış ve açıklık alanların %99'u yerleşim alanına dönüşmüştür. Bozuk ve karışık ormanlar giderek azalmış ve buna karşın saf Kayın meşcerelerinde alansal olarak büyük değişimler olmamıştır. 3 kapalı ormanlarda 1972 yılından 2015 yılına kadar %42 oranında artış olmuştur. Karbon depolama miktarları 1972, 2004 ve 2015 yıllarında sırasıyla 1071.3 Gg, 1122.8 Gg ve 1090.6 Gg hesaplanırken, hektardaki karbon yoğunluğu 1972'den 2015'e kadar geçen sürede 100 Mg/ha'dan 300 Mg/ha'a çıkmıştır. Bununla birlikte, 1972 yılından 2015 yılına kadar, toprak kaybı 1 milyon ha y^{-1} ve su üretimi 1,6 milyar m^3 $ha^{-1}y^{-1}$ azalmıştır. Yuvacık planlama biriminde 1972, 2004 ve 2015 yıllarında sırasıyla 6.13, 5.99 ve 6.30 yangın duyarlılık indeksi (FSI) hesaplanmış ve planlama biriminin 2. derece yangın duyarlılığına sahip olduğu tespit edilmiştir. Ayrıca, biyolojik çeşitlilik endeksleri dikkate alındığında Yuvacık ormanlarının olumlu yönde seyir gösterdiği söylenebilir.

Anahtar Kelimeler: Zamansal ve konumsal değişim, Ekosistem hizmetleri, Yangın duyarlılık indeksi, Karbon depolama, Su üretimi,Toprak kaybı, Biyolojik çeşitlilik

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ABREVIATIONS

AHP	: Analytical Hierarchy Process
BEF	: Biomass Expansion Factor
CF	: Carbon Factor
CLM	: Community Land Model
ECE	: Economic Commission for Europe
ERDAS	: Earth Resources Data Analysis System
FAO	: Food and Agriculture Organization Subunits and Programs of UN
FFOs	: Family Forest Owners
FSI	: Fire Sensitivity Index
GDF	: General Directorate of Forestry
GEF	: Global Environment Facility
GIS	: Geographical Information System
LDN	: Land Degradation Neutrality
LULCC	: Land Use Land Cover Change
MTBS	: Monitoring Trends in Burn Severity
PU	: Planning Unit
RS	: Remote sensing
UN	: United Nations
UNCBD	: United Nation convention on Biological Diversity
UNFCCC	: United Nation Framework & Convention on Climate Change
TEV	: Total Economic Value
WD	: Wood Density

1. INTRODUCTION

Turkey is located in the intersection of the Asian and European continents, with 95% area being situated in Asia (Koç et al., 2015). It is among the forested countries found along the Asian and European continental boundary and is important from both timber production and biodiversity standpoints. Forest of Turkey are primarily state owned and forests cover 28.6% of Turkey's territory region and have noteworthy economic, environmental and cultural functions. About 10% of Turkey's populations live in forest villages or forest-neighboring villages where timberland assessors make an imperative commitment to work (FAO, 2015). The forests are rich with timber species, making Turkey nearly self–sufficient in timber. Turkey's forest ecosystems offer an incredible number material and non-material qualities like natural, financial and socio-cultural qualities to society. These qualities incorporate various merchandise and enhancements for example, water creation, soil assurance, carbon sequestration, diversion, aesthetics, wildlife, scavenge and different timber items. Moreover, additionally, forests produce numerous non-timber forest items as nuts, leaves, tar, berries, mushroom, oil and rattan. In this substance, the key purpose of feasible forest management is support and improvement of these ecological, social and financial advantages for present and future (Keleş and Başkent, 2007).

Turkish woodlands were arranged from the mid 1960s as far as possible of the 2000s according to the conventional forest planning approach primarily based on timber management (Zengin et al., 2013). By 1960s, forests were overseen for the most part with a solitary tree choice silviculture systems regardless of the biological characteristics of existing commercial trees. For example, uneven-aged management practice were applied to forests composed solely of light demanding trees for example pine forests. Hence, unregulated and peculiar woodland structures were made across the country. Understanding the impending results of unseemly management activities of the time, even-aged management rehearses were presented after 1963. Foresters endeavored just to meet the admissible cut levels and decided in management plans by using different forms of clear-cut management action. Managers accidentally dismissed the recharging of the harvested areas because of substantial obligations of management, short supply of seedlings in nurseries, not well specialized foresters and absence of a control system. Consequently, many clear-cut areas were left untreated, exposing them to harsh natural disturbances such as weed competition, soil erosion, and wind blow-down (ALTERFOR, 2017).

Besides, the planning procedure has gradually advanced after some time and observably changed throughout the most recent couple of decades in Turkey. From the main management plan, arranged in 1917, to the late 1990's, backwoods were overseen for basically item creation as boosting timber production as per classical planning approach. Albeit a few endeavors were knowledgeable about certain districts as pilot undertakings, for example, Mediterranean forests use venture (1980s), Turkish-German collaborative model (1990s) Forest Resource Information System (FRIS) (late 1990s) and Global Environment Facility Fund (GEF II) (2000s) to supplant the negative impacts of the traditional methodology, numerous utilization planning has turned into the Turkish forestry service plan over the most recent two decades (ALTERFOR, 2017).

Based on the research done in Eastern Black Sea timberlands in Turkey have been overseen with both even-aged and uneven-aged management approaches. The timberlands, in any case, are extremely debased and drained as a result of misunderstanding especially in applying uneven-aged management practices. Their findings clarify the management plans between two continuous periods, 1971-1990 and 1983-2004. The investigation appeared that significant changes happened in arranging parameters between two periods; the timberland landbase and passable cut levels diminished and developing stock expanded. They illustrated that a few components such as conflicting volume and increase tables, need of silviculture plans, need of location classification, destitute territorial socio-economic structure, conflicting forest management planning process and staff arrangement were together responsible for such sensational changes and recommended few suggestions for way better management of locales differing and delicate forest within the future (Köse and Başkent, 2001).

In the 1990s, most forestry in Turkey was focused on the harvesting of mature stands. However, Turkish forests have been on the move towards environement-based utilitarian forest management planning including non-timber forest merchandise and services. During 2000s, all overseen timberlands were relegated to monetary capacities. As indicated by the recent forestry statistics, the rate area devoted to economic, ecological and socio-cultural roles of Turkish forests are 50%, 42% and 8% respectively (MFW, 2016).

By virtue of the Turkey's geography that is harsh and soak, with a few particular biogeographic areas, bolster numerous endemic species and characteristic biological systems. There was practically 20.2 million ha of all out forested region in 1973 while in 2015 it was determined as 22.6 million ha, relating almost 50000 ha increment for every year (GDF, 2019).

Due to the changes in forest management planning approaches, the forest ecosystem structure and composition have changed. They are likewise changed with forest management exercises connected in forest ecosystems, land-use changes, human pressure, and other common occasion like fires, creepy crawly assault and environemental change. These adjustments in land use, timberland spread changes and forest biological system structure and creation have reported by different researchers such as (Bewket, 2002; Pavon, et al., 2003; Gautam, et al., 2003; Wakeel, et al., 2005; Upadhyay, et al., 2005; Cayuela, et al., 2006, Keleş and Başkent, 2007; Sivrikaya et al., 2007; Çakır et al., 2008; Kadıoğulları et al., 2008; Günlü et al., 2009; Simeonova et al., 2019). As result, there is a need to consider the alteration in forest ecosystem esteems with changes woodland management planning approaches notwithstanding the adjustments in land-use/forest cover and forest ecosystem structure and composition. Although there are conducted studies on the spatiotemporal changes of land use / land cover, there are limited studies to introducing the changes in the outputs of selected ecosystem services.

The research conducted in Anhui provinces in period of 2009-2014, has focused on physical quantinty and functions of forest ecosystem sevices to determine the diversity of sapatail and temporal change. Their outputs have revealed the amount values of woodland ecosystem services to be lessen than the former esteem (Tan et al., 2016). According to the spatiotemporal change analysis done in Sanjianguan between 1978 and 2012, they clarified the destruction of aesthetic quality yet the recreational environment has gotten to be more appropriate owing to climate alter. They dedicated that these changes may diminish ecotourism and increment mass tourism, which would assist increment weight on the environment (Zeng et al., 2018).

Yuvacık forest management plan was designed in 1972-1991 and arranged in 3 categories. The usage long stretches of 1994 in the management plan; these 3 arrangements were first blended. This management plan has been made by the directorate of forest and grouping of the unit's woodland depended on the age's classes and coppice task amid the management plan of 1994 till 2003 years. Based on plan of 1972, each classes have similar forest functions which divided into 2 management units. first management unit consists of beech species for maximum wood production and second is thicket forest. The non-economic worth from woodland encased social wellbeing, amusement, resting space, stylish, tourism, and instruction and route capacities (GDF, 1972). The last mentioned management plan is slightly the same for both planning units of GDF, (2004) and GDF, (2015a) by and large, the forests roles were woodland items generation, nature conservation, fight against erosion, adjustment of climate, community wellbeing, hydrologic, national defense and recreational capacities though Turkey. Notwithstanding, because of the management plan of 1994-2003, the area of forest was 10129.0 ha, degraded forest was 7841.0 ha and the all out forests area was 17790.0 ha. As per the management plan of 2004, the absolute area of Yuvacık was 17970.0 ha with 8379.0 ha of woodland, 1750.0 ha of coppice forest and 7841,0 ha of deforested backwoods. Regardless of the planning management of 2015 the total area was 12408.8 ha with 6627.4 ha of forests, 228.3 ha of coppice and 5553.1 ha of deforested area (GDF, 1972; GDF, 2004; GDF, 2015a). Moreover, Yuvacık PU were categorized through management units as mentioned in table bellow:

Table 1. Management units of Yuvacık PU over the three planning periods

	1972	(%)	2004	(%)	2015	(%)
Management units	Area(Ha)		Area(Ha)		Area(Ha)	
Natural park	-	-	1,026.5	9.6	458.5	6.9
Recreation	-	-	-	-	33.6	0.5
Soil conservation	-	-	1,173	11	707	10.7
Timber production	5,834.3	-	7093	66.3	4,280	64.6
Water production	-	-	1,399.5	13.1	1,148	17.3
Total	5,834.3	100	10,692	100	6,627.1	100

1.2. Objectives

Various scientific studies was done by focusing on the water production, carbon, biodiversity and timber production as the forest ecosystem and to predict the link between ecosystem services (Vacik, et al., 2015, Perhans and Gustafsson, 2015, Ezquerro et al., 2016). On account of the various expectations by the communities take away to the forest resources like providing outcomes and utilities such as carbon storage, water production, soil protection, hunting, amenities and recreational facilities for the society besides conventional wood and non-wood forest products. As the result, thoroughly the last decade forest management has become the fundamental component of national forest policy.

In spite of enormous various surveys have considered distinctive scales of forest ecosystem services; few have focused on spatiotemporal dynamic changes of forest ecosystem services. To provide more accurate comprehension, the main objectives of this study was to determine the spatiotemporal changes of ecosystem services through Yuvacık forest planning unit in 3 different period in terms of displaying the spatial temporal changes of land cover, crown closure, development stage and changes of the ecosystem outputs in terms of biodiversity, soil loss, water production, carbon storage and forest fire vulnerability as there were no any recent studies which have done about it.

1.2.1. Spatiotemporal Changes

1.2.1.1. Temporal Changes

More studies were made about spatiotemporal changes in forest ecosystems through Turkey and generally in the world. Based on the field study done in Artvin forest planning unit about evaluating the changes of the forest ecosystem so that to clarify vegetation dynamics, structure and environmental problems of forest landscapes, anthropogenic and natural impacts between 1972 and 2002. By applying clementsian theory, the obtained inheritance stages and land cover types recommended the study to protect and manage the biodiversity through forest management. To determine the spatiotemporal changes, they used the high resolution satellite images found from Ikonos and Remote Sensing (RS), aerial pictures and Geographic Information System (GIS). Afterwards, the obtained results, clarified that between 1972 and 2002 were reduction of forest area. Whereas 106 and 222 ha were severally reduce in forest area patches. This respectively decrease of forest patches occurred due to, industrial development, dam construction, fragmentation, urbanization, and uncontrolled forest activities such as clear cutting and insect outbreaks which negatively disturb and destroy the forest cover and ecosystem through field study area (Çakır et al., 2007).

According to Keleş et al. (2008), during the study done for spatiotemporal in Artvin forest, was obtained that 88.4% of the total area forest in 1972 decreased to 79.8% in 2002. This changement were divided into two consecutives period, first were occurred due to 198 ha of forest cover changed through agriculture and residential areas in (1972-1985) and 158 ha of degraded forests become residential and agriculture in second round (1985-2002). The results were showed that the rate population in Artvin multiply two times in 30 years. Due to this multiplication, the population were over exploited the Artvin's forest cover in terms of settlement, agriculture, infrastructures such as road, dam, hospitals, schools and insects outbreaks and over use of natural ecosystems.

The study that made in northeastern Turkey, especially Rize as study area, was showed that the spatiotemporal changes in forest ecosystems of Rize, the analysis were done for land use and forest cover patterns. The investigations were done by assessing the temporal changes of spatial structure of forest conditions by using the spatial forest cover maps of 1984 and 2007. The results obtained showed that were a high changement in terms of spatial and temporal land use and forest cover. Whereas the significant changes occurred between 1984 and 2007 and in this period 2.30% of the total forest cover areas were decreased. In another hand 12506 ha of productive forest were decreased and 14805 ha of degraded forests area was increased in the same period. Otherwise the analysis was made on the spatial and temporal changes of crown closure and developments changes. The results clarified that medium crown closure of forest cover area were increased while development stages were stayed to grow as mature same time regeneration increased. The research occurred in terms of crown closure and development stages, showed the forest area decreased but also increased in terms of quality (Günlü et al., 2009).

The field study done in coastal gulf region, southeast China to determine spatial temporal change of land use during 1988 and 2007, by using GIS and Remote Sensing (RS), they come out of the results which showed that residential, agriculture and aquaculture areas were increased and beach area, woodland and orchard were decreased through the same period. Furthermore, landscape pattern structure were transformed so complex through two decades ago while the pattern structure and fragmentation were strengthened in gulf region of China. Moreover, due to the results, spatial changes of rural landscape pattern and urban area were reviewed respectively through two patterns of landscape metrics (Huang et al., 2010).

Kadıoğulları and Karahalil (2013) determined that for better understand the spatiotemporal change of carbon storage in forest biomass through forest ecosystems especially Köprülü Canyon as protected forest areas since 1973 that play a key role in climate change mitigation and comprehend the forest dynamics and evaluate these issues in future park planning, they estimated the changes in forest biomass C storage between 1965 and 2008. By considering the two periods of forest inventory, they used Biomass Expansion Factors (BEFs) to estimate the forest biomass C pool. As the result found, showed that there were drastic changes in C stock in above and below ground forest ecosystem increased nearly by 46% from one period to the other due mainly to the increase of growing stock and quality of forest ecosystem structure.

Recent study done by Çil and Karahalil (2015) about spatiotemporal changes on development stage, tree species and crown closure with the indexes like average patch size and number of patches for the dominated tree species such as beech were conducted. The study declared that the increase and decrease of forest area, crown closure and development stages occurred due to the application of management measure through the study area. Furthermore, the field study was conducted to facilitate the determination of acceptable cutting, make decision about merging the fragmentation structures through afforestation, rehabilitation, to protect endangered species from improper forest functions.

Afterwards, the spatiotemporal changes research were conducted in terms of various parameters such as crown closure, development stages and tree species though Ovacık Planning Unit between 1971 and 2008 were recommended to conduct the comparison analysis between current and past intervention so that they can keep equilibrium among conservation and obtain the efficient future forest management. Moreover, in order to carry out a supervised classification for three diverse marked classes, were used ERDAS Imagine 2010 ™ software, Landsat satellite images and stand maps of 1971 and 2008 of forest management plans. Furthermore, patch analyst program were used to describe the spatial and temporal change of the forest fragments and distribution. Due to the results of analysis demonstrated 392.1 ha decreased through pure spruce stands while 607.6 ha of mixed stands were increased. Otherwise, 122.8 ha were increased in 1971 and 2207.7 ha through 2008 in terms “a” and “c” development stages. In another hand, 4455.2 ha of “d” development stages were decreased and 1698.8 ha of forest area occurred from even aged management technic were transformed into selection forest during the same period. Otherwise, 2424.9 ha of middle crown closure forests (40-70%) were decreased and 2276.1 ha of closed crown closure (> 70%) were increased between 1971 and 2008. In addition , based on the number of patches, mean patch size and area weighted with shape index , the patch analyst proved that the fragmentation were increased respectively through alike period (Kılıç and Karahalil, 2015).

Due to the study conducted in northwest China in terms of spatiotemporal LULC between 1995 and 2015 in oasis, it was very urge interesting field study because of the impacts of oasis on ecosystem services. The obtained results showed the prominent LULC change was the expansion of cropland and degradation of grassland. Afterwards, the analysis show 6.51% of cropland was increased while 30.98% of grassland was reduced. Similarly to the changement of landscape, the results occurred showed that the structure of forest area and cropland were increased as well as the tendencies fragmentation which found in other LULC kinds. For the contribution of the future management of the land use cover through oasis and sustainably of ecosystems, and for clarifying the changes of land use cover, the analysis of socioeconomic were done after recognizing through the oasis ecosystems the direction of land use cover was declining (Zubaida et al., 2018).

Futhermore, the recent study done in Bangladesh for spatiotemporal change of land cover use (LULC) between 1990 and 2017 in the heterogeneous Coastal Region for the reason alone of determining the extremely comprehension about the occurrence high population and environment from the far side of coastal region of Bangladesh. Based on their results, by using multi-temporal LULC maps described that the coastal areas of Bangladesh experienced a final rise rate in agricultural (5.44%), residential (4.91%) and river (4.52%) areas from 1990 to 2017. The classification of Bangladesh’s coastal land use cover change remains difficulty due to various barriers like extremely level of landscape assortment and deficient of remote sensing data (Abdullah et al., 2019).

Moreover, by glancing at reseach conducted in Gölcük planning unit about LULC over 43 years, the findings revealed positive advancements in forest cover and structure as regards of development stage and crown closure. It dedicated that due to these changes timber oriented approach altered to multiple use planning approach as well as the choice of transformation of coppice to high forests (Khan and Karahalil, 2019).

1.2.1.2. Spatial Changes

Spatial change analysis incorporates any of the formal procedures which consider substances utilizing their topological, geometric, or geographic properties. It is includes an assortment of strategies, numerous still in their early advancement, utilizing distinctive expository approaches and connected in areas as assorted as cosmology, with its studies of the placement of galaxies within the universe, to chip creation designing, with its utilize of place and route calculations to construct complex writing structures. In a more limited sense, spatial analysis is the technique connected to structures at the human scale, most strikingly within the examination of geographic data. Moreover the most target of spatial change analysis is to portray the structure and the pattern conveyance of spatial changes (URL-1, 2019).

A wide and assorted set of spatial measurements can be obtained. Whereas these metrics provide most of the recognized spatial patterns of urban growth, spatial metrics utilized in urban shrinkage researches are much scarcer and not about adequate to supply a comprehensive appraisal of its spatial patterns. Looking at Martin et al. (2003) research, investigates a system combining remote sensing (RS) and spatial metrics pointed at moving forward the investigation and modeling of urban increment and land use change.

Landscape metrics exist at the patch, class (patch type) and landscape level. At the class and landscape level, a few of the quantify landscape composition, whereas others evaluate landscape arrangement. Landscape composition and setup can influence ecological processes autonomously and interactively. Hence, it is particularly vital to get it for each metric what angle of landscape pattern is being measured. In expansion, numerous of the metrics are partially or totally excess; that's, they evaluate a comparable or distinguishable aspect of landscape pattern. In most cases, excess metrics will be exceptionally exceedingly or indeed impeccably related. For illustration, at the landscape level, patch density (PD) and mean patch size (MPS) will be flawlessly related since they present the same information (Turner and Garigal, 2001).

1.2.2. Forest Values

According to General Director of Forestry Report (GDF) 2019, Turkey has 22.6 million hectares (29% of the total area) forest area. However, as a result of misuse of forest resources over centuries, productive forests cover only about 57% of total forest area, and 94,70% of the forests are operated as grove, 5,30% are coppices, and the change in the forest area also affects the distribution of wealth. Between 1973-2018, the increment of Turkey's forests increased by 47 million m^3 (GDF, 2019).

Twelve (12) million ha (50% of forest land) is managed for wood production. Turkish forests also host a great diversity of flora with economic importance, including various medicinal, aromatic, industrial and ornamental plants; and provide the major habitats for most species of fauna. In some areas Turkish forests still include some of the last existing vestigial stands and pristine forest ecosystems of their type. The forests also play a vital role in watershed protection and the control of flooding and soil erosion, a major problem in Turkey. These functions are considered in management planning process and about 37% of the forest area has been planned for forest protection, nature conservation, hydrological, erosion control, esthetic, wildlife, game, recreation, national defense, climatic, public health, seed production, and cultural functions (GDF, 2019).

Considering the forest values in Turkey, the forests as well as natural resources provide various set of functions in order to produce the needs of the population. Always is complicated to clarify value of services and goods come from forest resources in terms of money. The economic value of forest study, simultaneously becoming faster interesting through Turkey as well as in other countries. These values are appearing as direct, indirect and existence of the natural resources as described as TEV opinion (Pak et al., 2010). As we have mentioned above, the foret values play a urge role through the entire country even though they still vague and complicated to determine. It is important for the society especially rural area where forest play a prominent role for their daily life in terms of wood and non wood products production and also forests regulate the global warming linked to climate change by absorbing the CO_2 emitted by the industries worldwide.

1.2.2.1. Timber Production

Forests and trees play a vital role within the economic, environmental and social landscape of the planet. Forestry is commonly a key economic driver in rural areas worldwide. This could be seen through the institution of recent plantations and therefore the resultant secondary process and worth addition industries arising from augmented timber resources. Moreover, timber provides exchange likewise as a substantial quantity of employment. For countries with few different natural resources and low producing capabilities, timber exports became essential to their development ways (URL-2, 2019).

In addition, admissible cut level could be a direct utilized to direct timber production in both plantation and natural forests depend on the volume, number of stems, or area cut over, either yearly or periodically (Robertson, 1971). Over the years, various define and algorithms have been proposed to help with the calculation of the allowable cut, yet until as of late the underlying precept has not been truly challenged. According to Evelyn (1664) classified the woods and forests into eighty segments, each year felling one of the divisions, so that no wood is felled in less than fourscore years. This counsel remains the basic premise for admissible cut, subject in this specific case to the caveat that recovery is satisfactory and that trees grow to maturity in 80 years (Jerome, 2014).

In addition to its forested area; add up to developing stock is 1,494 million m^3 (68.8 m^3 per hectare) standing tree volume and annual allowable cut has been decided as 17 million m^3 which has accounted for 40% of the yearly expansion (GFRA, 2015).

Baki et al., (2011) examined wood products industry of Turkey and recommended the process to develop its competitiveness position at global markets. The survey was conducted through 415 biggest wood industries by applying questionnaires system targeted by personally interrogation and through mail. Based on the results, little number of provinces of Turkey, the forest product manufactures was lexical bundled geographically. The interviewed people, 13% were applied outdated technology system and 63% were adopting new system of technology while 24% were applied advanced one. During 2001, the survey clarified that was economic crisis that affected prominently the wood products manufactures until 38% of workers and shuttered facilities was reduced. Depend on the unproductive of Turkish forest products manufactures are facing various barriers to upwards advancement. The research was provided the review and recommendations for development which are usable to industries and policy makers through Turkey and with similar manufactures of other countries.

1.2.2.2. Carbon Stock

The amount of carbon hold on in forests is vital for many reasons. as a result of carbonic acid gas is that the primary greenhouse gas emitted by human activities, changes in forest carbon can facilitate to mitigate global climate change or they will exacerbate the matter.

Tolunay (2011), the study explained that, for determining the Carbon stock through Turkish forest were used the national forest inventory as key point obtained in 2004 and present that due to the changement of climate, affect the carbon storage in the study areas forest. In order to obtain the spatiotemporal change of carbon, above ground, below ground biomass, dead wood, soil and litter were took into consideration. The results showed that, 2251.26 Tg C in 2004 was the total carbon obtained in the forest of Turkey. Whereas, 74.7% found in soil, 21.32% through tree biomass, and 3.9% for both dead wood and litter. While, the carbon rate were increased from 2.20 Tg C $year^{-1}$ in 1990 to 6.82 Tg C $year^{-1}$ in 2005. According to the results, through the forest of Turkey, 41.66 Mg ha^{-1} were obtained as carbon density in above biomass that is so few by comparing with the European Forests with 43.90 Mg ha^{-1} due to United Nations Economic Commission for Europe and the Food and Agriculture Organization of the United Nations (UN-ECE/FAO). In addition 312.31 Tg C removed from atmosphere by forests in Turkey emitted by anthropogenic in 2005. Afterward the study recommended adapting the regulation of forest management in terms of decreasing and prohibiting the illegal cutting of trees and rehabilitating in degraded forest area in order to increase the amount of carbon absorbed by the forest of Turkey.

1.2.2.3. Soil Conservation

Humanity incorporates a large advantage over all life on earth like the ability to grow food. Since the dawn of agriculture, food has become a lot of accessible to more folks. In giant half, this can be thanks to soil. Fertile soil results in higher harvests that facilitate meet our most simple desires. Those living in countries with healthy soil are then liberated to suppose, invent, produce and picture new prospects. once humans are properly nourished, they are doing wonderful things (URL-3, 2019).

The sum of soil loss in Turkey mostly carried by streams. In the year of 2018, it has been decreased from almost 500 million tons y^{-1} back within the 1970s to 154 million tons due to the afforestation practices, changes of irrigation strategies in agricultural zones, alternation of rangeland and erosion control studies. The goal is to decrease the number to 130 million tons within the following 5 years (URL-4, 2019).

Recent studies were done about the soil loss and conservation, according to Özsoy and Aksoy (2015), used remote sensing (RS) and GIS to assess and soil loss and clarify the susceptible areas onto soil erosion through watershed of Nilufer in Bursa province of Turkey between 1984 and 2011 years. The obtained results showed that 13.4% of Nilufer creek watershed area was at risk of soil erosion in 1984 and kept increasing at 15.3% in 2011. As previous studies explained, the soil erosion is the prominent phenomena that cause the soil loss in high amount with deforestation and uncontrolled grazing. That is why, this research was recommended to put attention on soil conservation and introduce the measures to fight against the soil erosion and land management to the households in study area. Not only soil erosion were assessed but also the annually sedimentation capacity of Nilufer creek watershed and found that 903 to 979 Mg $km^{-2}y^{-1}$ from 1984 to 2011.

Taking into account the research conducted by Karahalil (2009) in Köprülü Canyon national park, by using a strategic decision making model (Linear Program) was created over 50 years planning horizon and solved with LINDO ™. The analysis of soil loss has been assessed previously, by various researchers such as (Gül, 1998, Mısır, 2001; Karahalil, 2003; Yolasığmaz, 2004, Keleş and Karahalil, 2005; Karahalil, 2009).

One among the key goals of forest management is to conserve the soil. Based on the results obtianed from the model developed for determining the soil loss from 132 sample plots formed by using the linear regression analysis, the total mean soil loss was 0.865 ton/ha/year with ($p<0.001$) (Mısır et al., 2006).

Saygın et al., (2014) briefed the spatial distribution about the effects of erosion on watershed and ecosystem in order to establish the crucial tools for environmentalists, conservationists and engineers for the sustainability of environment and natural resources management. The results showed that the annually soil loss was 146,657.52 m^3 $year^{-1}$ and 50,450.19 m^3 $year^{-1}$ of sediment occur to the reservation in the study area. Afterwards, they recommended measures for soil protection and water catchment in order to prevent soil erosion in Saraykoy II irrigation dam located among Central Anatolia Steppe and the Black Sea Forests of Turkey.

1.2.2.4. Water Production

Water yield and water flow maintenance is one of the most important ecosystem service and goods to the population and plants all over the world. (Maes et al., 2016). Water is crucial for human security and one in every of the engines of property socio-economic development. It’s a necessary component for the obliteration of impoverishment and hunger. Water could be a precious resource that is bit by bit obtaining scarcer. Over half of the planet population is going to be living with water shortage at intervals fifty years owing to a worldwide water crisis, per a report issued by the global organization atmosphere program. In alternative words, it's extremely unlikely that there's aiming to be enough water for everyone unless the mandatory steps are taken at regional and international level. Population growth, industrial enterprise, urbanization and rising wealth within the twentieth century resulted in an exceedingly substantial increase in water consumption. Whereas the world’s population grew three fold, water use increased six fold throughout a similar amount. The demand on water resources can still increase throughout ensuing twenty-five years. The matter is more aggravated by the uneven water distribution on earth. Contrary to the overall perception, Turkey is neither a rustic made in fresh resources nor the richest country within the region during this respect (URL-5, 2019).

In Turkey, the average annual rainfall is 643 mm; the average rainfall per year corresponds to 501 billion cubic meters of water. 186 billion m^3 of this amount and various streams and seas and lakes in closed basins. In this case, Turkey’s annual gross water potential is 234 billion m^3. Turkey's 80 million ha area of approximately 28.05 million hectares, which constitutes one third of the arable land, and it also constitutes 25.85 million hectares of irrigable consists of land with 2% (1,574300 ha) surface area of water (GDF, 2014).

Kurt, (2015), investigated and assessed the spatial temporal changes in northwest coasts of Turkey, especially through Terkos Laguna Lake by using Geographical Information System (GIS) and Remote Sensing (RS) technics. To determine the changement of land cover happened in field study, land classification procedure were also applied. According to the results, showed that 23.78% come from 9.79 km^2, were decreased in Terkos Lake area from 1987 to 2014. While 85.62 km^2 of coastline increase to 116.45 km^2 equally to 57.74% in the same period. Afterwards, due to drought, vaporization, extravagant of resources and agriculture activities through the study area, this changement were obtained as speculative and efficient for the nourishment of the Lake. Moreover, the researcher recommended the plan of better management to prevent problems which occur though the study area to achieve 30 % of fresh water needed in İstanbul.

Furthermore, previously different researchers have conductected studies which incorporated with forest management such as (Keleş, 2003; Keleş and Karahalil, 2005; Karahalil, 2009; Değermenci, 2018).

1.2.2.5. Fire Vulnerability

Fire is commonly related to negative impacts on the surroundings. The result of smoke and dirt conjointly causes intense respiration discomfort and may worsen the health of humans with allergies and metabolism disorders. Though wildfires cause a great deal of destruction and loss of lives, like burn and injury vegetation communities, like forest that take many years to recover, kill or injure individual plants or animals, cause erosion and resultant deposit of creeks and wetlands and open up areas to the impacts of weed and wild animal invasion likewise as human access and mischief. They have a number of advantages too. The grown-up vegetation burnt down permits new ones to arise (URL-6, 2019).

The forest of Turkey is composed by the tree species which are extremely sensible to wild fire like Calabrian pine, black pine and maritime pine. By take a look at the various outbreak forest fires across Turkey, the statistic shows 6913 ha, 3117 ha and 3219 ha burned successively in 1972, 2014 and 2015 years. Furthermore, the total mean area burned from 1972 to 2015 were 533271.5 ha (GDF, 2015b).

Based on the research done about fire vulnerability forest ecosystem services in the western United States by Polly et al. (2018), were determined forest ecosystem fire vulnerability to mortality by the year 2049 due to dynamic changes through burned future and historical area by using the Community Land Model (CLM). Depend on the results, were predicted that 3% of fire vulnerability in Sierra Nevada and overrated by 3% through the Rocky Mountains. Moreover, through 1984 and 2012, the prediction of burned forest area by CLM was 28.6% while 20% was reported by MTBS as burned area in the same period due to survey data comparing with the results obtained by using CLM decreased at 8% (Whittier and Gray, 2016).

A study in Zarivar Lake forest area for analyzing the reasons which influencing the fire in study area, were obtained by using Remote Sensing (RS) data, GIS and Analytical Hierarchy Process (AHP). Otherwise, the temperature and human made factors was declared as the main reasons which impress the fire outbreak in Zarivar Lake forest area based on the results obtained from AHP analysis. Moreover, between 2009 and 2010 burned area was marked with the rate of 78.03% through very high, high and moderate fire vulnerability area. Afterwards, the map was created by using Arc Map in order to be used for forest management in dry season through study area (Rasooli et al., 2018).

1.2.2.6. Biodiversity

Biodiversity is a wide term that alludes to all life shapes found inside forested zones and biological functions they perform. As such, timberland biodiversity envelops not just trees, yet the huge number of plants, animals and micro-organisms which occupy woodland ranges and their related hereditary diversity. It can be also considered at diverse levels, counting the ecosystem, landscapes, species, populaces and genetics. Complex interaction can happen inside and among these levels. Through biological diverse timberlands, this complexity permits organisms to adjust to persistently changing natural conditions and to preserve environment capacities (URL-7, 2019).

Besides, biodiversity conservation infers to the preservation of of genes, species, habitats, ecosystems and ecological processes, to secure within the long term assets of environment, to provide food, dress, fuel, pharmaceutical and magnificence to mankind nowadays and tomorrow (DKM, 2016).

Eckehard et al. (2017), described the relationship between the forests and biodiversity, he explained forests are basic living spaces for biodiversity and they are moreover basic for the arrangement of a wide extends of biological services which are crucial to human well-being. He has provided the various prove that biodiversity contributes to timberland ecosystem working and the provision of biological system services such as biomass production, habitat provisioning services, pollination, and seed dispersal, resistance to wind storms, fire regulation and mitigation, pest regulation of native and invading insects, carbon sequestration, and cultural ecosystem services, in relation to forest type, structure and diversity. Moreover, he dedicated that planted timberlands offer plentiful opportunity for enhancing their composition and deferring qualities since replanting after harvesting may be a repeating process. Planting mixed woodlands ought to be given more thought as they are likely to supply a more extensive run of ecosystem services inside the forest and for adjoining land uses.

The changing requests of nowadays require an extended scope of timberland administration. Society is inquiring for feasible ranger service emphasizing biodiversity. Keeping up, moving forward conjointly coordination biodiversity into woodland administration plans have been a challenging assignment over the last decade. According to the research conducted about the effects of biodiversity concerns on economic profits of timber in forest management, explained the tradeoffs which occur between timber production and habitat for old growth dependent on species into forest ecosystem. Furthermore the findings showed the increment in amount of old growth forests by 5%, 10% and 15% successively. They also clarified that in case the timberlands are overseen for keeping up biodiversity, the net present value of the benefits of timber production is impressively reduced. In this case it would be conceivable to degree the opportunity fetched of biodiversity in terms of monetary returns (Karahalil and Keleş, 2005).

1.2.2.7. Forest and Community

According to (GDF, 2015a), inventory done by Institute of Statistics in Turkey in 2013 presented a population through forest and around villages of 143,181. The principle activities of the local communities which are living in the planning unit are agriculture and construction activities. Animals such cattle, goats and sheep graze through open lands. The forest utilization in planning unit includes firewood from deforested forest. Unplanned grazing activities in the planning unit has led to forest deterioration.

2. MATERIAL AND METHODS

2.1. Study Area

The Yuvacık forest planning unit is situated in Kocaeli, Turkey, according to the equator Yuvacık is 40045'30"- 400 33'43" with north latitudes and 29057'32"- 290 58'03" east longitudes due to Greenwich and WGS 84 UTM ZONE 36N and 6°coordinate zone (Figure 1).

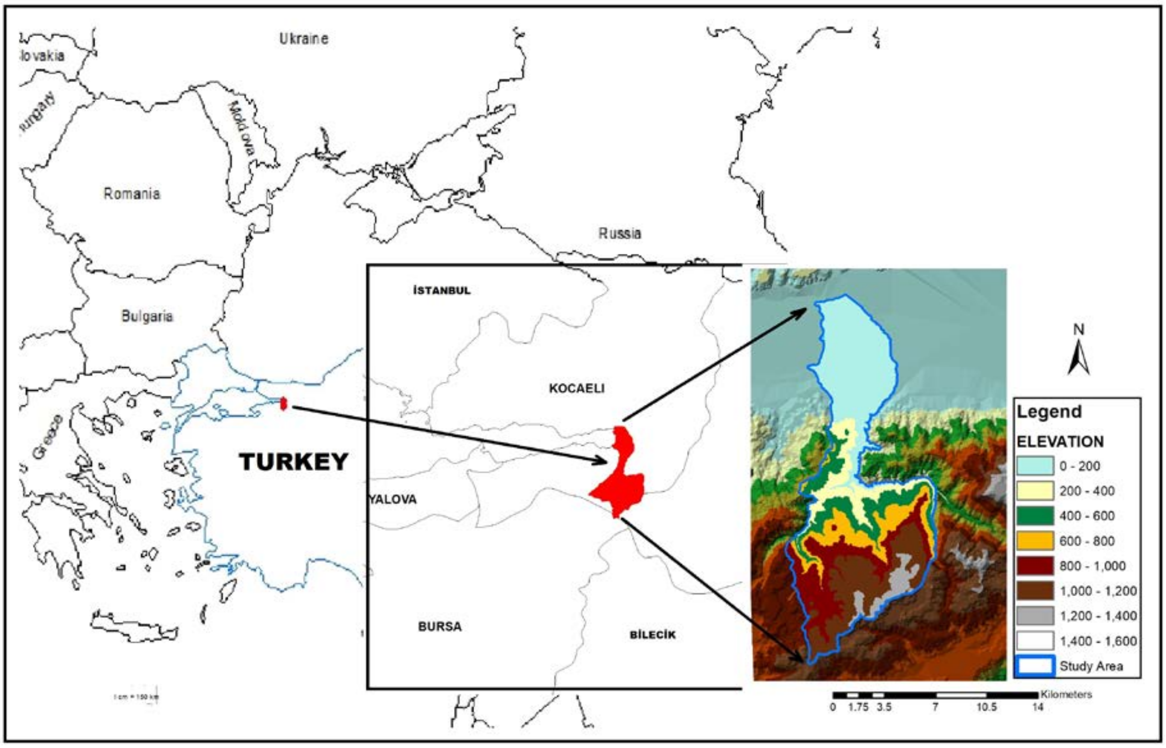

Figure 1. Spatial location of study area

The location of Yuvacık planning unit is in Gölcük and works under Gölcük Forest enterprise.

2.2. Methods

2.2.1. Temporal Changes

Spatiotemporal changes between 1972, 2004 and 2015 were studied. This was conducted through the analysis of tree species, development stages, crown closure, carbon stocks, water production and soil loss and creation of the LULCC maps in order to document the changes of spatiotemporal during the 43 years.

The tree species, crown closure and development stage parameters were used to describe and identify the stand types which were all obtained from aerial and satellite photographs and controlled and tallied by the ground sample plots during the field survey. The development stages divided through categories as shown in Table 2.

ArcGIS 10.3^{TM} software used for the analysis. Due to lack of digitalized map of 1972, topographic maps for the year was coordinated and digitalized using 1:25,000 scale. while digitalized maps of 2004 and 2015 were taken from GDF. Afterwards different classes were created such as tree species, development stage, and canopy depending on the criteria set in (GDF, 2014).

Since field study area boundary changed depending on the period, intersection was applied to combine similar boundaries in order to obtain the clearly results and the topographic error was corrected.

Pivot tables were made by using the intersection from ArcGIS from the classes created after digitalizing and analyzing the number of stand based on biometric, topographic and spatial metrics. Other classes were generated in order to assess the fire vulnerability of Yuvacık forest ecosystems. Maps were created using symbology as one of the ArcGIS tools. The changes in maps was generated from the classes was developed. The results were then obtained after using the management plans for 1972, 2004 and 2015 through database.

2.2.1.1. Land Use / Land Cover Classes

Land use/ land cover classes (Table 1) describe the boundaries of the classes included in the field study. The land use were presented as degraded forest, private forest, open lands, coppice forests, cadastral forest and mixed forests as shown in Table 1.

Table 2. Land use land cover classes

Land Use Classes	Explanation
Cadastral Forest (KDA)	It includes tree communities (generally bigger than 3.0 ha and not adjacent to state forest lands)
Coppice Forest	Coppice of productive (crown closure > 10%) poor, medium and good stands
Private Forest	It includes forested land owned by private owners
Degraded Forest	Forest which has been degraded (crown closure <10%)
Open Areas	Open land, mine, lake, water, etc
Residential Areas	Settlements, houses and commercial areas
Oak	Pure stands of *Quercus spp.* with crown closure > 10%
Beech	Pure stands of *Fagus orientalis* with crown closure > 10%
Hornbeam	Pure stands of *Carpinus orientalis* with crown closure > 10%

2.2.1.2. Development Stage Classes

The classes of development stage obtained according the diameters at breast height used in forest management through Turkey are as shown in Table 2.

Table 3. Development Stage categories

Development stage	**Description**	**dbh (cm)**
a	Juvenile stage	dbh < 7.9
b	Sapling-pole stage	8 ≤dbh<20
c	Small tree-large pole stage	20≤dbh<36
d	Medium tree stage	36≤dbh<52
e	Large tree stage	dbh≥52
k	Multistory	
Coppice Forest	Good, Poor, Medium, Medium-Good and Medium-Poor	
Degraded Forest	Forest which has been degraded, canopy covers less than 10%.	
Open Areas	Open lands, agriculture, residential area, mine, warehouse, lake, waters streams and graveyard etc.	
Private Forest	It includes forested land owned by private owners.	
Cadastral Forest	It includes tree communities (they are bigger than 3.0 ha and not adjacent to state forest lands).	

2.2.1.3. Crown Closure Categories

The different categories of crown closure of tree species used in field study area were described in Table 4.

Table 4. Crown Closure Categories

Crown closure category	Crown closure (%)
Degraded Forest	< 10%
Dispersed Forest	11-40%
Middle Covered Forest	41-70%
Dense Covered Forest	71-100%
Non Forest	Open Lands
Coppice Forest	Good and Medium-Poor
Cadastral Forest (KDA)	Cadastral Forest
Private Forest	Private Forest.
Residential areas	Residential areas

2.2.2. Spatial Changes

Patch Analyst program by Rempel et al., (2012) was applied in determining the spatial changes concerned with the specified periods. GIS was matched with the program and was able to function as an extension to ArcGIS10.1^{TM} software. To assess the spatial changes of Yuvacık PU for 43 years, edge density, number of patches, area weighted mean shape index, mean patch size, area heaviness and mean shape index were used. To better understand spatial changes of landscape structure with shape and size of the chosen classes of patches through landscape, the landscape metrics proxy tools we used. To determine landscape metrics, tree species cover maps for 1972, 2004 and 2015 were used to acquire the perimeters, areas and their forest classes.

2.2.3. Mapping Carbon Storage

The carbon storage maps were processed using the stand type procreated in 1972, 2004 and 2015 courtesy of stereo hermeneutics of aerial and satellite images of 1972, 2004 and 2015 as well as the field study data from the GDF forest management plan. The stand type maps and forest inventory data were used to display the carbon storage of Yuvacık forests.

BEFs and CF to the stands volume were applied and the technics of GIS utilized to construct and manage the spatial database of the field study to obtain the C value. The produced C maps from three different periods were classified and described based on C storage change drivers by using the stand maps. Coefficients applied for the determination of C storage sequestration were according to Tolunay, (2011) as shown in Table 5.

Table 5. BEF and WD coefficients used to calculate C storage sequestration (Tolunay 2011)

Tree species	**Beech**	**Chestnut**	**Oak**	**Mix of coniferous**	**Mix of deciduous**	**Mix coniferous and decidious**
WD(Mg m^3)	0.53	0.48	0.57	0.446	0.541	0.493
BEF	1.228	1.320	1.324	1.195	1.230	1.212

The estimation of C storage was determined and the values of biomass for every species were calculated one by one by using BEFs according to (IPCC, 2006; FAO, 2015). The C stocks though different parts of forested landscape such as above ground, below ground, litter, dead good and soil were estimated by using the species coefficients according to Tolunay, (2011).

To determine the above ground biomass carbon, the total volume for every stand type was multiplied by specified wood density (WD), BEF and CF (Table 6). While the below ground carbon were determined by multiplying above ground carbon with root ratio (0.5 for softwoods and 0.48 for hardwoods). Otherwise, the carbon storage for open lands, residential area and cadastral forest was supposed as “0”. The total carbon storage was obtained by changing the total weight biomass by making summation of soil, dead good, litter, below ground and above ground carbon.

Table 6. Coefficients applied for the determination of C storage sequestration

Tree species	AG biomass(Mg/ha)	Root to shoot	C factor	Litter (Mg/ha)	Soil (Mg/ha)	Dead wood
Coniferous	<50	0.4	0.51	7.46	76.56	1% of growing stock
	50-150	0.29				
	>150	0.2				
Deciduous	<75	0.46	0.48	3.75	84.82	
	75–150	0.23				
	>150	0.24				
Mix. con. and dec.	<75	0.43	0.495	5.605	80.69	
	75–150	0.26				
	>150	0.22				

2.2.4. Water Production and Soil Loss Analysis

According to Karahalil (2003), the determination of soil loss in planning unit, were calculated by using the formula as explained below with the help of all samples which selected from different stands of planning unit with help of the geographical information system technics and digitalized aerial images between 1972, 2004 and 2015.

In this research the soil loss presented as ton/ha/year and basal area in (m^2/ha) according to Karahalil (2003).

$$TSL = LnSL * Area\ (ha) \text{ and } LnSL = 2.553079 - 0.0650 * BA \quad (1)$$

TSL: Total Soil Loss (tonnes); BA: Basal Area (m^2h^{-1})

The water production expresed as m^3/ha/year and the diameter (cm) due to Karahalil (2009).

$$TWP = LnWP * Area\ (ha) \text{ and } LnWP = 8.7493 - 0.0151 * D \quad (2)$$

D: Diameter (cm); TWP: Total water production (m^3)

2.2.5. Wildfire Vulnerability in Yuvacık Forest

Fire vulnerability through the Yuvacık forest was determined by using created classes based on the number of stands which were defined by biometric, topographic and spatial metrics characters (ALTERFOR, 2017).

Table 7. The list of biometric, topographic, spatial criteria and fire sensitivity indices species

Species (Fuel Type)	**All Hardwood Trees(Oak,Beech)**			**Pine (Calabrian pine, Anatolian pine)**			**Pine (others)**		
Age	<40	80	>80	<40	60	>60	<40	80	>80
FSI	1	3	2	10	7	5	9	5	4
Basal Area	50	40	30	20	10	0			
FSI	4	5	6	7	4	0			
#trees	200	1000	500	250	50	20			
FSI	4	5	6	9	7	3			

Slope		**Aspect**		**Elevation**		**Canopy**		**Development stages**	
%	**FSI**		**FSI**	**M**	**FSI**	**%**	**FSI**	**DBH class**	**FSI**
<5	2	N	1	<200	10	10	2	a (0-19,9cm)	9
15	5	NE	2	500	7	40	5	b (20-35,9cm)	7
30	9	E	3	1000	5	70	8	c 36-51,99cm)	5
>30	10	SE	4	>1000	3	>70	10	d (>52cm)	2
		S	10					ab= a	9
		SW	8					bc=b	7
		W	6					cd=d	2
		NW	3					abd=b	7
								bd= c	5
								Coppice=b	7

Patch Config	**Near Circle**			**Regular**			**Irregular**			**Meandering**	
$\frac{(2\sqrt{\pi}\sqrt{Area})}{Perimeter}$	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	
FSI	10	9	8	7	6	5	4	3	2	1	

The classes were obtained by analyzing tree species, basal area, and number of trees, development stages, age, topography and shape of stands. The ranges of Fire Sensitivity Index (FSI) was classified at a scale of 0 and 10, where, 0 being that there is no danger of fire while 10 indicated that were highly sensitive of fire danger. The various fire vulnerability classes were defined as: 1 - very high vulnerability, 2- high vulnerability, 3 - average vulnerability, 4- low vulnerability and 5- very low or no vulnerability after combined weighted values parameters. Biometric, topographic, spatial parameters with fire sensitivity index and the relative weighting of each parameter were used to adjust the overall fire vulnerability index as given in Table 7 and 8.

However, the relative contribution of each parameter/index to the fire vulnerability is not the same in reality. Whereas there is no sound scientific research, as far as we know, the relative weighting of each parameter ought to be utilized to alter the overall fire vulnerability index. This is the prominet reason weightings for each parameter have been used to finalize the vulnerability value in this study.

Table 8. The weighting parameters

Soft and Hard wood stand Ages	Basal Area, Number of Trees and DBH	Canopy	Elevation, Slope and Aspect	Patch config.
0.2	0.14	0.18	0.1	0.1

2.2.6. Displaying Biodiversity in Yuvacık Forest

Biodiveristy of Yuvacık forest over 43 years were analyzed. This quantification became operational from catch data during 1972, 2004 to 2015. Processing and calculations was evaluated by using the software Excel, Patch Analysis corporated with Arc GIS.

Apart from the spatial changes in terms of biodiversity in Yuvacık PU, tree species with dbh more than, proporition (%) of first tree in stand, diameter (cm) and volume (m^3) parameters were taken into consideration as they are prominent biodiveristy indicators. These parameters reveal the aboundance, dominate and growth density of the tree species accross the forest areas. Morover, by using the mean values of these paramaters, helped to compute the Shannon diversity index (H) and Shannon’s evenness index of Yuvacık forest as it is presented in the next chapters of this study.

Furthermore, as mentioned above, "Patch Analyst" program were used and work as extension to ArcGIS 10.1^{TM} software to determine the indexes such as number of patches, mean patch size and area weighted average shape index which helped to evaluate the spatial changes of Yuvacık PU and its effects on biodiversity and ecosystem over 43 years. In addition, have selected to use Patch Analyst as is used for spatial pattern analysis, often in support of habitat modeling, biodiversity conservation and forest management. In short, after the analysis, findings helped to anticipate the biodiversity of Yuvacık PU between 1972, 2004 and 2015.

The Shannon Diversity Index calucation formula is explained below:

$$H = \sum_{i=1}^{s} - (Pi * \ln Pi)$$

where:

H = the Shannon diversity index; Pi = fraction of the entire population made up of species i

S = numbers of species encountered; ∑ = sum from species 1 to species S;

Note: The power to which the base e (e = 2.718281828.......) must be raised to obtain a number is called the natural logarithm (ln) of the number.

3. RESULTS AND DISCUSSION

3.1. The Changes in Land Use/ Land Cover

The created map on changes in tree species indicate that open lands was replaced by the residential area and beech to mixed forest. This principle change of open lands to residential area, led to decrease of forest stands such as coppice and Beech forest which are the consequence of reduction of ecosystem. Even though these changes occured the forest cover area uphold to rising due to the application of forest management plans and control of human activities in Yuvacık PU during 1972 and 2015 as shown in Table 9, Table 10 and Table 11.

The transition table for 1972 and 2004 showed open lands of 6256.2 ha in 1972 which decreased to 3501.1 ha in 2004. While the residential area was 1.6 ha in 1972 which increased to 1167.4 ha in 2004. Further, 71.9 ha of degraded, 51.9 ha of Beech and 18.2 ha of mixed forests converted to open lands in 2004 as shown in Table 9. The area of open lands turned to residential area in 2004 was 1163.2 ha.

Between 2004 and 2015, open lands in 2004 (3501.1 ha) increased to 3559.4 ha in 2015 which corresponds to a 1.6% increase in open lands. The increase was due to 446.6 ha of degraded forest in 2004 being converted to open lands in 2015. The residential area in 2004 (1167.4 ha) increased to 1315.2 ha in 2015 (Table 10). What's more , there were the new classes appeared in the study area such as KDA (cadastral forests) and private forests.

The overall changes between the years 1972 to 2015 were in the form of open lands reducing from 6256.2 ha in 1972 to 3559.4 ha in 2015 and increase in residential area from 1.6 ha in 1972 to 1315.2 ha in 2015. From the transition table, significant changes that happened through this period resulted in 1315.1ha or 99.9% of open lands changing to residential area between 1972 and 2015 (Table 11). The transition of tree species showed that degraded forests decreased and mixed forests increased progressively whereas beech pure stands remained stable between other pure stands such as Oak and Hornbeam (Figure 2).

The qualitative and quantitative results showed that there had been prominent spatiotemporal on land use / land cover classes. These changes through 43 years included emerging new land use classes such as private and cadastral forest, while others like coppice forest and Oak stands had disappeared. There was no private nor cadastral forests in this region. Khan (2017)'s results also supported this phenomenon, too. According to her study near Yuvacık PU, cadastral forests were emerged as new land cover class and residential areas increased in Gölcük over a period of 43 years.

It can be attributed to forest policy change in Turkey. According to a national decision was made about coppice forests to be replaced by high forest in 2006. Since then coppice forest areas have extremely dropped in Yuvacık and all around Turkey as well. These findings are in line with the Çakır et al. (2008)'s study who reported extreme changes land use and land cover classes in İstanbul due to urbanization and new forestry policy in Turkey.

Table 9. Yuvacık matrix of tree species covers changement between 1972 and 2004 PU (ha)

		2004 Area (ha)								
		Degra-ded	**Coppi-ce**	**Carpi-nus**	**Beech**	**Mix**	**Oak**	**Open Land**	**Resid. ential**	**Total**
1972 Area (ha)	**Degraded**	173.8			131.2	221.2	19.3	71.9	1.5	618.9
	Coppice	4.5			43.4	218.9		16.6		283.4
	Carpinus	16.0				121.9		0.8	1.0	139.6
	Beech	69.2		0.6	1485.1	1503.6		51.9	1.6	3112.0
	Quercus				7.7	76.6				84.3
	Mixed	58.5		0.3	567.8	951.3		18.2	0.0	1596.1
	Open land	926.1	78.4	6.8	114.3	588.7	38.7	3340.0	1163.2	6256.2
	Residential							1.6		1.6
	Total	1248	78.4	7.7	2349.5	3682.1	58.0	3501.1	1167.4	12092.1

Table 10. Yuvacık matrix of tree species covers changement between 2004 and 2015 PU (ha)

		2015 Area (ha)							
		Degra-ded	Beech	KDA	Mix	Open Land	Private forest	Reside-ntial	Total
2004 Area (ha)	Degraded	293.9	67.8	94.7	295.1	446.6	47.5	2.3	1248.0
	Coppice	0.4		14.0	51.0	13.0			78.4
	Carpinus		1.2		1.9	4.6			7.7
	Beech	18.1	1915.3	43.7	347.7	24.6		0.1	2349.5
	Mix	46.9	621.7	283.2	2615.8	114.6			3682.1
	Oak	1.0		15.5	28.6	12.9			58.0
	Open land	67.9	36.1	154.8	124.8	2583.1	16.9	517.6	3501.1
	Residential	0.4	0.2	8.5	2.7	360.0	0.5	795.1	1167.4
	Total	428.6	2642.3	614.3	3467.5	3559.4	64.9	1315.2	12092.1

Table 11. Yuvacık matrix of tree species covers changement between 1972 and 2015 PU

		2015 Area (ha)							
		Degra-ded	Beech	KDA	Mix	Open Land	Private forest	Reside-ntial	Total
1972 Area (ha)	Degraded	91.0	107.3	58.8	247.0	84.2	30.5	0.1	618.9
	Coppice	12.5	38.5	8.9	208.3	15.2			283.4
	Carpinus	1.6	15.0	2.4	119.1	1.4			139.6
	Beech	29.7	1649.0	69.3	1332.1	31.9			3112.0
	Mixed	21.7	709.0	9.7	848.0	7.7			1596.1
	Quercus sp		9.4		74.9				84.3
	Open Land	272.1	114.2	465.1	638.0	3417.3	34.4	1315.1	6256.2
	Residential					1.6			1.6
	Total	428.6	2642.3	614.3	3467.5	3559.4	64.9	1315.2	12092.1

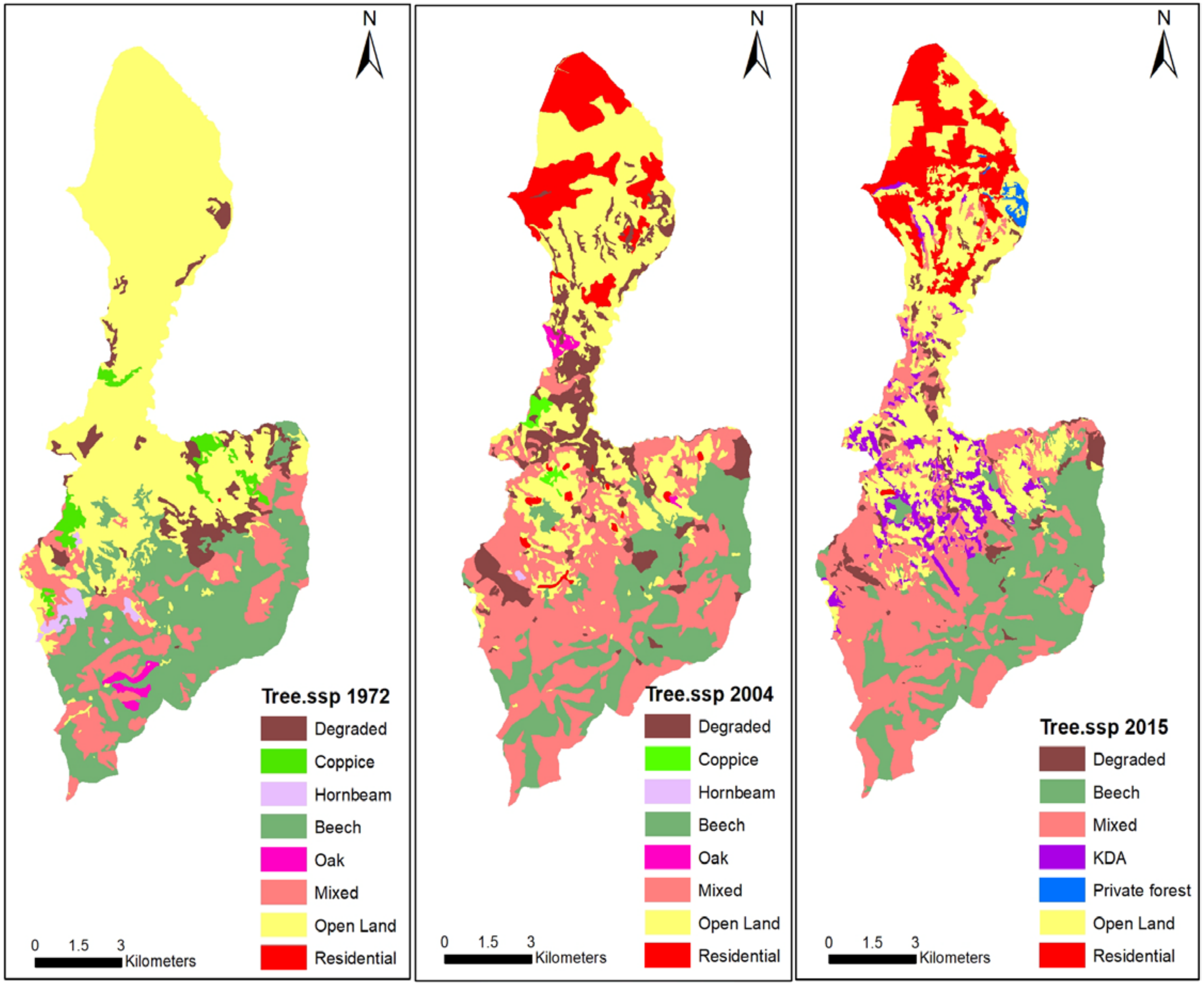

Figure 2. Land use and land cover maps of Yuvacık PU in 1972, 2004 and 2015

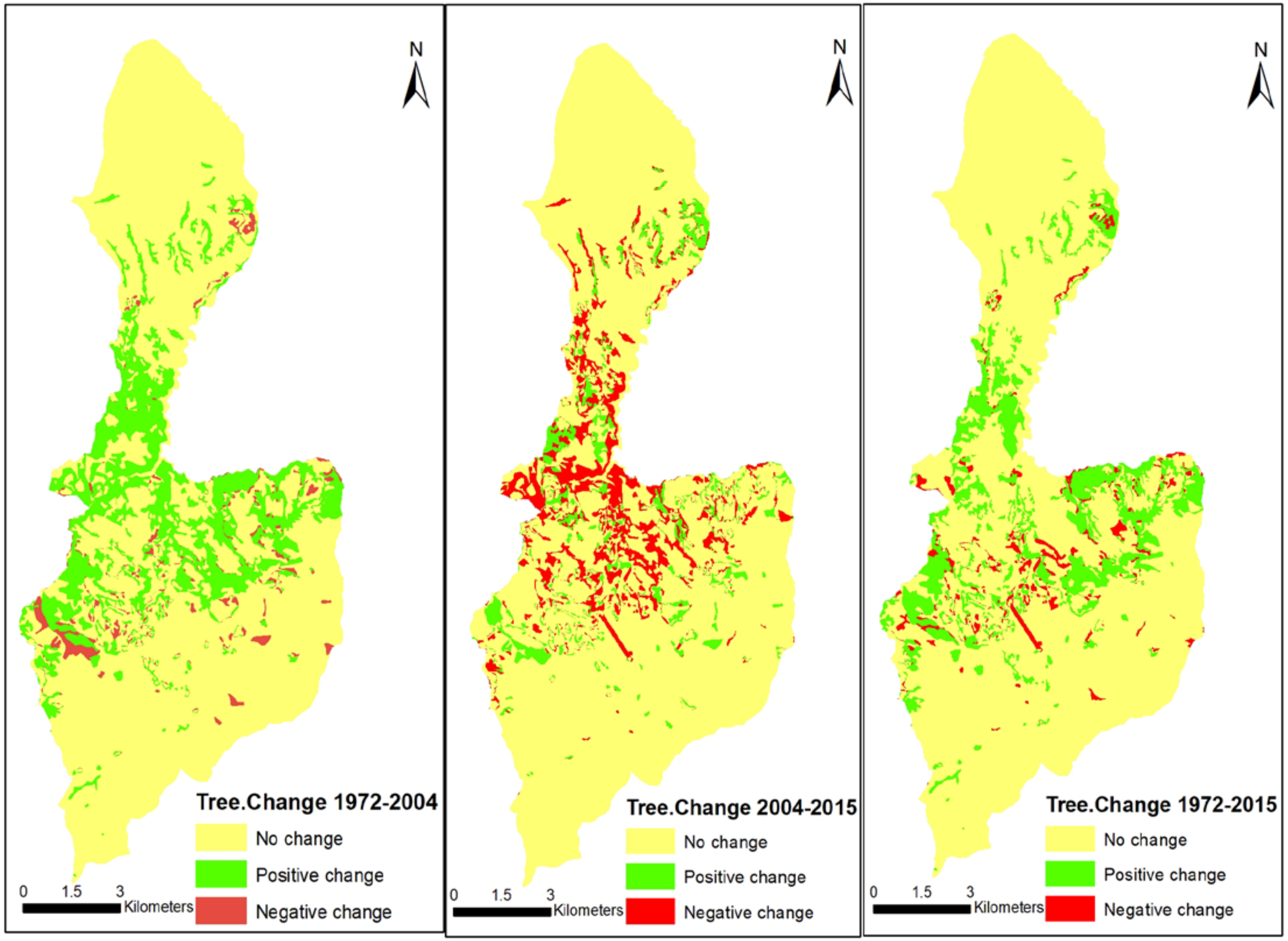

Figure 3. Forest cover change maps of Yuvacık PU between three periods

3.2. The Changes in Development Stages

Other than the land cover classes, the changes in stands' developmental stages were analyzed (Table 12, table 13 and table 14). The transition tables showed a highly trend from thinner development stages to thicker stages observing between 1972 - 2004 and 1972 - 2015 periods. Thus, 1471.2 ha of "bd" changed in "cd" stages and 183.1 ha of "bd" to "d" stages between 1972-2004. Moreover, 681.3 ha of "ab" changed to "bc" stages and 507.4 ha transformed to "cd" in 2004 (Table 12).

From 2004 to 2015, 167.8 ha of "ab" decreased to 26.6 ha in 2015 and 2638.2 ha of "bc" decreased to 1583.9 ha in 2015 due to transition to 534.9 ha of "bc" stages which changed in "c" stage and 367.4 ha of "cd" stages forwarded to "d" stages which boosted from 216.7 ha to 446.5 ha in 2015 (Table 13). This was due to tree dbh increment over time.

The pivot table obtained through 1972 and 2015 shows the shift of satands (a and ab) from thiner to higher development stages (bc, c and cd). Which is showing the trends of Yuvacık forests from juvenile stages to the large tree stage. ab stages were only 1354.0 ha in 1972. In 2015, they declined to 26.6 ha together. In another hand, 1099.4 ha of "bd" stage changed into "cd" and 300.8 ha into "d" in 2015. Same as 630.3 ha of "ab" stage altered into "cd" and 618.9 ha of degraded forests was declined until 428.6 ha as for its 219.4 has amended into "bc" stages in 2015 (Table 14).

Table 12. The areal changes in development stages changement between 1972 and 2004 (ha)

		2004 Area (ha)												
		a	**ab**	**b**	**bc**	**c**	**cd**	**d**	**d/a**	**Degreaded**	**Coppice**	**Open Land**	**Residential**	**Total**
1972 Area (ha)	**a**	0.4		38.0	158.7		12.8			6.8		16.4	1.0	234.1
	ab	0.9			681.3	101.3	507.4	2.9		37.7		21.7	0.8	1354.0
	abd				167.7	61.6	287.3	1.1		0.6		3.3	0.8	522.5
	b	3.5			342.8	8.4	321.5	8.6		26.7		13.8		725.2
	bd	12.5			241.3	27.4	1471.2	183.1	36.8	71.8		15.5		2059.6
	d				7.9		6.7	20.4						35.0
	Degreaded		28.5	27.7	292.4		22.8	0.3		173.8		71.9	1.5	618.9
	Coppice	1.0	85.0	3.2	174.2					4.5		17.1		285.0
	Open Land	16.9	54.4	45.8	571.9	0.2	57.4	0.2	1.6	926.1	78.4	3340.0	1163.2	6256.2
	Residential											1.6		1.6
	Total	35.2	167.8	114.8	2638.2	199.0	2687.2	216.7	38.4	1248.0	78.4	3501.1	1167.4	12092.1

Table 13. Yuvacık matrix of tree development stage changement between 2004 and 2015 PU (ha)

		2015 Area (ha)																
		a	**ab**	**b**	**bc**	**c**	**cd**	**cd/a**	**d**	**d/a**	**d/ab**	**e**	**Degreaded**	**Open Land**	**Residential**	**KDA**	**P. forest**	**Total**
2004 Area (ha)	**a**		11.4	1.5	7.0		2.2		0.1	0.6			0.0	7.0		5.5		35.2
	ab			84.3	46.3		8.6						5.2	11.2		12.2		167.8
	b			4.9	59.4								2.6	11.9	0.1	35.8		114.8
	bc	0.6	9.2	58.1	1011.2	534.9	531.4	2.5	18.8	16.1	1.0	0.6	51.7	122.2		280.0		2638.2
	c					148.8	48.7		1.5				0.0					199.0
	cd	17.2	1.1	1.7	93.5	157.1	1833.2	3.1	367.4	177.0	14.4	3.3	5.8	3.4		8.9		2687.2
	d	4.8			1.9	1.7	45.3		49.9	51.9	39.7	21.1	0.1	0.3				216.7
	d/a	20.2					3.3		2.4	4.5	6.6		0.6	0.7				38.4
	Degreaded	4.2	0.7	49.5	217.8	16.0	56.0	2.2	5.0	11.5			293.9	446.6	2.3	94.7	47.5	1248.0
	Coppice			5.4	45.5								0.4	13.0		14.0		78.4
	Open Land	3.0	4.1	23.3	98.5	4.7	19.3		1.3	5.9	0.7		67.9	2583.1	517.6	154.8	16.9	3501.1
	Residential			0.2	2.7								0.4	360.0	795.1	8.5	0.5	1167.4
	Total	49.8	26.6	228.9	1583.9	863.1	2548.0	7.9	446.5	267.5	62.5	25.1	428.6	3559.4	1315.2	614.3	64.9	12092.1

Table 14. Yuvacık matrix of tree development stage changement between 1972 and 2015 PU (ha)

		2015Area (ha)																
		a	**ab**	**b**	**bc**	**c**	**cd**	**cd/a**	**d**	**d/a**	**d/ab**	**e**	**Degraded**	**Open Land**	**Resid.**	**KDA**	**Private forest**	**Total**
1972 Area (ha)	**a**			0.5	117.3	15.3	33.4		1.5				2.1	10.1		54.0		234.1
	ab	0.5	0.3	14.1	286.3	365.9	630.3	0.7	15.6	1.5		0.1	9.2	14.6		15.0		1354.0
	abd			1.7	22.6	128.5	310.3		53.9					2.7		2.8		522.5
	b		5.3	4.3	109.7	151.3	342.3	0.6	70.7	15.4	0.1	1.5	9.1	10.0		4.9		725.2
	bd	40.8	11.3	0.4	140.4	127.7	1099.4	4.8	300.8	220.7	48.7	23.5	32.6	3.7		4.7		2059.6
	d				9.4				0.1	12.6	12.8							35.0
	Degreaded	3.5	4.2	52.8	219.4	29.4	38.6	0.8	1.3	4.3			91.0	84.2	0.0	58.8	30.5	618.9
	Coppice			64.7	146.3	21.3	16.0						12.5	15.2		8.9		285.0
	Open Land	5.0	5.5	90.4	532.4	23.7	77.8	1.0	2.7	12.9	0.9		272.1	3417.3	1315.1	465.1	34.4	6256.2
	Residential													1.6				1.6
	Total	49.8	26.6	228.9	1583.9	863.1	2548.0	7.9	446.5	267.5	62.5	25.1	428.6	3559.4	1315.2	614.3	64.9	12092.1

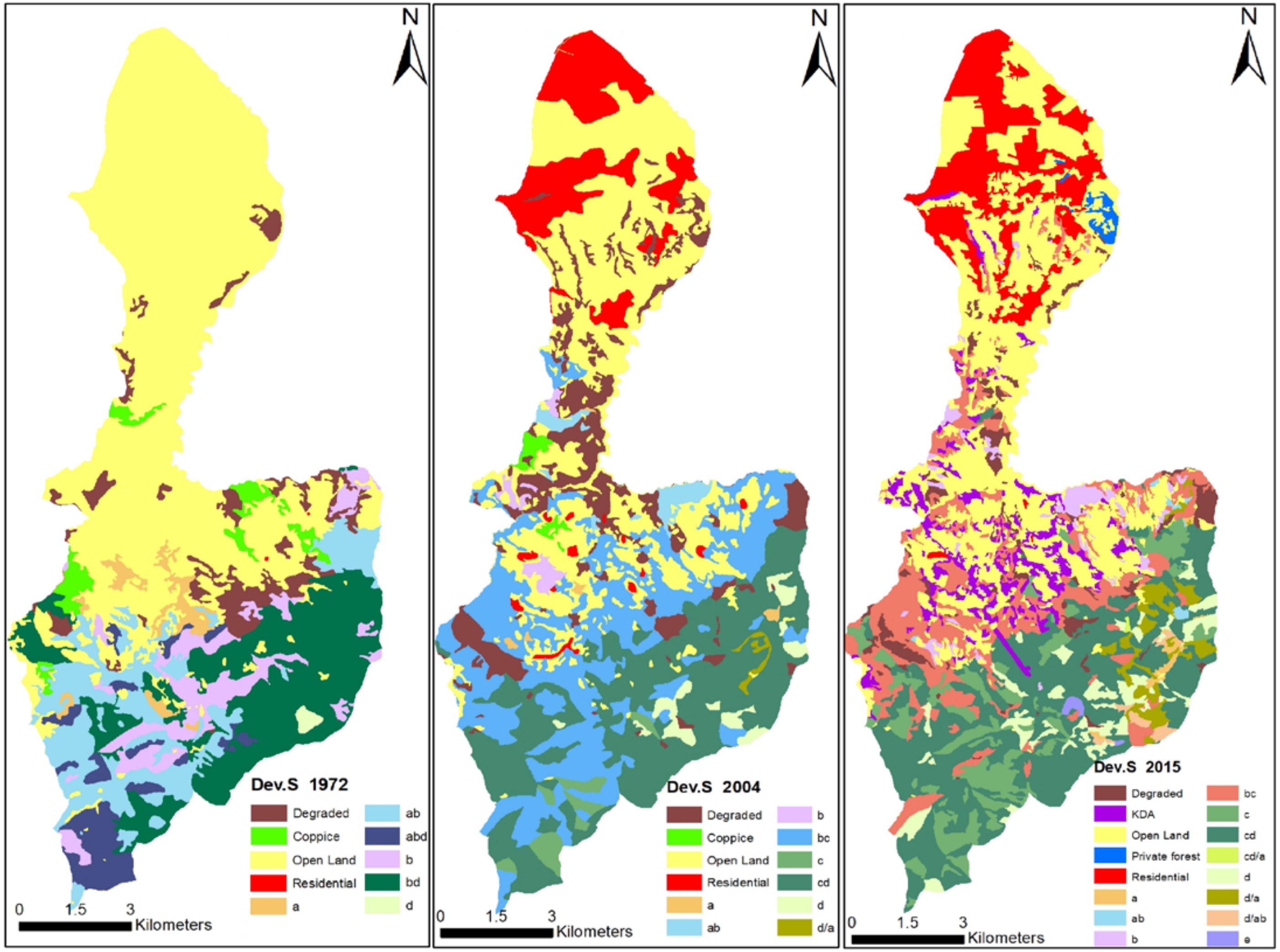

Figure 4. Development Stages of forest in Yuvacık PU in 1972, 2004 and 2015

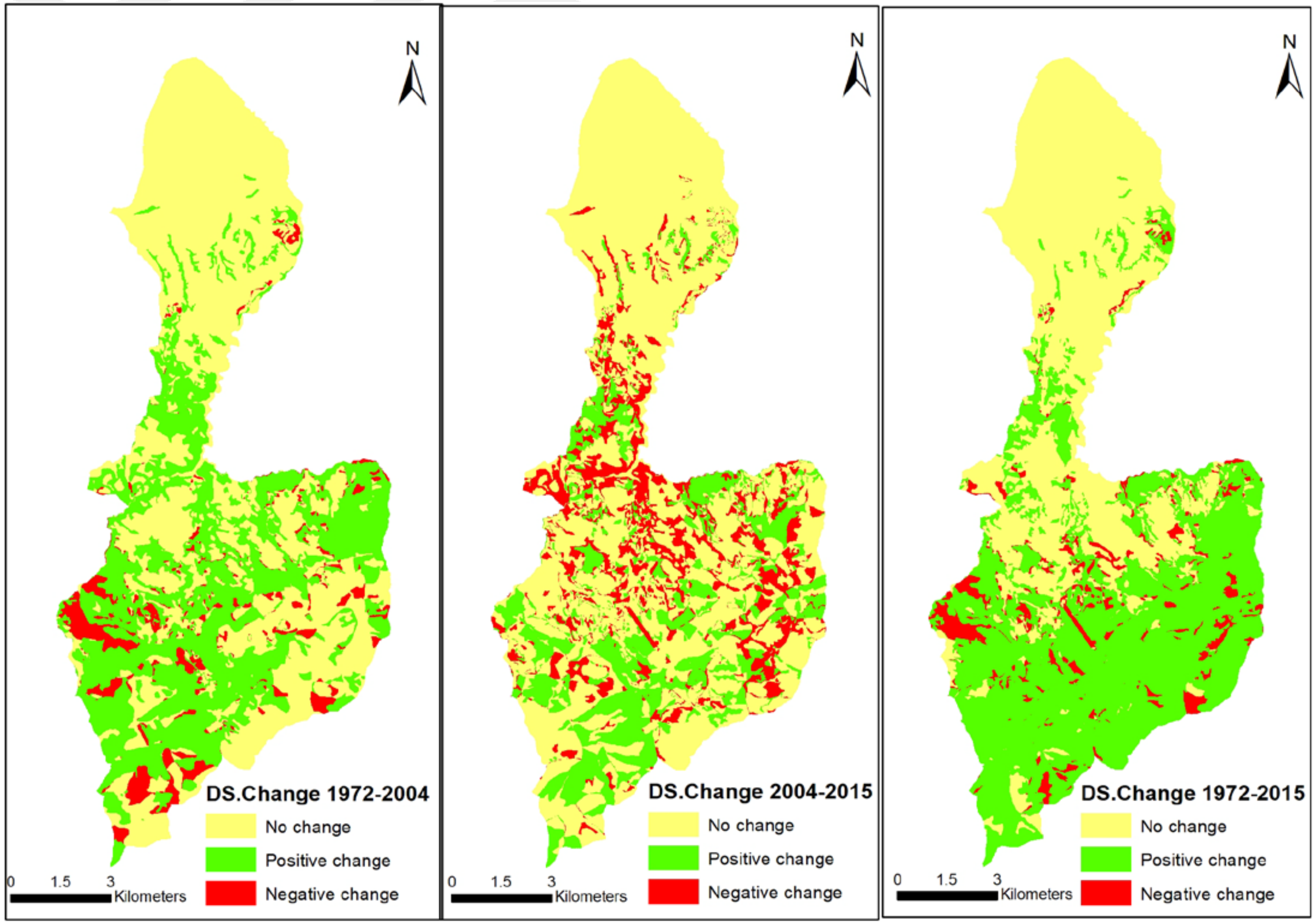

Figure 5. Maps of Development Stage changement between 1972, 2004 and 2015 in Yuvacık PU

3.3. The Changes in Crown Closures

Yuvacık forests were examined in terms of crown closure. The highest positive change occurred between the periods 1972 - 2004. The period for 2004 - 2015 presented a modarate negative change on degraded forests (canopy cover is < 10%). The results show the positive changes come after the new trees from crown closure type 1, 2 and 3. Whereas the negative change come after degraded forests changed into the open lands and open land areas amended into residential areas as mentioned before (Figure 7).

Tabel 15 shows transition total hectal of crown closure ”3” in 1972 increased from 2909.0 to 5714.8 ha in 2004 because of 1447.9 ha of crown closure “2”, 288.1 ha of crown closure “1” and 369.3 ha of degraded forests changed into crown closure category “3”. In the same period, 1627.3 ha of crown closure “2” decreased to 282.3 ha, and 395.7 ha of crown closure “1” decreased to 100.2 ha in 2004 (Table 15).

Between 2004 and 2015, 5714.8 ha of crown closure “3” decreased to 5194.9 ha in 2015 and 1248.0 ha of degraded forest decreased to 428.6 ha in 2015. The results showed that crown closure category “3” decreased because of 565.4 ha changed into forests crown closure "2", 336.8 ha changed into cadastral forests and 148.7 ha also turned in open lands, whereas, degraded forest reduced due to 446.6 ha changed in open lands in 2015. As showed through the map obtained between 2004 and 2015, the coppice forest has disappeared in 2015 while the crown closure of type "2" has boosted in 2015. In another hand, 100.2 ha of crown closure category "1" increased to 150.9 ha in the same year (Table 16).

The change of crown closure between 1972 and 2015 was extremely positive even if 1.6 ha of residential areas in 1972 increased to 1315.2 ha in 2015 and 6256.2 ha of open lands decreased to 3559.4 ha in 2015 but the 283.4 ha of coppice forest had disappeared in 2015 because of 236.6 ha have changed to "3" crown closure. While, 618.9 ha of degraded forest in 1972 decreased to 428.6 ha in 2015. The 2909.0 ha of crown closure category "3" in 1972 increased to 5194.9 ha in 2015. This comes up after 667.7 ha of open lands, 309.6 ha of degraded forest and 1321.0 ha of crown closure types "2" changed into crown closure category "3" in 2015. As well as 1627.3 ha of crown closure category "2" in 1972 declined to 764.0 ha in 2015. The results clarified that 1315.1 ha of open lands become residential areas in 2015. Moreover, Yuvacık forest revealed as dense covered forest due to crown closure type “3" remained dominante at the end of period (Table 17).

Based on our results, crown losure category “3” was dominant in Yuvacık forests in the last period 2015 due to the prominant positive change over 43 years. However, the increase of residential areas were not negatively affect the improvement of forests even though negative changes could be due to the clear cutting of forests to build houses, creation of touristic areas, business and need of firewood in Western Anatolia (GDF, 2004).

Table 15. Crown closure transition matrix of Yuvacık PU between 1972 and 2004

		2004 Year Area (ha)							
		1	**2**	**3**	**Degreaded**	**Coppice**	**Open Land**	**Residential**	**Total**
1972 Area (ha)	**1**	1.1	67.5	288.2	25.2		13.7		395.7
	2	37.3	36.9	1447.9	79.5		24.8	0.9	1627.3
	3	44.9	165.6	2625.5	38.9		32.5	1.7	2909.0
	Degreaded		2.4	369.3	173.8		71.9	1.5	618.9
	Coppice			262.3	4.5		16.6		283.4
	Open Land	16.9	9.9	721.7	926.1	78.4	3340.0	1163.2	6256.2
	Residential						1.6		1.6
	Total	100.2	282.3	5714.8	1248.0	78.4	3501.1	1167.4	12092.1

Table 16. Crown closure transition matrix of Yuvacık PU between 2004 and 2015

		2015 Area (ha)								
		1	**2**	**3**	**Degreaded**	**KDA**	**Open Land**	**Private forest**	**Residential**	**Total**
2004 Area (ha)	**1**	15.6	15.5	57.0	0.6	5.5	6.2			100.2
	2	40.5	85.6	154.3	0.1		1.8			282.3
	3	73.3	565.4	4525.1	65.3	336.8	148.7		0.1	5714.8
	Degreaded	18.3	63.3	281.4	293.9	94.7	446.6	47.5	2.3	1248.0
	Coppice		7.1	43.8	0.4	14.0	13.0			78.4
	Open Land	3.3	26.6	131.0	67.9	154.8	2583.1	16.9	517.6	3501.1
	Residential		0.6	2.3	0.4	8.5	360.0	0.5	795.1	1167.4
	Total	150.9	764.0	5194.9	428.6	614.3	3559.4	64.9	1315.2	12092.1

Table 17. Crown closure transition matrix of Yuvacık PU between 1972 and 2015 (ha)

		2015 Area (ha)								
		1	**2**	**3**	**Degreaded**	**KDA**	**Open Land**	**Private forest**	**Residential**	**Total**
1972 Area (ha)	**1**	12.4	66.3	296.2	13.7		7.2			395.7
	2	41.0	207.0	1321.0	27.6	17.6	13.0			1627.3
	3	80.3	368.4	2363.9	11.8	63.8	20.8			2909.0
	Degreaded	14.0	30.8	309.6	91.0	58.8	84.2	30.5	0.01	618.9
	Coppice		10.2	236.6	12.5	8.9	15.2			283.4
	Open Land	3.1	81.3	667.7	272.1	465.1	3417.3	34.4	1315.1	6256.2
	Residential						1.6			1.6
	Total	150.9	764.0	5194.9	428.6	614.3	3559.4	64.9	1315.2	12092.1

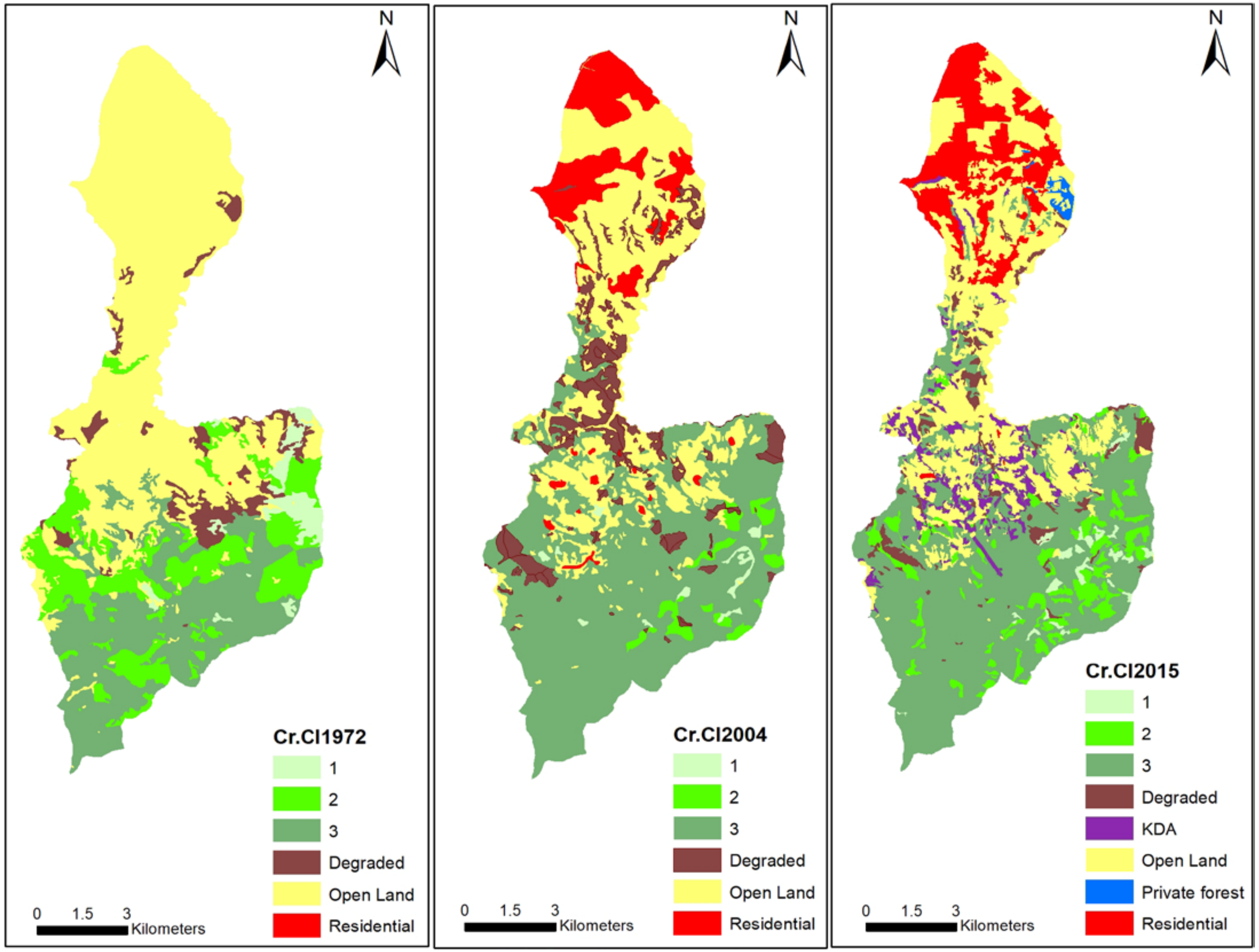

Figure 6. Maps of Crown closure between 1972, 2004 and 2005 in Yuvacik PU

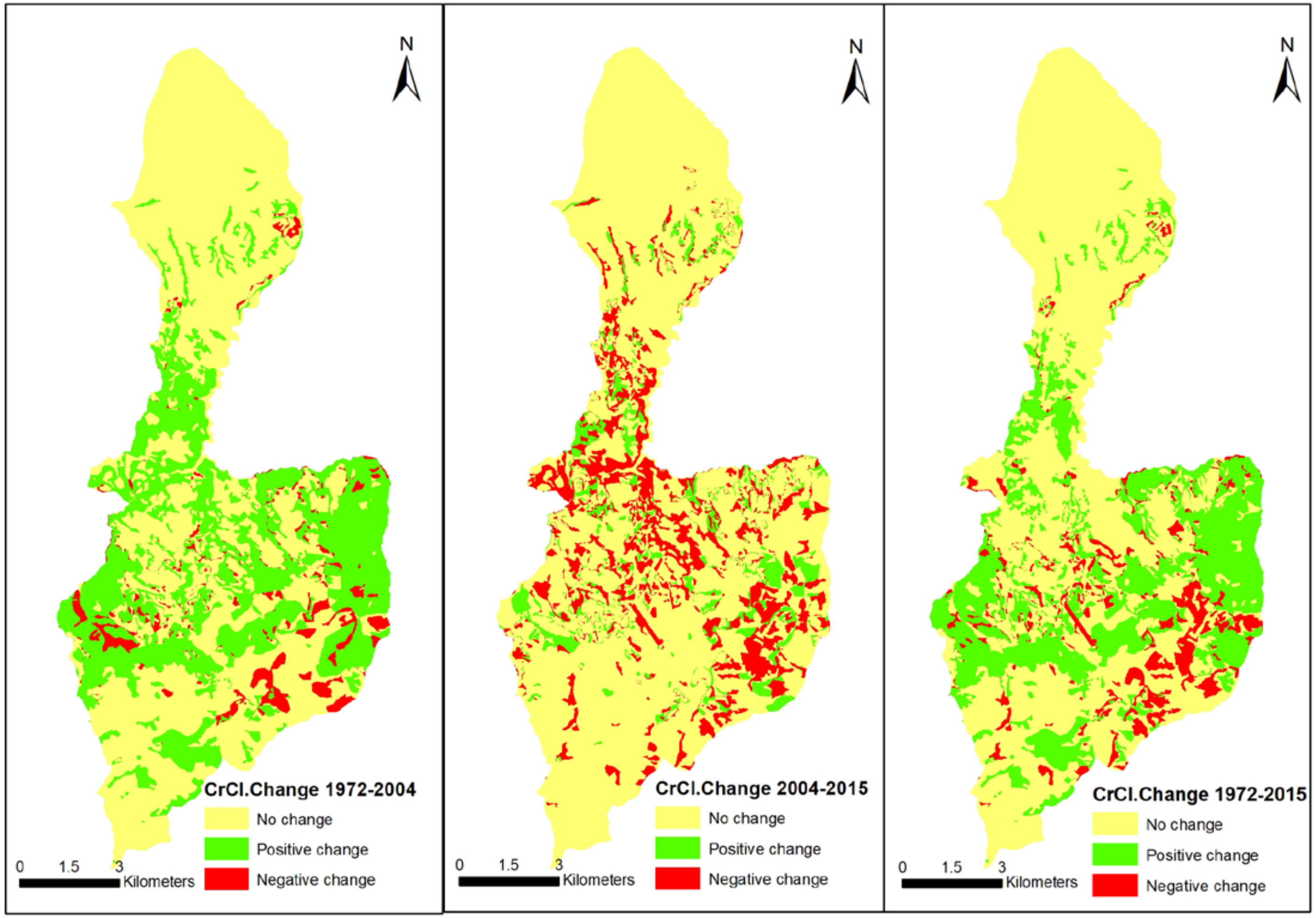

Figure 7. Maps of Crown closure changes between 1972, 2004 and 2015 in Yuvacık PU

3.4. Carbon Sequestration Potential in Yuvacik PU

The results obtained show Carbon stocks increased from 1972 to 2015 through above ground and below ground. However, Carbon stocks in litter and soil decreased during the same period. Above ground C stocks increased from 29.2% in 1972 to 37.3% in 2015 whereas soil Carbon stocks decreased from 60.9% in 1972 to 51.5% in 2015. In 1972, the Carbon stored was 1,071.3 Gg which increased to 1,122.8 Gg in 2004, hence a change of 4.8% increase in Carbon storage between 1972 and 2004. However, the amount of C storage decreased from 1,122.8 Gg to 1,090.6 Gg (2.9%) between 2004 and 2015. Otherwise, the Carbon stored during the 43 years period is around 1.8% (Table 18).

The distribution of Carbon density through Yuvacık forest ecosystem during 1972, 2004 and 2015 showed dramatic changes due to tree species/ land uses changes over the periods. Accordingly, the Carbon density of the forest ecosystem varied from 100 to 300 Mg/ha as shown in (Figure 8). The results are comparable with that of 150 to 350 Mg/ha obtained in Çaykara PU in a study conducted between 1971 and 2010. In the study, there was a 66.8% of C increase over 39 years (Karahalil et al., 2018).

According to MEF (2011), it was found that annually net increment and Carbon stock through the forests of Turkey goes up regularly depend on increase of forest cover area. In 1990, results showed the increment rate was 12.02 M ton yr^{-1}; raise up to 15.64 M ton yr^{-1} in 2009 on the same time preceding the increase in the Carbon stock between 44.08 M ton yr^{-1} to 57.36 M ton yr^{-1}. The results obtained in Gölcük planning unit, indicated that total stored Carbon was 487,575 tons, while 308,592 tons was for total biomass and 178,983 tons for soil C in 2015 (GDF, 2015a).

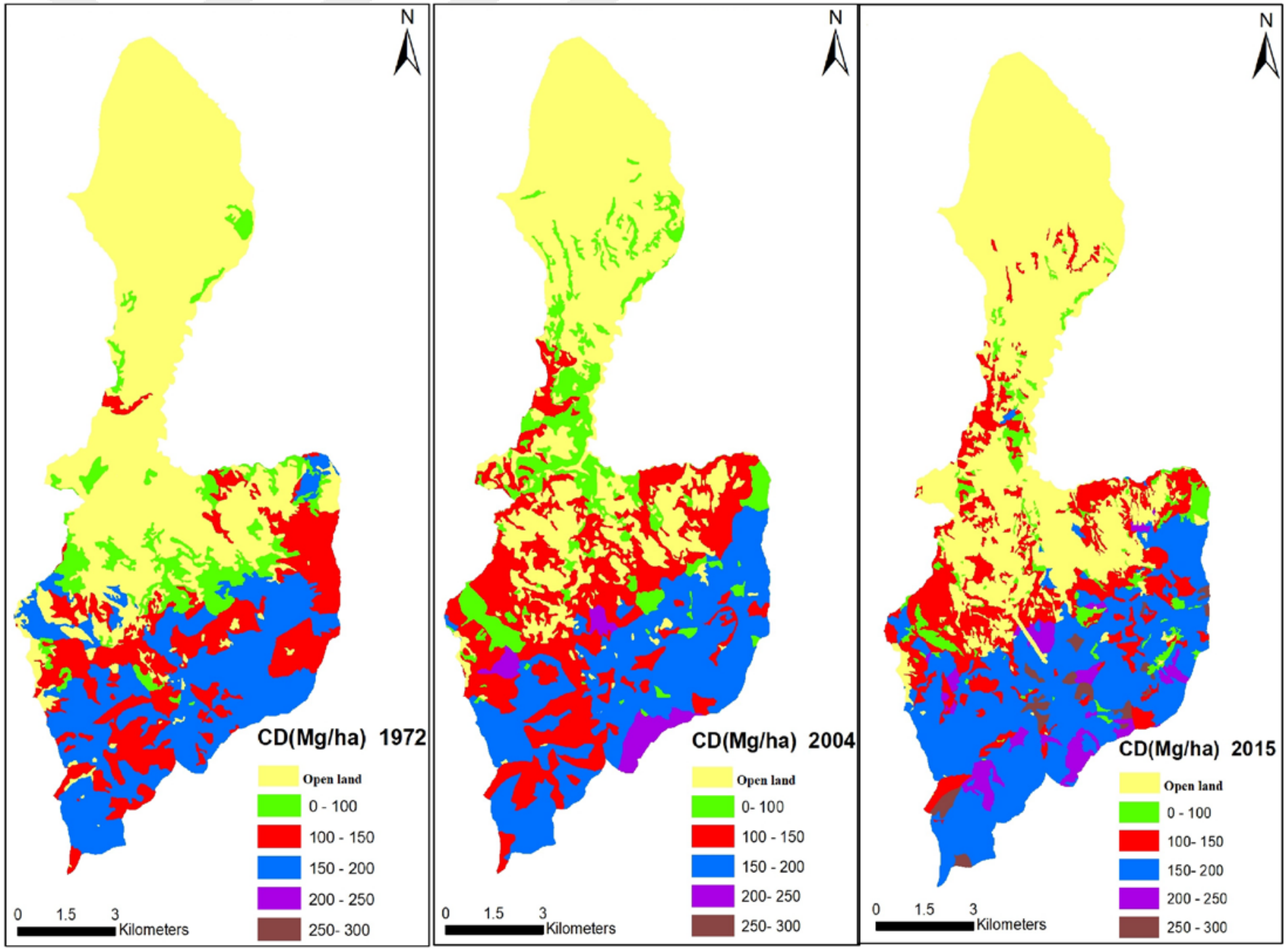

Figure 8. Maps of carbon density between 1972, 2004 and 2005 in Yuvacık PU

Table 18. The Carbon stocks (Gg) in the carbon pools of Yuvacık PU in 1972, 2004 and 2015

Land cover	Above ground			Below Ground			Litter			Dead Wood			Soil			Total		
	1972	2004	2015	1972	2004	2015	1972	2004	2015	1972	2004	2015	1972	2004	2015	1972	2004	2015
Degraded	4.8	4.4	1.7	2.2	2.0	0.8	3.9	4.8	1.6	0.0	0.0	0.0	87.2	108.1	36.8	98.1	119.4	40.8
Coppice	12.3	1.2	0.0	3.5	0.3	0.0	3.4	0.3	0.0	0.1	0.0	0.0	76.5	6.6	0.0	95.8	8.5	0.0
Carpinus	3.8	0.0	0.0	0.9	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	12.0	0.7	0.0	17.2	0.7	0.0
Beech	203.8	162.3	203.7	46.9	37.5	47.6	12.6	8.8	10.0	1.7	1.3	1.7	284.7	200.0	225.6	549.7	410.0	488.0
Oak	3.7	2.5	0.0	0.8	0.6	0.0	0.3	0.2	0.0	0.0	0.0	0.0	7.1	4.9	0.0	12.0	0.0	0.0
Mixed	84.3	199.4	200.9	20.3	46.0	46.4	8.5	13.9	13.4	0.7	1.6	1.6	184.8	315.2	299.5	298.6	576.1	561.7
Total	312.6	369.8	406.3	74.7	86.4	94.7	29.1	28.1	25.0	2.5	3.0	3.3	652.3	635.5	561.8	1,071.3	1,122.8	1,090.6
%	29.2	32.9	37.3	7.0	7.7	8.7	2.7	2.5	2.3	0.2	0.3	0.3	60.9	56.6	51.5	100	100	100

3.5. Soil Loss in Yuvacık PU

The results of soil loss for the years of 1972, 2004 and 2015 showed that total soil loss was 1,121,814. 2 tones yr^{-1}, 435,149.0 tones yr^{-1} and 108,549.6 tones yr^{-1} respectively. The results show that soil loss reduced from 1972 to 2015 with the highest soil loss seen during 1972. Generally, soil loss in the Yuvacık forest ecosystem was reduced by 90.3% during the study period (Table 19). It can be attributed to the real increase of basal area of forest stands.

Table 19. Yuvacık forest soil loss in 1972, 2004 and 2015

Tree Species	Soil Loss in tones per year		
	1972	2004	2015
Degraded	494,216.5	234,954.3	351,66.3
Coppice	118,046.6	18.9	0.0
Hornbeam	14,215.3	0.0	0.0
Beech	317,054.8	50,446.8	29,809.6
Oak	2,736.5	3,074.2	0.0
Mixed	175,544.6	146,654.7	43,573.8
Total	1,121,814.3	435,149.0	108,549.6

Soil loss in 1972 was obtained from the degraded forest with 494,216.5 tones yr^{-1}, followed by Beech stand with 317,054.8 tones yr^{-1}, mixed forest 175,544. 6 tones y^{-1} and coppice forest with 118,046. 5 tones y^{-1} (Figure 9).

Futhermore, the reduction of soil loss in Yuvacık PU can mainly be attributed to the increase in the growing stock, positive forestry activities, control of human activities such as agriculture, bee keeping, touristic activities and establishment of various measures for soil erosion, pests and diseases control, fight against illegal logging, crop clearing, controlled grazing and natural disasters due to the land degradation neutrality (LDN) targets (MFW, 2016).

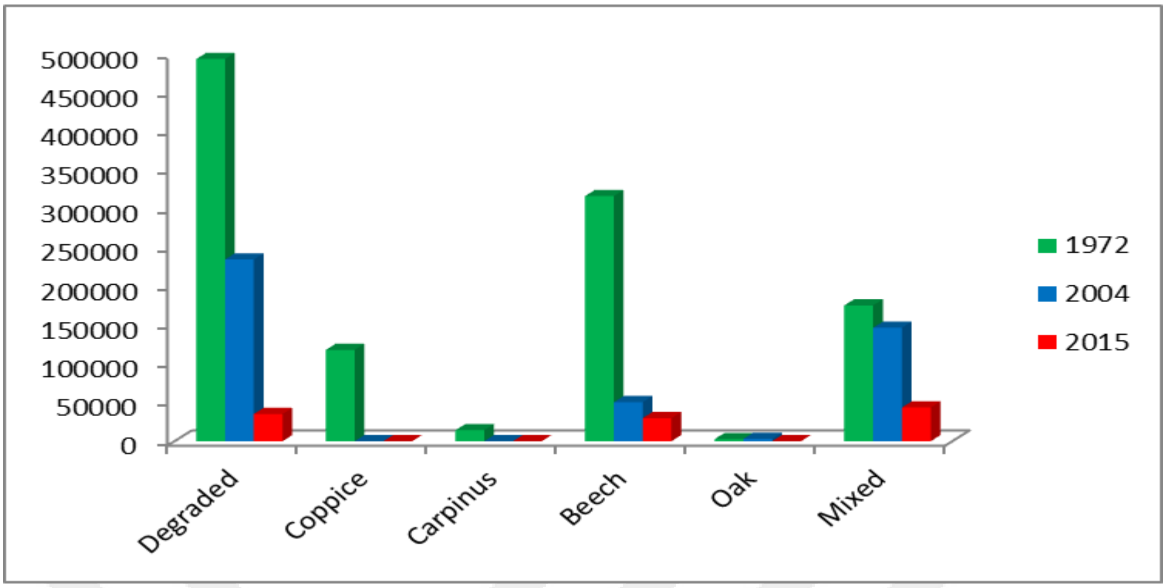

Figure 9. Yuvacık forest soil loss (tonnes) in 1972, 2004 and 2015

3.6. Water Production in Yuvacık PU

The amount of water produced in 1972 was 1,866 billion m^3y^{-1}; 658,295 million m^3 y^{-1} in 2004 and 272,924 million m^3 y^{-1} in 2015 (Table 20). Despite high loss of soil in 1972 in the beech forest, it produced more water with 1,169 billion m^3 y^{-1}, followed by mixed forest with 398,824 million m^3 y^{-1}in 2004 and 384,608 million m^3 y^{-1} in 1972. Degraded forest known as highest loss of soil, produced 222,814 million m^3 y^{-1} in 1972. There was a decrease of 85.4% of water production between 1972 and 2015 (Figure 10).

According to GDF (2004), stand parameters such as age, height, diamater, crown closure and tree species affects the water yield. So, by looking at previous chapter about the water production process, diameter was used as key parameter that can be reffered as the main reason for having more water produced in Yuvacık PU during 43 years. These results can dedicate the rise of dimeter of forest stand is the reason of increament of water production in the study area. These findings can be compared to that of Maçka forest over the research done in 2016. The results obtained showed the amount of water produced was 3751.2 m^3 ha^{-1} y^{-1} in forest and 2986.1 m^3 ha^{-1} y^{-1} in open area (Kezik et al., 2016).

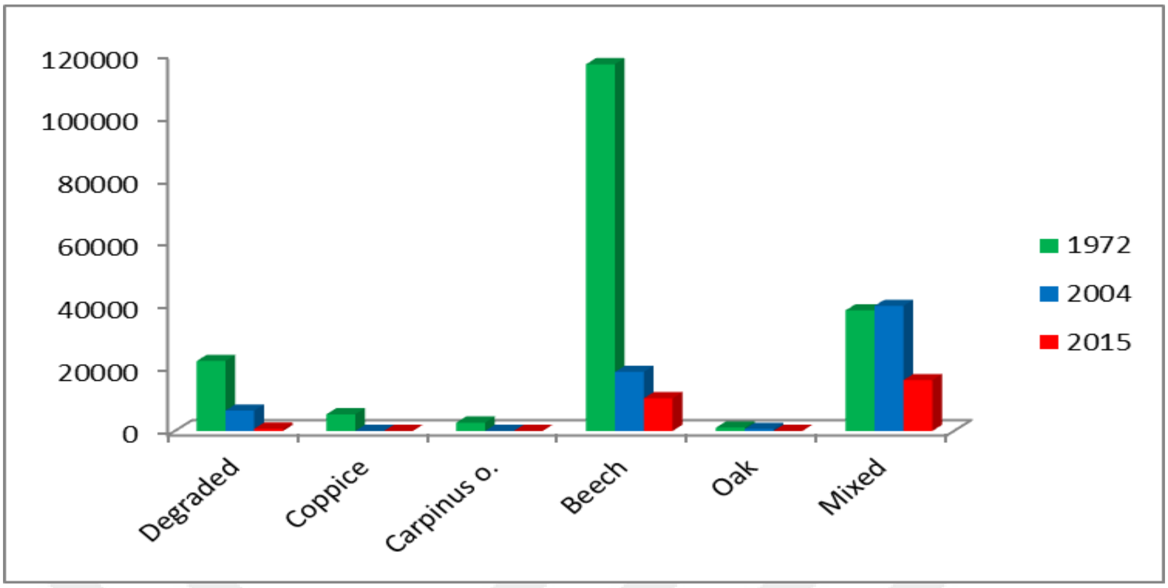

Figure 10. Yuvacık Forest water production (m^3) in 1972, 2004 and 2015

Table 20. Yuvacık Forest Water Production in 1972, 2004 and 2015

Tree Species	Water Production in m^3 * 1000 per Year		
	1972	2004	2015
Degraded	222,814.4	64,748.6	6,951.5
Coppice	52,897.7	9.2	0.0
Hornbeam	26,526.9	0.0	0.0
Beech	1,169,245.9	188,112.6	103,963.4
Oak	10,496.7	6,600.0	0
Mixed	384,608.3	398,824.5	162,009.5
Total	1,866,590.3	658,295.2	272,924.6

3.7. Wildfire Vulnerability in Yuvacık Forest Ecosystem

The class of wildfire vulnerability from 1972, 2004 and 2015 was expressed due to Table 21. The Fire Sensitivity Index (FSI) of 5 classes was obtained by using biometric, topographic, spatial parameters (tree species, basal area, and number of trees, development stages, age, topography and shape of stands). Since the relative contribution of each parameter of index to the fire vulnerability was not the same in reality, all relative weighting of each parameter was needed to be used to determine the overall fire vulnerability index. Based on professional understanding, judgment and results obtained after analysis, fire vulnerability of Yuvacık forests was found in class “2” (High fire vulnerability) between 1972, 2004 and 2015 (Table 22).

Table 21. Classes of wildfire vulnerability in Yuvacık forest PU.

Classes	Interval of class	FSI
5	(0.2-1.86)	Very low/ no vulnerability
4	(1.87-3.53)	Low vulnerability
3	(3.54-5.21)	Average Vulnerability
2	(5.22-6.88)	High Vulnerability
1	(6.89-8.55)	Very high vulnerability

Table 22. Range of wildfire in Yuvacık forest

Year	Interval class	Fire index
1972	6.13	High Vulnerability
2004	5.99	High Vulnerability
2015	6.30	High Vulnerability

In fact, Yuvacık forest ecosystems were found in high wildfire vulnerability (2^{nd} class) with respectively Fire Sensibility Index of 6.13, 5.99 and 6.30 due to high number of trees, low of basal area, high slope, thinner class of development stages, high crown closure and forest cover of Yuvacık PU. The results clarified that Turkey' forest lands facing high risk of wildfire because of climate change, socio-economic factors and practically 50% of forest is composed by fire sensitive species such as calabrian pine, black pine and maritime pine (GDF, 2009). In accordance with Mertol et al. (2018) were sum up the prominent reasons of wild fire in coastal line of Mediterranean such flammable vegetation with extremely starvation and over-temperature in summers.

Several research was done about causes of wildfire of forest all over the world, such as forest cover types, the location stands, changes in weather and high bush and shrub with high biomass (Botequim, et al., 2013, Garcia-Gonzalo et al., 2012, González, et al., 2007, Marques, et al., 2011, Zeng, et al., 2010, Sağlam and Bilgili, 2000; Küçük and Sağlam, 2004). Thus, it was seen that the findings of present study were line with the above-mentioned literature.

3.8. Biodiversity in Yuvacık PU

The spatial temporal change of Yuvacık forests were also analyzed so that i can be aware about the biodiversity in the study area as cited in Table 23, 24 and 25 over 43 years. Results present that urge amount of positive change observing between 1972, 2004 and 2015. This apparent positive alter over 43 years demonstrates the total average dbh of trees more than 36 cm in the stands rose up to 19,2 % (18), 51,5 % (38) and 44,4% (46) consecutively. This can easly dedicate the well growth of Yuvacık forests from the young to mature stages not only that but also in growing stock. This results clarify a stronger biodiversity in Yuvacık forest that linked to its growth trends. Based on the shannon diversity index we have found as 1.3, 1.6 and 1.6 and shannon evenness index 0.6, 0.8 and 0. 8 successively between 1972, 2004 and 2015. So, it shows that the tree species more than 36 dbh of yuvacık planning unity are evenly diversty and heterogeneity as shannon diversity is more than 1 and shannon evenness index is closed to biodiveversity index expressed as 1 (URL-4, 2019).

Similarly, the pivot table obtained for 1972, 2004 and 2015 shows that the average volume of the beech was 196.9, 220.3 and 245.1 m^3 ha $^{-1}$ year^{-1} increased in serial. This can infer that beech species appeared as flag tree in Yuvacık forests over 43 years. Moreover, in terms of diameter, beech species rise more than others followed by mix forests during the whole period. In other hand, in 1972; 105,3 m^3 of Hornbeam and 120.1 m^3; 117.6 m^3 of Oak species apprreared within 1972 and 2004 of tree more than 36 cm dbh have been vanished in 2015.

Table 23. Biodiversity indicators for Yuvacık Planning Unit 1972

Tree species	Num.Tree >36 Cm	Prop.fr.tr. %	Diameter (cm)	Volume (m^3)
Degraded	21	46.5	9.4	15.6
Coppice	0	79.9	12.2	23.7
Hornbeam	11	80.4	14.7	105.3
Beech	104	95.6	24.2	196.9
Oak	16	90.1	18.0	120.1
Mixed	34	55.1	22.1	139.5
Total average	18	19.2	5.2	37.0

Table 24. Biodiversity indicators for Yuvacık Planning Unit 2004

Tree species	Num. Tree >36 Cm	Prop.fr.tr. %	Diameter(cm)	Volume (m^3)
Degraded	0	99.9	43.4	10.0
Coppice	0	85.4	8.0	49.5
Hornbeam	0	100.0	6.0	0.0
Beech	118	97.9	29.2	220.3
Oak	21	97.5	22.0	117.6
Mix	51	69.3	24.4	1.9
Total average	38	51.5	17.8	96.1

Table 25. Biodiversity indicators for Yuvacık Planning Unit 2015

Tree species	Num. Tree >36 Cm	Prop.fr.tr. %	Diameter(cm)	Volume (m^3)
Degraded	0	83.1	64.8	11.6
Beech	133	98.0	34.6	245.1
Mix	58	70.0	25.1	177.4
Total average	46	44.4	17.1	104.9

By glancing at the research conducted from Leipzig University and the German Centre for Integrative Biodiversity Research (iDiv), forests fulfill various necessary roles, and do so especially well on the off chance that they have differing qualities of trees. They have showed that several of ecosystem functions done well in heterogeneity forests where is an extreme rate of biodiversity. Their results explained that while trees live in forest rather than homogeneity species, they rise at high level, store more carbon and are safer to bothers and infections than trees in species-poor timberlands. They also find that forest functions are directly related to nutrient and carbon sequestration process, development and versatility of the trees and woodland regeneration (Radcliffe et al., 2017).

Large-diameter trees (here defined as those with a diameter ≥36 cm at breast) contribute excessively to biological system work, counting biomass and carbon capacity. The heterogeneous structure of late-successional woodlands incorporates variety in tree density and size across the landscape, as well as the variety in vertical canopy structure (Clark, 1996, Franklin et al., 2002, Franklin and Van Pelt, 2004 and Lindenmayer et al., 2012). They found that expectations for large-diameter tree plenitude and spatial designs based on scaling hypothesis and competition hypothesis, the biggest 1.4% of trees accounted for 49.4% of aboveground biomass, underscoring the significance of huge trees for giving the biological system benefit of carbon capacity (Lutz et al., 2012).

This can be compared to our results showed high biodiversity index of Yuvacık forest over 43 years where this forest play a key role in hosting large different birds species due to its dimater and crown closure obtain “3” as dense forest. Not only that, it intervene in boosting the economy of rural people by producing timber and various wood products. Our findings showed extremely aboundancy of Yuvacık forests in terms of density and diameters as mentioned above through tables.

Table 26. Biodiversity index for Yuvacık Planning Unit

Years	1972	2004	2015
Shannon’s Deversity Index	1.3	1.6	1.6
Shannon’s Evenness Index	0.6	0.8	0.8

High values of Shannon diversity index (H) would be representative of more diverse communities. A community with only one species would have Shannon diversity index (H) value of 0 because Pi would equal 1 and be multiplied by lnPi which would equal zero. If the species are evenly distributed then the Shannon diversity index (H) value would be high. So the Shannon diversity index (H) and shannon’s evenness index value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community as it mentioned above (Table 26).

Other than the timberland composition and land cover-forest cover sort changes, the spatial structure of woodland arrangement was too explored. The analysis of landscape pattern demonstrated that the Number of Patches (NP) rose from 135 to 312 during 32 years and peaked to 437 in 2015. Mean Patch Size (MPS) declined from 586.4 ha to 326.0 ha between 1972 and 2015. Edge Density (ED) increased from 58.1 to 107.2 m ha^{-1}. Area Weighted Mean Shape Index (AWMSI) climbed from 25.4 to 35.0 (Table 27).

Table 27. Change of landscape pattern in Yuvacık Planning

Class	NP			MPS			ED			AWMSI		
	1972	2004	2015	1972	2004	2015	1972	2004	2015	1972	2004	2015
Residential	2	22	12	0.8	57.2	121.0	0.1	5.8	8.9	1.0	2.0	5.4
Open Land	53	126	96	118.0	28.7	38.7	18.8	27.7	33.8	5.3	5.8	9.2
Mixed	27	54	94	59.1	68.8	37.6	12.3	21.9	28.1	2.7	5.4	6.4
Beech	11	15	26	282.9	157.2	102.3	14.6	11.0	13.1	6.7	3.4	5.3
Oak	3	2	-	28.1	29.0	-	0.9	0.7	-	2.0	2.8	-
Hornbeam	4	1	-	34.9	7.7	-	1.2	0.1	-	2.4	1.2	-
Coppice	7	7	-	40.5	11.2	-	2.9	0.9		2.3	2.2	
Degraded	28	85	99	22.1	15.0	4.4	7.3	15.1	8.6	3.1	2.9	2.0
KDA	-	-	106	-	-	5.8	-	-	13.5	-	-	2.7
Private F.	-	-	4	-	-	16.2	-	-	1.1	-	-	3.9
Total	135	312	437	586.4	374.7	326.0	58.1	83.2	107.2	25.4	25.7	35.0

The number of patches was nearly two times in open land and mixed forests from 53 to 126 and 27 to 54 successively between 1972 and 2004. While degraded forests the same records increased from 28 to 85 in the same period. In additional, it was raised slightly from 11 to 15 in Beech stands and in Oak, Hornbeam plummeted slightly.

The changes appeared that increase in number of patches and littler patches, and diminish in mean patch size illustrated that the forest landscape has gone into a more fragmented structure that contrarily influences biodiversity and the strength of the ecosystem. To sum up, plain increment in woodland areas may not continuously be great circumstance. The quality, composition and the arrangement of forest landscape ought to also be dissected to show the dynamics of biological system in terms of ecological and prudent maintainability over a longer time bigger range. Moreover, there are prominent pioneer reasons which led to the fragmentation of the forest in study area like rise up of population, urbanization, tourism activities and forest fire outbreak due to the location of Yuvacık forest located in the Marmara region.

These findings are very comparable to alike various studies. Karahalil et al. (2007) obtained that add up to number of patches expanded from 59 to 287 between 1965 and 2004 in Ballıbucak planning unit of Köprülü Canyon NP. Another research illustrated that MPS declined from 163.6 ha to 47.9 ha between 1984 and 2007 (Günlü et al., 2009). Additionally, Keleş et al. (2008) shown an increment within the number of patches from 108 to 202 between 1972 and 2002 a long time in Artvin territory of Turkey.

4. CONCLUSIONS AND SUGGESTIONS

Main theme through environment management and sustainable of natural resources has been dynamics of forest cover, land cover and ecosystem services. Land use and cover changes mainly result from human activities such as urbanization, agriculture activities, forest exploitation, infrastructures and socio-economic influences pre-disposed to the environment affecting it in terms of water production, carbon sequestration, soil loss and wildfire vulnerability. This research was conducted to determine and clarify the spatial and temporal changes of forest cover types and land use with emphasis on ecosystem services.

Creation and application of forest ecosystem management and sustainability practices require first to understand the dynamics of forest cover through spatially and temporally as the main parameters. The change map of tree species demonstrated that since 1972 until 2015 coppice forests, beech and degraded forest dramatically reduced, while mixed forest rose approximately two times at the end of period. The open lands up to 99% have prominently replaced by residential area by 2015. Therefore, the outputs showed that has been high positive amendment of forest in terms of growth. The crown closure map showed that coppice has "1", "2" and "3" crown closure, so they are disappeared in 2015 due to its transformation through forest of crown closure category "3" and "2", cadastral forest, degraded forests and open lands. The amount of forest of crown closure category "3" in 1972 was 2909.0 ha and increased up to 5194.9 ha in 2015 that remained as flag forest cover type in Yuvacık PU.

According to the results obtained from development stages, tree species and crown closure maps and biodiversity index rate showed that the forest area increased with resultant of forest management practices applied and controled human activities in study area from 1972 to 2015. The map of carbon sequestration during 1972 and 2015 shows the spatial and temporal changes of carbon storage increasing through above ground, below ground and in dead wood while the carbon storage was decreased in litter and soil. Soil loss in Yuvacık planning unit showed a drastic decrease due to the increase of basal area. Total water produced can be rise or decline due to forest cover structures as i have mentioned above. Besides of spatial and temporal changes of forest structures, and land use, the results showed that Yuvacık PU classified in 2^{nd} class of high fire vulnerability that risky and dangerous to environment.

Based on the results of this study, there are spatiotemporal changes of forests cover, land use and ecosystem services in study area. The implementation of forest management guidelines agreement signed by Turkey through the ministerial conferences as UNCBD, UNFCCC, GEF, Pan Europe/Rio and Forest Europe has been fulfiled. As per the current situation, it can easily be deduced that Yuvacık forest PU is fulfilling those agreements as the forest cover is rising even though the residential area is increasing in the study area, the forest management practices have been put into actions. Hence posing future challenges, Turkey points to contribute to the collective endeavors to fight against desertification, disappearance of endangered species, reduction of biological diversity and climate change.

Understanding timberland dynamics is basic to plan the feasible management of Yuvacık PU as the transient alter of both composition and arrangement of forest cover types are pivotal components of biological system conditions and capacities. The rate and sum of land/forest covert sort changes as a result of either the chronicled bequest of forest structure or continuous threats or factors influencing the current pattern to shape are to be measured to assist superior plan future forest management activities and environment approaches for a given nation.

After the works of this master thesis, the following recommendations were formulated:

- Ecosystem services should be digitalized in order to facilitate the researchers in terms of data collection and maximizing the time of analysis.
- More realistic and accurate models should be developed for appraising the spatatiotemporal change in terms of landscape metrics.
- Climate change should be incorporate with forest management plans for sustainable of environement.
- Different criterias and indicators should be taken into account during the digitizing forest values in order to provide accurent results.
- This study is not conclusive and hence further studies are recommended on the spatiotemporal changes of land use / land cover and ecosystem services.

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CURRICULUM VITAE

SAUTI Raymond was born in Rubavu District, western province of Rwanda. He completed his secondary education school as best student with high GPA in Biochemistry at College of science ADEC Ruhanga, Rwanda. SAUTI registered for Bachelor of Science degree in University of Rwanda College of Agriculture, Animal Science and Veterinary Medicine, Rwanda where he granted a degree as best graduate student in department of Forest and Nature Conservation with award of Bachelor of Science with Honours in Agroforestry and Engineer GCE + 5 Years. He worked in high school called Lycee de Gisenyi as a Teacher and supervisor for finalist students before getting allowance to study his Master of Science degree in Forestry Engineering at Karadeniz Technical University in Turkey. He speaks Kinyarwanda as mother language and foreigner languages such as English, French, Turkish and Bulgarian.

SAUTI ‘s motivation is,

“Education is not the filling of a pail, but the lighting of a fire”