KARADENIZ TECHNICAL UNIVERSITY
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FOREST ENGINEERING DEPARTMENT

EXPLORING THE SPATIOTEMPORAL DYNAMICS OF GÖLCÜK PLANNING UNIT OVER 43 YEARS AND IMPLICATIONS OF INTERNATIONAL CONVENTIONS TO MANAGEMENT PLANNING APPROACH

MASTER THESIS

Sidra Ijaz KHAN

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THESIS STATEMENT

I hereby declare that all the information contained in this master thesis titled 'Exploring the spatiotemporal dynamics of Gölcük planning unit over 43 years and and implications of international conventions to management planning approach' is as a result of my works under the supervision of Asst. Prof. Uzay KARAHALİL and with accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully acknowledged and cited all the material and results that are not originating directly from this work. 28/09/2017

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SUMMARY

EXPLORING THE SPATIOTEMPORAL DYNAMICS OF GÖLCÜK PLANNING UNIT OVER 43 YEARS AND IMPLICATIONS OF INTERNATIONAL CONVENTIONS TO ECOSYSTEM MANAGEMENT PLANNING

Sidra Ijaz KHAN

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Supervisor: Asst. Prof. Uzay KARAHALİL
2017, 66 Pages.

The objectives of this study are to measure Land Use Land Cover Change & forest cover type changes by studying the spatial-temporal dynamics over 43 years using GIS, analyze patterns of change in the landscape of Gölcük planning unit with special focus on forest fragmentation and analysis of forest management dynamics in relation to Turkey's commitments on forestry related international agreements. The study area covers 12307.8 ha of Gölcük Forest management planning unit. Using the spatial database of 1972, 2004 and 2015. The LULCC map 1972 to 2015 shows that the coppice forest and agricultural area reduced and an additional cadastral and mix class of residential and agriculture emerged as well as forest area was increased.The species mix map revealed that the coppice forest is replaced by mixed forest and pure stands, the increase in forest cover in non-forest areas thus decreasing the non-forest area and deforested areas. Crown closure and development stage change map shows large amount of positive change showing between 1972 and 2015, and 1972 to 2004. In 1972, 5856.2 ha total forest area whereas, in 2004,7581.3ha total forest area exist which increased to 8307.4 ha total forest area in 2015. The forest value maps show general economic and noneconomic functions in 1972 changed to aesthetic, firewood, herbal uses and soil erosion control functions in 2004 and 2015. The patch analysis also shows the fragmentation of landscape which can be susceptible to the harsh environmental conditions. After 2004, as Turkey signed UNCBD and UNFCCC forestry related agreement so the management plans were prepared according to ecosystem-based multiple uses such as ecologic, biodiversity, recreational, economic and socio-cultural functions.

Key Words: Spatiotemporal, LULCC, UNCCD.

Yüksek Lisans Tezi

ÖZET

GÖLCÜK ORMAN İŞLETME ŞEFLİĞİ ORMAN KAYNAKLARINDA MEYDANA GELEN ZAMANSAL VE KONUMSAL DEĞİŞİMİNİN 43 YILLIK ANALİZİ VE ULUSLARARASI ANTLAŞMALARIN PLANLAMA SÜRECİNE YANSIMALARI

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Orman kaynaklarının sürdürülebilir şekilde planlanabilmesi için, orman dinamiğini zamansal ve konumsal olarak ortaya koyan çalışmaların yapılması kaçınılmazdır. Bu çalışmanın amacı, 43 yıllık bir sürede arazi kullanımı/arazi örtüsünde meydana gelen değişikliklerin CBS yardmıyla ortaya konması, parçalılığın farklı indisler kullanılarak analiz edilmesi ve uluslararası antlaşmaların planlama yaklaşımına olan etkilerinin ortaya konmasıdır. Çalışma alanı olarak; 1972, 2004 ve 2015 yıllarına ait konumsal veri tabanı kullanılan 12307.8 ha büyüklüğündeki Gölcük Orman İşletme Şefliği seçilmiştir. Arazi örtüsündeki değişim incelendiğinde, 1972 ile 2015 yılları arasında, bozuk orman alanları ve tarım alanlarının azaldığını ve orman alanlarında ise artış olduğu tespit edilmiştir. 1972 yılında 253 ha büyüklüğündeki orman alanı 2015 yılında orman dışı alana dönüşürken, buna karşın aynı periyotta, 1882 ha büyüklüğündeki orman dışı alan ise, orman alanine dönüşmüşütür. Gelişim çağı haritası, 1972 yılında var olan 1328 ha büyüklüğündeki baltalık alanın, 2015 yılına gelindiğinde "b" çağına ve 1968 ha büyüklüğündeki alanın ise "bc" çağına geçiş yaptığını göstermiştir. Kapalılık dikkate alındığında, 803 ha büyüklüğündeki ormansız alanın tam kapalı ormana ve 508 ha büyüklüğündeki bozuk alanın da yine tam kapalı ormana dönüştüğü görülmüştür. Orman fonksiyonları dikkate alındığında ise, 1972 yılında üretim ormanı olarak planlanan Gölcük Orman İşletme Şefliğinin, son periyotta estetik, odun dışı orman ürünleri ve toprak koruma olmak üzere farklı orman fonksşyonlarının dikkate alınarak işletildiği tespit edilmiştir. Orman ekosistemindeki konumsal yapı irdelendiğinde, ise parçalılığın arttığı ve kırılgan bir yapıya kavuştuğu ortaya konmuştur.

Anahtar Kelimeler: Spatiotemporal, LULCC, UNCCD.

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ABREVIATIONS

GDP: Gross Domestic Product.

GDF: General Directorate of Forestry.

NWFP: Non Wood Forest Products.

US: United State.

GIS: Geographical Information system

RS: Remote sensing.

LULCC: Land Use & Land Cover Change.

UNFCCC: United Nation framework & Convention on Climate Change.

UNCBD: United Nation convention on Biological Diversity.

SFM: Sustainable Forest Management.

COP: Conference of Paris

REDD+: Reducing Emissions from Deforestation and Forest Degradation.

UNCCD: Unıted Natıon Conference on combating Deforestation.

GEF: Global Environment Facility.

CITES: Convention on International Trade of Endangered Species.

ITTA: International Tropical Trade Agreement

WTO: World Trade Organization

FLEGT: Forest Law, Enforcement, Governance and Trade

UV-B: Ultra Violet-B

TIKA: Turkish Cooperation and Development Agency

ECE: European Economic Commission

FAO: UN Food and Agriculture Organization Subunits and Programs

COF: Committee on Forestry

WFC: World Forestry Congress

NEFC: Near East Forestry Commission

EFC: European Forestry Commission

FRA: Assessment of Forest Resources

UNIDO: UN Industrial Development Organization

OECD: European Economic Cooperation Organization

ECO: Economic Cooperation Organization

WB: World Bank

IUFRO: Ulternity Association of Forestry Research Organizations.

EUSTAFOR: European Forestry Association

IUCN: World Wildlife Protection Organization

CIFOR: International Forestry Research Center

JICA: Japan International Cooperation Agency

GIZA: German International Cooperation Agency

AFD: French Development Agency

EFI: European Forestry Institute

EFIMED: European Forest Institute Mediterranean Regional Office

REC: Regional Environmental Center

GDP: Gross Domestic Product

MCPFE: Ministerial Conference on the Protection of Forests in Europe

MPS: Mean patch size

AWSI: Area Weighted Shape Index

PSCV: Patch size coefficient of variation

INDC: Intended Nationally Determined Contribution

GEF: Global Environment Facility

NBSAP: National Biological Diversity Strategy and Action Plan

KTU: Karadeniz Technical University

GFI: Global Forest Inventory

1.GENERAL INFORMATION

1.1. Introduction

Turkey has 9000 plant species of which 3000 is endemic. Approximately 800 woody taxa occur in the country's forests. According to the forest inventories published by the Department of Forest Management in 2015, the total forested area in 1973 was 20.2 million ha whereas in 2015 it is calculated as 22.3 million ha, corresponding nearly 50000 ha increase per year. The productive forest is 48.2% and 51.8% is categorized as severely degraded unproductive forest. The natural forest of Turkey estimates about 91.6% and 8.4% is determined as planted forest. The forest of Turkey provides ecological (42%), sociocultural (8%) and economical (52%) functions (MFW, 2016). That brief information herald of the strong dynamics in terms of land use/land cover changes in Turkish forests.

Turkey has three biogeographical regions are Euro-Siberian Biogeographical Region which includes: broad-leaved and coniferous forests, humid and semi-humid coniferous forests, dry Oak and Pine forests, and shrub (maquis and pseudo-maquis) formation. Then the Mediterranean Biogeographical Region which includes: shrub (maquis and garigue) formation, low-altitude Mediterranean belt forests, Aegean high mountain forests, Mediterranean high mountain forests. Irano-Turanian Biogeographical Region which encompasses: Central Anatolia Steppe Forests, Central Anatolia Dry Black Pine, Oak and Juniper Forests and Eastern Anatolia Dry Oak Forests. These rich forest ecosystems of Turkey provide habitats for a great number of endemic plant species (MEF, 2007).

Moreover, the planning process has slowly evolved over time and noticeably changed over the last few decades in Turkey. From the first management plan, prepared in 1917, to the late 1990’s, forests were managed for principally commodity production as maximizing timber production according to classical planning approach. Although some attempts were experienced in some regions as pilot projects such as Mediterranean forest use project (1970s and 1980s), Turkish-German collaborative model (1990s) Forest Resource Information System (FRIS) (late 1990s) and Global Environment Facility Fund (GEF II) (2000s) to replace the negative effects of the classical approach, multiple-use planning has become the

Turkish forestry agenda in the last two decades. By 1960s, forests were managed mostly with a single-tree selection silvicultural system regardless of the biological characteristics of existing commercial trees. For instance, uneven-aged management practices were applied to forests composed solely of light demanding trees (e.g., pine forests) even though those forests reflect single-layered even-aged stand structures. Unregulated and anomalous forest structures were created across the country leaving the forest managers with great dilemma. Realizing the detrimental consequences of inappropriate management actions of the time, even-aged management practices were introduced immediately after 1963. However, foresters were seen only to meet the allowable cut levels, and applied various forms of clear-cut management action. The practitioners unwittingly neglected the renewal of the harvested areas due to heavy administrational duties, short supply of seedlings in nurseries, ill-equipped technical foresters and lack of a control mechanism. As a result, many clear-cut areas were left untreated, exposing them to harsh natural disturbances such as weed competition, soil erosion, and wind blow-down. Thus, the idea of regeneration by either natural succession or plantation was virtually overlooked. It was after 1971 that both uneven-aged management methods for tolerant trees dominated forests and even-aged for the rest of the forests were implemented across the country. On the other hand, neo-classic area-control or wood production oriented management of forest resources carried important shortcomings besides unresolved ownership, no spatial database established, forest stratification not carried; site, biodiversity, health and capacity inventory not conducted with GIS and RS, conservation of various forest values were not accommodated, decision making process with operations research techniques not conducted, and participation was not materialized. Therefore, modern management initiatives were undertaken later in the late 1990s. Various forms of multiple-use forest planning approaches were used in some forest districts. Since 2008, the planning process in Turkey has completely turned to an ecosystem based forest management concept accommodating biodiversity conservation, participation, multiple uses, and information technologies (ALTERFOR, 2017).

Başkent et al. (2008) briefed the ecosystem-based multiple use forest management planning approach in Turkey. Forest values such as biodiversity conservation are integrated into forest management planning. Forest values demands set the base to formulate policies and objectives. Effective participation of stake holders leads to the fulfillment of conflict-free management objectives. Latest research techniques can help to identify and apply the best operation while planning forest management. The planning process encompasses ground truth data, sample plots, aerial photography and forest inventory. In forest inventory increment of an area and growing stock is measured. Three main criterions for growing stock are crown closure, development stage, and type of species. The harvest time is scheduled according to "area/size regulation method".

Considering the tree richness in different biogeographic regions, application of different management methods and planning processes over time as well as other global factors such as climate change, urbanization or migration, land use and land cover changes should be displayed and forest dynamics should also be documented for better management. In order to maintain the ecological integrity and sustainable use of forest values in particular forest ecosystems, a sensible forest management is desired. Where timber is easily valued, on the other hand, it is difficult to quantify the amount and monetary value of forest ecosystem services such as water production and soil conservation. While analyzing temporal dynamics, the spatial analysis using GIS can serve as a significant indicator for changes in the forest resources such as number, size, and distribution of patches. The metrics obtain reveals the landscape structure from the past till present and predict the future which can potentially benefit the future planning of forest management (Karahalil et al., 2009). Therefore, researchers have been tried to document the spatiotemporal changes in land use/land cover especially for the last two decades in different regions in the world including Turkey for the same purposes (Bewket, 2002; Pavon, et al., 2003; Gautam, et al., 2003; Köchli and Brang, 2005; Wakeel, et al., 2005; Upadhyay, et al., 2005; Cayuela, et al., 2006; Başkent and Kadıoğulları, 2007; Karnieli, et al., 2008; Kennedy and Spies, 2004; Liu, et al., 2006; Xu, et al., 2007; Kadıoğulları and Başkent, 2008; Park and Stenstrom, 2008; Günlü, et al., 2009; Terzioğlu, et al., 2009; Turan et al., 2010; Terzioğlu, et al., 2009; Paudel and Yuan, 2012; Dewan, et al., 2012; Kadıoğulları, 2013; Kadıoğulları, et al., 2014; Beilin, et al., 2014; Şen, et al., 2015).

Among them, Ateşoğlu (2014) determine the vegetation cover of Bartin urban area from 1975-2011 in order to carry out land use and physical planning. Landsat satellite images data of 1975, 1987, 2000 and 2011 were used in the study. According to the results of vegetation status analysis 537.29 ha of the area (14.59 %) lost its vegetation quality between 1975 and 2011. The corresponding ratio of the areas included in green areas, which was out of vegetation area, remained at negative 3.33 %. This result depicted that urban structuring out of vegetation was high. The results showed that vegetation contribution on the ecological quality of study area was decreasing continuously and the effect it had on urban ecosystem was negative.

Çakır et al. (2007) determined successional changes of the plant in forest ecosystem in order to explain vegetation dynamics, structure and environmental problems of forest landscapes. The study also assessed anthropogenic and natural impacts from 1972 to 2002 in the Artvin Forest Planning Unit, in NE of Turkey. It proposed conservation of biodiversity in forest management plan using succession stages and land cover types which were determined using Clementsian theory. Geographic Information System (GIS) and Remote Sensing (RS), aerial photos and high-resolution satellite images obtained from Ikonos were used for spatial analysis. The results showed a decrease in forest area from 1972 and 2002 and decrease in forest patches were 106 and 222 respectively. They observed fragmentation, urbanization, industrial development, and dam construction, together with unregulated forestry activities with clear-cut as well as insect outbreaks, affected the secondary forest succession and fragmented the forest ecosystem in the study area. Determining the secondary forest succession in detail is necessary for the sustainable management of such fragmented forest areas and for the preparation of biodiversity-friendly integrated forest management plans.

Kadioğullari et al. (2008) determined that for sustainable management of forest, understanding the changing dynamic of land use and forest cover is important. The study focused on spatial and temporal changes in forest cover at Torul State Forest Enterprise area of Northeastern Turkey. Using GIS and FRAGSTAT forest-cover type maps from 1984 and 2005 showed huge changes in the temporal and spatial dynamics of land use i.e. forest cover. 19.9 % of the total forest was increased between 1984 and 2005 whereas; productive forest area was increased by 3161 ha. The degraded forest area was also increased by 9216 ha. Overall, the crown closure of the forest increased. Because of regeneration activities, the area of regeneration was increased and the older development stage stand was left to grow. These results clearly showed the forest quality increased while keeping in view these two parameters i.e. the crown closure and development stage. The possible reason behind was emigration of the rural population in Torul. The large fragmentation of landscape resulted as a result of heavy timber subtraction, illegal cutting, and uncontrolled stand treatments substantially over the last 21 year.

Günlü et al. (2009) conducted a study to analyze spatial and temporal changes in land use and forest cover patterns in Rize forest enterprise of the North Eastern part of Turkey. Forest cover type maps from 1984 and 2007 using GIS and FRAGSTATS used to run the spatial analysis. The statistical analysis showed the change of forest area between 1984 and 2007 i.e. 2.30% decrease in total forested areas. The productive forest areas decreased to 12506 ha but the degraded forest areas also increased to 14805 ha. Therefore, total forest areas decreased. They also examined the quality of forest by determining the crown closure and development stages which revealed the medium crown closures forest was increased. "Regenerated area increased while the other development stages were left to grow to mature development stages in the period. This is partially due to out-migration of the rural population in Rize and Çayeli towns. In terms, of spatial configuration, analysis of the metrics revealed that landscape structure in Study area had changed substantially over the 23-year study period, resulting in fragmentation of the landscape as indicated by the large patch numbers and the smaller mean patch sizes due to heavy timber subtraction, illegal cutting, and uncontrolled stand treatments".

Karahalil et al. (2009) studied that an effective forest management plan in national parks can be prepared after analyzing the historical changes of forest structure and its temporal changes in order to design the future interventions for the forest. Forest cover type maps were prepared for 1965, 1984 and 2008 after digitizing using geographic information systems. A spatial database was built for nearly 36000 ha of Köprülü Canyon National Park. Temporal and spatial (number, size and spatial distributions of patches) changes of forest resources were determined using FRAGSTATS™ program. The results showed that in the temporal and spatial dynamics of land cover/forest cover there are notable changes. Mixed forests increased about 151.7% (1570.7 ha) like agricultural and urban areas 39.8% (777.5 ha) and productive forests (crown closure > 10%) increased 21.9% (2838.8 ha) too, while other open lands decreased about 27.5% (1326.3 ha) and 459 ha pure cedar stands entirely converted mostly to the degraded and mixed forests from 1965 to 2008. In terms of spatial analysis of the metrics revealed, landscape fragmentation and changes in structure over the 43-years resulting in an increased total number of patches and decreased mean patch. They concluded that GIS coupled with fragmentation analysis has a powerful role in analyzing spatiotemporal dynamics of forest landscape for effective national park planning.

Ozen Turan et al. (2010) analyzed spatial and temporal changes in land use and land cover patterns. The study analyzed landscape structure and cover change of forest cover type maps using spatial database i.e. GIS and evaluated temporal changes of forest conditions. The results revealed that forest area increased in 13 years and defragmentation of landscape and immigration of local population to the urban area occurred. The monitoring and understanding of the dynamics of LULCC are vital for sustainable forest resource management.

Huang et al. (2010) quantitatively characterize the spatiotemporal change of land use and landscape pattern over the period 1988–2007 by using GIS, RS, gradient analysis, and landscape pattern metrics in a coastal gulf region, southeast China. The results showed an increase in cropland, buildup land and aquiculture area and a decrease in the orchard, woodland and beach area during 1988–2007. Fragmentation and pattern structures of landscape were strengthened but landscape pattern structure became more complex in the last two decades in Luoyuan gulf region. The study revealed that the spatial difference of urban and rural landscape pattern can be detected distinctively in two transects in terms of landscape metrics.

Lu et al. (2011) studied that while in adaptation and mitigation of global environmental change ecosystems can play a vital role. In order to reach a sustainable future for the biosphere, a sustainable ecosystem management is crucial. The degradation of ecology has been witnessed in these ecosystems at multiple levels and geographic locations. The main reasons for ecosystem degradation were biophysical (e.g., climate change) and socioeconomic factors and (e.g., intensive human use), which are the driving forces behind these changes. The study proposed four recommendations in order to further improve ecosystem management in China i.e. “advance ecosystem management towards an application-oriented, multidisciplinary science, establish a well-functioning national ecological monitoring and data sharing mechanism, develop impact and effectiveness assessment approaches for policies, plans, and ecological restoration projects and promote legal and institutional innovations to balance the intrinsic needs of ecological and socioeconomic systems".

In recent studies, conducted on the Terkos Laguna Lake and its surroundings, located in northwest coasts of Turkey to monitor its changes again GIS and RS techniques were used. By using land classifications, land use as well as the changes occurring in lake areas and surrounding coastline were identified. In the study area, the approachment of residential areas towards lake was prominent. In this study, Kurt (2015) found a decrease in the ratio of 9.79 km^2 (23.78 %) took place in the area of Terkos Lake in a period of 27 years from 1987 to 2014. The coastline fell to 85.62 km^2 by decreasing 116.45 km (57.74 %) in this period of 27 years. These changes were positive and effective for the nourishment of the lake due to agricultural activities, the excessive of the resources and, drought and vaporization. The case study raised the importance to make a sustainable management plan in order to prevent the occurrence of unavoidable problems in the area which is fulfilling 30 % of İstanbul's fresh water needs (Kurt, 2015).

Çil and karahalil (2015) monitor spatial and temporal changes in Gökçealan Planning Unit, Turkey. In this study, the spatial changes of tree species, development stage and crown closure and indexes such as a number of patches, average patch size for beech dominated tree species were displayed. As the management in the interventions which resulted in the decrease or increase in forest area, course of crown closure and trend in development stages. This spatial condition affects the decision for future depending upon the spatial structure such as if the forest is more like homogeneous or patch type. This research "assist to determine the level of allowable cut, to decide to merge the fragmented structure via afforestation, to begin the rehabilitation, to support species those existing in the past but tended to be disappearing or to evaluating sensitive habitats by allocating under proper forest functions".

Kılıç and karahalil (2015) suggested that in order to determine effective future forest management interventions and maintain a balance between conservation the use of comparison study to analyze current and past intervention is necessary. Therefore, a temporal and spatial changes analysis of parameters such as tree species, development age and crown closure in Ovacik Planning Unit was investigated for 40 years. Stand maps 1971 and 2008 of forest management plans and Landsat satellite images were used to conduct a supervised classification using ERDAS Imagine 2010 TM software for the three different selected classes and were compared with the stand maps. A patch analyst program which shows the spatial features such as the number, size of the forest fragments and spatial distribution changes were demonstrated. “When the obtained results are analyzed, a reduction of 392.1 ha in pure spruce stands while an increase of 607.6 ha in mixed stands were determined considering tree species. On the other hand, stands in “an” and “c” development age in 1971 increased respectively 122.8 ha and 2207.7 ha in 2008 considering the development stages. Furthermore, stands in “d” development age decreased about 4455.2 ha and 1698.8 ha forest area that managed as even aged were changed to selection forests in the same period. It was understood that middle (CC %40-70) crown closure forests decreased about 2424.9 ha while closed (CC>%70) crown closure forests increased about 2276.1 cabin 40 years”. The patch analyst showed that fragmentation was increased considering the number of patches, mean patch size and area weighted mean shape index for the same period.

Zahra et al. (2016) examined that in order to develop land use classification maps the use of geospatial techniques such as remote sensing and Geographic Information System (GIS) can serve the purpose. It gives a wide variety of selection of areas such as agricultural, industrial or urban sector of a region. The study was conducted in the capital of Pakistan, Islamabad city and its surroundings to detect the change in land use in response to the new developments (agriculture, commercial, industrial and urban) in the city. Thus from 1992 to 2012 the land use/cover changes in Islamabad was evaluated. “Quantification of spatial and temporal dynamics of land use/cover changes was accomplished by using two satellite images, and classifying them via supervised classification algorithm and finally applying post-classification change detection technique in GIS. The increase was observed in the agricultural area, built-up area and water body from 1992 to 2012. On the other hand, forest and barren area followed a declining trend”. The reasons behind this changes were economic development, climate change and population growth. A wide range of environmental impacts such as degraded habitat quality resulted as an outcome of rapid urbanization and deforestation.

A study in Tehran for designing and implementation of mitigation plans for land use land cover changes was conducted. The LULCC was classified for an arid area and the study aimed to map land use/cover by pixel and object based image classification methods to analyze landscape fragmentation and determine the effects of two different classification methods on landscape metrics. Ground truth data were used for both classification methods. Land use/cover maps of the southwest area of Tehran city for the years 1985, 2000 and 2014 were made while keeping in view the accuracy classification concept i.e. Landsat images were used for accuracy assessment. The results showed that the most important changes in built-up agricultural land categories were observed in zone B (Shahriar, Robat Karim and Eslamshahr) between 1985 and 2014. The landscape metrics obtained for all categories pictured high landscape fragmentation in the study area". The studies showed that with the help of GIS how LULCC is analyzed to obtain improved maps based on the types of classification which can be either object base or pixel based. However, both of them showed similar abilities and concluded that depending upon the surface to determine such as barren land, agriculture or buildings the classification methods can be used according (Sabr et al., 2016).

Given studies showed that, understanding and analyzing the factors affecting land-cover change, forest dynamics and spatiotemporal changes of forest ecosystems is an important factor in the management of forest products and services. The number as well as the spatial distributions of land-cover patches or forestations/deforestations throughout the landscape has an important impact on the sustainability of both forest products and services. Numerous studies were conducted to detect the land use and land cover changes and it is understood that, the forest dynamics can be analyzed over time using GIS and remotely sensed data. Change detection using GIS helps in estimating the trends of change in land use (Güler et al., 2007) and forest cover type, to a certain extent (Kadioğullari et al., 2008). The change in land use indicates an important role in environmental changes and its role in biodiversity loss and global change (Wang et al., 2006). Therefore, LULCC in various landscapes give a high scope to conduct a study in the study area. Due to the changes in forest resources and planning approaches, there is need of researches. While planning process of forests we need to investigate the trend in the forest need to merge fragmented structure via afforestation, begin the rehabilitation, evaluate the effects of past intervention, how we can perform the monitoring, changes in land cover, and to what direction. These queries requires knowledge about decrease or increase in terms of forest area, trend in development stages such as towards thinner or thicker diameter classes or course of the crown closure, spatial structure of forests as homogeneous or patch type, species those existing in the past but tended to be disappear and interaction of these human induced disturbances to land cover.

Moreover, while the literature reveals the importance of LULCC changes with the timeline in order to study the previous, present trend and predict future trends, the role of the international community to raise awareness and setting up guidelines for researchers and for future researchers is notable. The international processes such as Rio, Pan Europe, Forest Europe or GEF are serving as basic guidelines in the forestry. Based on the literature review a large number of researches have been conducted on detecting land use land cover changes including forest cover type changes. However, hardly there is any research to relate the LULCC and forest change to forest management planning process and guidelines as well as international agreements. There is a need to build constructive criticism and suggest innovation for multiple values of forest management in context with Turkey commitments on forestry related international agreements. A scientific research is required to highlight its implications towards forest management planning among decision makers and professionals. Therefore, the overall objectives of this study are:

- To measure LULCC changes by studying the temporal dynamics from 1972 to 2015 using GIS.
- To analyze patterns of changes in the landscape of the study area with special focus on forest fragmentation.
- Critical analysis of forest management dynamics in relation to Turkey's commitments on forestry related international agreements.

1.2. International Agreements Related to Turkish Forestry

International agreements are taken into account while planning the basic principles of multi-use forest management planning in Turkey (Başkent et al., 2008). The history of first ever conferences with the focus on environment date back to 1972 in UN Conference on the

Human Environment (UNCHE), Stockholm's followed by Montreal Protocol on ozone protection in 1987. After UNCHE it follows up conference includes intergovernmental panel on forests (IPF) 1995-1997, the Intergovernmental Forum on Forests (IFF) 1997-2000 and United Nation Forum on the Forest (UNFF) 2000-present. The first ever formal convention on forestry took place in 1990 called Global Forest Convention which was endorsed by G-7 industrial states. Then in 1992, UN Conference on Environment and Development (UNCED) took place in Rio de Janeiro which resulted into followings agendas, agenda 21 which focus on sustainable development goals which include sustainable forest management (SFM), Rio declaration on environment & development, statement of forest principle which is a non-binding legal framework targeting conservation, management, sustainable development of all types of forest and UNFCCC & UNCBD. The UNFCCC held in 1992 and came into force in 1994. It majors agreements includes: Kyoto Protocol 1997 which concerns GHGs emission and developed annex I and annex II countries to adapt three mechanisms i.e. international emission targets (IET), clean development mechanism (CDM) and joint implementation (JI). Then IPCC's which resulted in UNFCCC which has a follow-up COP conference. It has three main tasks, adaptation committee, cancum adaptation, cancum agreements. Then the COP conference is known as Paris agreement. It discussed issues on agriculture, LULUCF, REDD+ and REDD++ Web Platform. In COP-2 1995, forest biodiversity was included on the agenda. In COP-3 1996, sustainable use of forest biodiversity and in COP-4 1998, a technical ad-hoc expert group on forest biodiversity was formulated that review the status, trends & threats to forest biodiversity and suggests actions on conservation and sustainable use of forest biodiversity. Lastly, global warming which focuses on the overall temperature changes and rising of sea levels resulting in catastrophic natural disasters (URL-1, 2017).

Rapid process was also created some regional initiatives such as Pan-European or Near East. Those processes have also certain effects on the management of forest resources. For instance, the six Pan-European criteria for sustainable forest management includes, "maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles, maintenance of forest ecosystems health and vitality, maintenance and encouragement of productive functions of forests (wood and non-wood), maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems, maintenance, conservation and appropriate enhancement of protective functions in forest management (notably soil and water) and maintenance of other socio-economic functions and conditions" (GDF, 2008).

Forestry related conventions which remain in the highlights were UNFCCC, UNCBD, UNCCD and seven other multilateral agreements. In UNFCCC, Kyoto Protocol sustainable forest management practices, afforestation and reforestation were proposed. Industrialized countries signing the non-legally bound agreements can use them to trap carbon in their forest in the form of the sink which will lower their emission targets allowed. Convention on Biodiversity 1992 became effective in 1993, the goals were: conservation of biological diversity, sustainable use of components of biological diversity, fair & equitable sharing of genetic resources. Forest ecosystem encompasses 70% of world plants & animal species. In UNCBD, forest biodiversity policy framework and forest dependent people were also in agenda. GEF funds and support forest biodiversity. In 1994 UNCCD later enforced in 1996 included sustainable forest management, protection & expansion of forest and deforestation. Ramsar Convention on Wetland 1971 enforced in 1975 was held on mangroves forest. It was followed by World Heritage Convention in 1972 which came into force in 1975 it declared 61 forest protected sites and in-situ conservation in the forest area. 16 tree species were declared as threatened timber species in 1973 at Convention on International Trade of Endangered Species (CITES) enforced in 1975. The Vienna Convention 1988 for ozone layer protection also raised the importance of forest by calling them as UV-B tolerant. ITTA 1994 enforced in 1997 held on sustainable management of timber forest and trade. WTO in 1994 enforced 1995 bans on timber export, introduced eco-labelling, certification, sustainable forest management, improve market access to forest products and services, Community-based processing, and marketing of wood and NWFP. Measures to prevent and combat trade in illegally harvested wood was part of FLEGT 2003. (URL-1, 2017 and URL-2, 2017)

"The Ministerial Conference on the Protection of Forests in Europe 1 (MCPFE) launched in provides a regional policy framework on forests and forestry in Europe. MCPFE has defined the main concepts underlying the idea of sustainable forest management. The implementation of the ministerial commitments is carried out by countries at the national level and through the MCPFE Work Programme at the pan European level in cooperation with the

UN Economic Commission for Europe (UNECE), the UN Food and Agriculture Organization (FAO), the Environment for Europe (EfE) Ministerial Process and the Pan-European Biological and Landscape Diversity Strategy (PEBLDS), as well as other partners. The UNECE Timber Committee and the FAO European Forestry Commission are two regional bodies of the UN family who jointly implement an integrated programme whose objective is to “strengthen the forest sector and its contribution to sustainable development throughout the UNECE region”. The programme focuses on monitoring and analysis, promoting sustainable forest management, including through capacity building, and providing a forum for exchange on policies and topical issues. The Pan-European Biological and Landscape Diversity Strategy (PEBLDS) was developed in 1994 to stop and reverse the degradation of biological and landscape diversity values in Europe, promoting the integration of biological and landscape diversity considerations into social and economic sectors. The Strategy provides a framework to promote a consistent approach and common objectives for national and regional action to implement the Convention on Biological Diversity. To halt the loss of biodiversity in the Pan-European Region, catalytic actions have been defined with stakeholders, reflected in the PEBLDS Pan-European 2010 Biodiversity Implementation Plan.

Mentioned various international agreements and processes related to forestry, meetings, conferences, seminars and similar activities held within this scope are also affected forestry approaches or regulations.

In brief, international contracts related to environment and forestry issues that are the subject of Turkey are as follows: From Rio summit outputs chapter 11, titled "fighting against deforestation", forestry principles, Rio declaration, agenda 21, United Nations Convention on Biological Diversity, United Nations Convention to Combat Desertification and United Nations Framework Convention on Climate Change. The Cartagena and Nagoya Protocols under the Biological Diversity Convention, under the UN Framework Convention on Climate Change, the Kyoto Protocol and United Nations Economic Commission for Europe (UNECE) Long-range Transboundary. (EMEP) Convention on Long-Term Financing of the Co-operation Program for the Monitoring and Evaluation of Air Polluters' Long-Term Transmission in Europe, Convention on Wetlands of International Presence as Water birds Living Environment (RAMSAR), The Convention on the Protection of the Wildlife and

Livelihoods of Europe (BERN) and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The International Convention on the Protection of Birds and Convention on the Protection of World Cultural and Natural Heritage (World Heritage Convention), and Protection of the Mediterranean Sea and Coastal Zone Conservation Agreement (BARCELONA). European Landscape Contract (Florence Convention) and the Convention on the Prevention of Land Pollution (Paris Convention), and Stockholm Convention on Damage Organic Pollutants (Stockholm Convention). The Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) and Convention on the Protection of the Ozone Layer (Vienna Convention). Protocol on the Investigation of the Ozone Layer (Montreal Protocol) and Convention on the Control of the Transport and Disposal of Hazardous Wastes (Basel Convention). Mediterranean Forestry Partnership Agreement and EU legislation, policies and initiatives related to forests. Moreover, international processes related to environment and forestry issues that are the subject of our country are as follows: Intergovernmental Forestry Panel (IPF) and Forum (IFF), UN Forestry Forum (UNFF), Ministerial Conference on Forest Preservation in Europe (FOREST EUROPE), Near East Forestry and Pasture Process and Strengthening and Governance of Forest Laws in Europe and North Asia Region Process (ENA-FLEG) (Anonymous, 2007; Anonymous, 2011).

Mentioned, agreements or contacts have certain effects on the management planning of forest resources especially the allocation of forest values with increasing ecological and social aspects as can be seen in the study area Gölcük.

2.MATERIAL AND METHODS

2.1. Study Area

The Gölcük forest management unit selected as study area is a state owned forest with a small part belongs to private owner. The study area is 40°43'35"-40°36′50″ with north latitudes, 29°42'28"-29°50'47" between the east longitudes and ED 1950 UTM ZONE 35N and 6°coordinate zone (Figure 1).

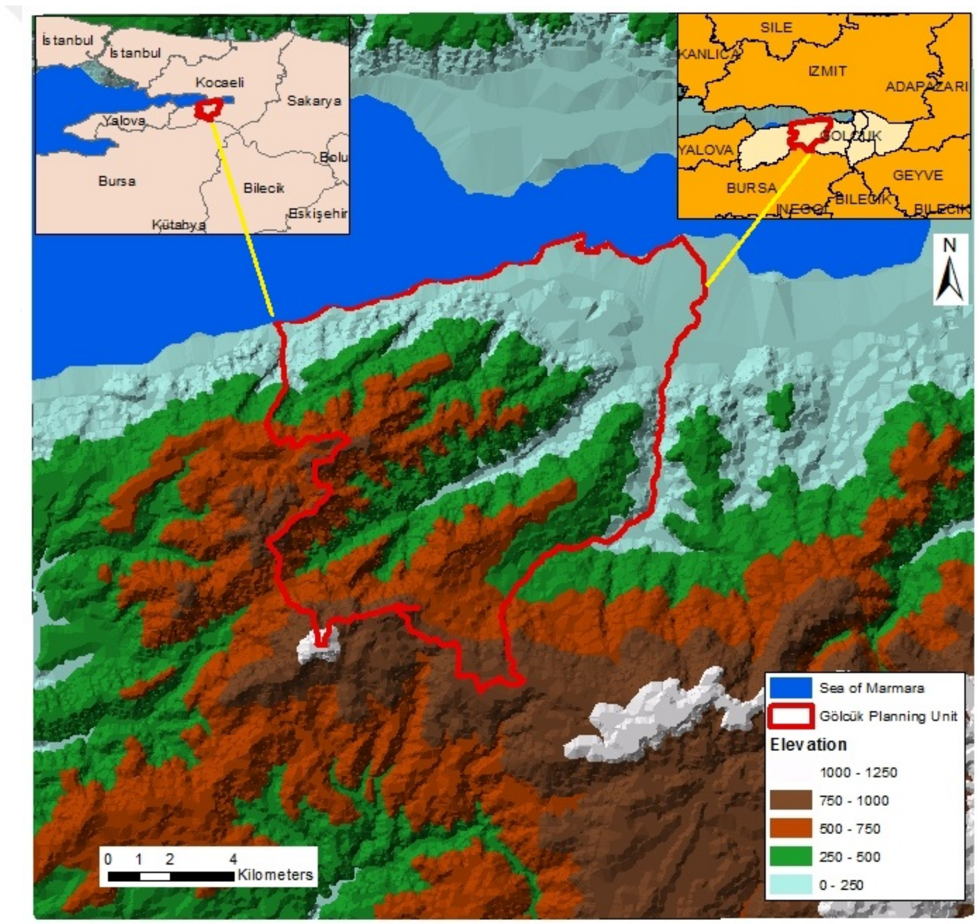

Figure 1. Spatial location of the study area

The planning unit has the Sea of Marmara on the north, Kadirga on the east, Mahmudiye on the south and in the west are Karamürsel cities. The planning unit remains within the property boundaries of Kocaeli Province and administratively works under Gölcük State Forest Enterprise, affiliated to Sakarya Regional Directorate of Forestry.

2.2. People and Forest

According to Turkey's Statistical Institute, the Population census of 2013 shows that the population within the forest, in the forest and near villages is 143181 (GDF, 2015). The main livelihoods of the people living in the planning unit are agriculture and forestry. Cattle and sheep belonging to peasants graze in open areas. The people in the planned unit apart from the forest production activities supply forest villager's firewood from the forest. Since grazing is uncontrolled, this issue continues to damage the forest partly.

2.3. Methods

In order to conduct 43 years of analysis, 1972, 2004 and 2015 years dataset is used to find spatial-temporal change. In order to obtain the spatiotemporal analysis species mix, development stages, crown cover, growing stock, forest value maps and LULCC map were generated. The analysis was made using Arc Map 9.2. Firstly, the cartographic map of 1972 is coordinated with the help of typographic maps and then digitized with a 1/3000 scale. After digitizing following classes such as land use, development stage, growing stock, forest value and canopy cover according to the criteria set in regulations (GDF, 2014) using management plan for 1972, 2004 and 2015 were entered in the attribute tables of database. The topographic error was checked. As boundary of study area varied each period, the tool intersects in Arc tool box used to combine common boundary. Then using symbolizes, maps were generated which are discussed in the next chapter (GDF, 2008; GDF, 2014). Forest functions/values map were made according to the functions mentioned in the plans. In order to display spatial changes related to specified periods, "Patch Analyst" program were used which can operate as extension to ArcGIS software. Indexes such as number of patches, mean patch size and area weighted average shape index were used to evaluate the spatial changes Gölcük PU for 43 years. In order to handle, the changes considering different composition components, such as tree species, development stages or crown closure, some classes were generated for the coordination of data generated in different periods.

2.3.1 Land Use Classes

Land use classes represent the limits of land use existing in the study area. For the land use cover change map, the stands were classified as forest, non-forest, degraded, private forest, agriculture, open areas and residential areas as shown in the table below for 1972, 2004 and 2015 (Table 1).

Table 1. Land use classes and description

Land Use Classes	Description
High Forest	It includes productive (crown closure >10%) deciduous, conifers, pure stands and mixed high forest stands
Cadastral Forest	It includes tree communities with cadastral problems (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, etc.
Agriculture	Agricultural lands
Residential Areas	Settlements, houses and commercial areas
Agriculture & Residential areas	Mix of Agriculture and Residential areas

2.3.2 Species Mix Types Classes

Species mix types classes show the existing tree species and stand type in the study area. In this research, stand is classified as non-forest, degraded, coppice forest, private forest and mixed forest. Whereas, the high forest is further classified in the pure stands as shown in the table below for 1972, 2004 and 2015 (Table 2).

Table 2. Species mix classes and description

Species Mix Type Classes	Description
Non Forest	Open lands, agriculture residential area, mine, warehouse, roads, graveyard and etc.
Private Forest	It includes forested land owned by private owners
Mixed Forest	It includes mixed productive (crown closure>10%) high forest stands
Coppice Forest	Coppice of poor medium and good stands
Degraded Forest	Forest which has been degraded or failed to regenerate. Canopy cover less than 10%
Cadastral Forest	It includes tree communities with cadastral problems (generally bigger than 3.0 ha and not adjacent to state forest lands)
Kn	*Fagus orientalis*
Ks	*Castanea sativa*
Çz	*Pinus brutia*
Mz, Ms, M	*Quercus spp.*
Kz	*Alnus glutinose*
Kv	*Populus spp.*
Ya	*Robinia pseudoacacia*

2.3.3 Development Stage Classes

Development stage classes are determined on basis of tree diameter at breast height. Development stage used in forest management of Turkey is shown in the table below and further classes according to the available dataset were added (Table 3).

Table 3. Stand development stage

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	
	Medium-poor	
Degraded Forest	Forest which has been degraded or failed to regenerate. Canopy cover less then 10%	
Non Forest	Open lands, agriculture, open land, 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 with cadastral problems (generally bigger than 3.0 ha and not adjacent to state forest lands)	

2.3.4 Crown Closure Classes

Crown closure classes show the crown closure or canopy cover of trees or stand. The crown closure classes with codes and percentage use are described below (Table 4).

Table 4. Stand crown closure classes.

Code	Crown closure classes	Percentage %
0	Degraded stands	Less than 10%
1	Dispersed Forest	11-40%
2	Mild covered	41-70%
3	Dense/full covered	71-100%
4	Non Forest	Other than forest
5	Private Forest	Private and cadastral forest

2.3.5 Spatial Matrics

A wide and diverse set of spatial metrics can be found. While these metrics address most of the identified spatial patterns of urban growth, spatial metrics used in urban shrinkage studies are much scarcer and not nearly sufficient to provide a comprehensive assessment of its spatial patterns. Martin et al., (2003) explores a framework combining remote sensing and spatial metrics aimed at improving the analysis and modeling of urban growth and land use change. Starting with a review of recent developments in each of these fields, we show how the systematic, combined use of these tools can contribute an important new level of information to urban modeling and urban analysis in general. We claim that the proposed approach leads to an improved understanding and representation of urban dynamics and helps to develop alternative conceptions of urban spatial structure and change.

3. RESULTS

From 1972 till 1991 the Gölcük forest management was planned in Ayvaşa Serisi and Naldöken series and operated on the basis of the province. In 1972 plan general hector area was 6946.30 ha, 4566.63 ha forest area and 2378.77 ha of non-forest. The hector area of forest consists of normal coppice i.e. 4488.14 ha, 194.39 ha coppice forest and 12.30 ha of degraded coppice forest. In 1994 the forests of Gölcük forest management was planned by combining these series with organized plan. The total area of Gölcük was 17641 ha out of which 9512 ha of woodland and 8129 ha of open area was present. In 1994-2003 planning years, the Gölcük Forest Management total area consisted of 12493 ha of forest whereas in 7945 ha area, deforestation occurred. According to 2004 plan the general hector area of forest planning unit is 20425 ha out of which the total forest area is 12263 ha, 7912 ha account for non-forest and 250 ha is private forest. Whereas, in 2015 the total forest area is 6328.5 ha, open area is 81.3 ha, and non-forest area is 5727.5 ha and the general area is accounted as 12137.3 ha (GDF, 1972; GDF, 2004; GDF, 2015).

3.1. Changes in Land Use Land Cover Type

The trend of land use land cover in 1972, 20014 and 2015 were given in Figure 2. Over 43 year’s coppice, agriculture and degraded forest decreased. Open areas and private forest areas remained same almost. Residential area increased slightly. Additionally, cadastral forest, a mixed class of agriculture and residential area emerged in 2015 which indicates the new types of land use class introduced in the area according to new use. The most evident change is the high forest which increased approximately up to 3000 ha from 1972 to 2015.

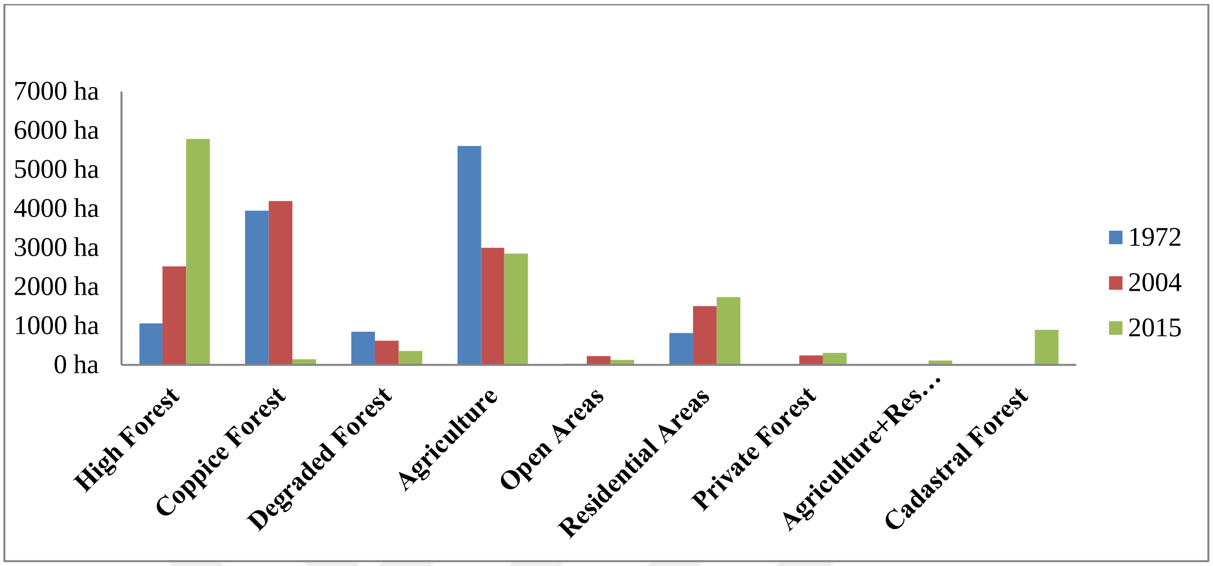

Figure 2. Land use/land cover graph in 1972, 2004 and 2015.

Coppice forests were decreased at a very significant amount due to the change in policy by directorate general in 2004 where the coppice forest was decided to be replaced by high forest and graph clearly explicit that coppice forest almost dissapered in the last period. Degraded forests were progressively decreased. Private forests were appeared in the last two periods. etc.

LULCC map shows that degraded forest and agricultural area shrunk which resulted in an increase in the forest area (Figure 3). An increase in a number of open areas can be seen in 2004 which are replaced by forest areas in 2015. The residential areas have been greatly increased replacing the agricultural land. Moreover, the increasing amount of private forest is also evident from the year 2004 until 2015. The change maps from 1972 and 2015 depict a significant amount of change occurred during this period of time.

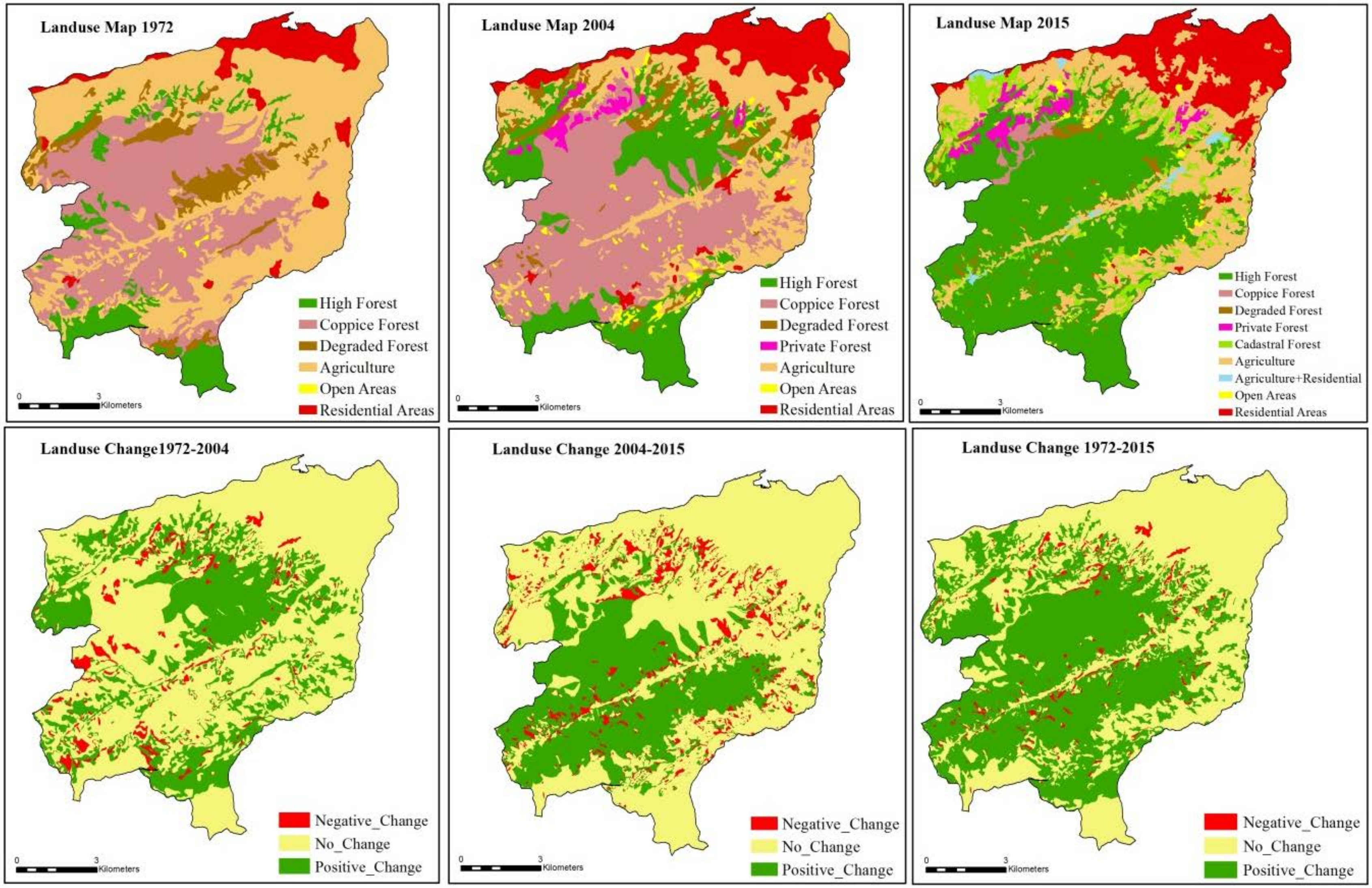

Figure 3. LULCC Map of 1972, 2004 and 2015.

As land use classes represent the limits of land use existing in the study area. So for the land use change map, the stands were classified as forest, non-forest, degraded, private forest, agriculture, open areas and residential areas as shown in the below table for 1972, 2004 and 2015 (Table 5).

The analysis shows that 742.9 ha agriculture land in 1972 turned to residential area in 2004. On the other hand, 420.6 ha and 849.3 ha agriculture area changed to degraded and coppice forest respectively. 313.8 ha of degraded forest converted to coppice forest and 331.4 ha converted to high forest. Similarly, 933.8 ha of coppice forest converted to high forest and 238.3 ha of high forest converted to coppice forest.

The transition metrics analysis shows that in 2004, 7585 ha of total forest areas are present (which includes coppice, degraded, high forest and private forest) whereas, in 2015 the total forest area is 7486 ha. Out of 12307 ha of the area existing 628 ha of forest area converted into non forest in 2015 whereas 529 ha of non-forest area converted to forest. Thus the result shows an increasing amount of forest area. 500 ha agriculture area converted to residential areas and vice versa 171.5 ha to agriculture area. 212.4 ha of degraded forest converted to agriculture and 146 ha to cadastral forest and 149.8 ha to high forest. 3461.7 ha of coppice forest converted to high forest.

Similarly, the pivot table obtained for 1972 and 2015 also indicates that in 1972, 5857 ha of total forest areas is present(which includes coppice, degraded, high forest and private forest) whereas, in 2015 the total forest area is 7486 ha. Out of 12307 ha of the area existing 253 ha of forest area converted into the non-forest in 2015 whereas 1882 ha of non-forest area converted to forest. Thus the result shows an increasing amount of forest area. 1053.1 ha of agriculture area converted into residential area and 870 ha to High forest. 570 ha of degraded forest converted into high forest and 3469.3 ha of coppice forest changed into high forest.

Table 5. Change matrix for land use/land cover between 1972 and 2004 in Gölcük PU (ha)

		2004							
		Agriculture	**Residential Area**	**Open Areas**	**Degraded Forest**	**Coppice Forest**	**High Forest**	**Private Forest**	**Total**
1972	**Agriculture**	2776.6	742.9	169.7	420.6	849.3	581.4	60.1	5600.4
	Residential Area	49.9	755.4	-	2.7	8.3	0.9	-	817.2
	Open Areas	-	-	3.8	1.5	27.6	0.0	-	33.0
	Degraded Forest	43.9	0.0	6.5	137.1	313.8	331.4	11.9	844.6
	Coppice Forest	76.9	6.3	35.0	30.5	2764.7	933.8	97.9	3945.2
	High Forest	48.3	1.7	5.8	21.7	238.3	676.7	74.8	1067.3
	Total	2995.5	1506.4	220.8	614.1	4202.0	2524.3	244.6	12307.8

Table 6. Change matrix for land use/land cover between 2004 and 2015 in Gölcük PU (ha)

		2015									
		Agricul.	**Agr.+Resi.**	**Residential**	**Open Area**	**Cada. For.**	**Deg. For.**	**Copp. For.**	**High For.**	**Priva. For.**	**Total**
2004	**Agricul.**	2005.7	52.7	500.2	56.5	195.3	77.7	1.7	97.2	8.5	2995.5
	Residential	171.5	54.7	1224.8	4.8	46.3	0.8	-	3.6	-	1506.4
	Open Areas	102.6	0.1	8.5	10.9	18.3	22.6	-	55.1	2.6	220.8
	Private Forest	8.3	-	-	0.1	11.1	1.7	2.4	39.1	182.0	244.6
	Degra. For.	212.4	0.9	5.7	8.9	146.0	76.0	-	149.8	14.4	614.1
	Coppice For.	205.7	3.9	0.2	32.0	214.7	123.5	142.1	3461.7	18.2	4202.0
	High Forest	137.6	1.7	0.7	10.0	272.8	49.3	-	1976.5	75.7	2524.3
	Total	2843.9	114.0	904.6	146.3	351.5	5782.9	123.2	301.3	1740.1	12307.8

Table 7. Change matrix for land use/land cover between 1972 and 2015 in Gölcük PU (ha)

		2015									
		Agricul.	**Agri+Res**	**Residen.**	**Open Ar.**	**Cad. For.**	**Degr. For.**	**Cop. For.**	**High For.**	**Priv. For.**	**Total**
1972	**Agricult.**	2549.6	72.3	1053.1	87.7	704.5	169.9	6.3	870.0	87.0	5600.4
	Resident.	100.3	33.4	669.4	0.0	10.6	1.2	-	2.4	-	817.2
	Open Ar.	0.8	-	-	1.4	1.2	1.0	-	28.6	-	33.0
	Deg. For.	47.5	2.8	0.3	12.2	58.6	117.0	22.1	570.0	14.1	844.6
	Cop. For.	85.1	5.5	-	18.0	89.6	56.3	112.8	3469.3	108.5	3945.2
	High For.	60.6	-	17.3	4.0	40.1	6.0	5.1	842.6	91.7	1067.3
	Total	2843.9	114.0	1740.1	123.2	904.6	351.5	146.3	5782.9	301.3	12307.8

3.2. Changes in Tree Species Mix

The changes in main tree species and mixture were further analyzed and given in Figure 4. The map obtained showed clearly that the coppice forest is replaced by mixed forest and pure stands. This practice was introduced by general directorate of forestry in 2004. Three major changes are prominent the coppice forest replaced by mixed and pure stands, the increase in forest cover in non-forest areas which in result caused decrease in the non-forest area. This means that the forest has gone healthier than before. The change maps from 1972 and 2015 show that a significant amount of change occurred during this period of time. A survey was conducted to reveal the causes of this change.

In the pivot table obtained for 1972 and 2004, the degraded forest consists of 844 ha in 1972 which reduced to 614 ha in 2004. In contrary to that, the non-forest area of 6450 ha in 1972 decreased to 4722 ha in 2004. 302 of degraded forest converted to mixed forest in 2004.424 ha of non-forest converted to degraded forest, 523 ha to mixed forest and 885 ha to coppice forest. 911 ha of coppice forest in 1972, changed to mixed high forest in 2004. Moreover, there is a significant change which shall be considered that is a change of coppice practice. In 2004 the Forest Directorate decided to convert Turkish forest from coppice to mixed and pure stands. As a result of this 916 ha of coppice is changed to the mixed forest in 2004 (Table 8).

The transition table obtained for 2004 and 2015, the degraded forest consists of 614 ha in 2004 which reduced to 351 ha in 2015. In contrary to that, the non-forest area of 4722 ha in 2004 increased to 4821 ha in 2015. 3350 ha of coppice forest in 1972, changed to mixed high forest in 2005. 227 ha of degraded forest converted to non-forest in 2015 whereas 101 ha of non-forest converted to the degraded forest which indicates that regeneration occurred in the areas (Table 9).

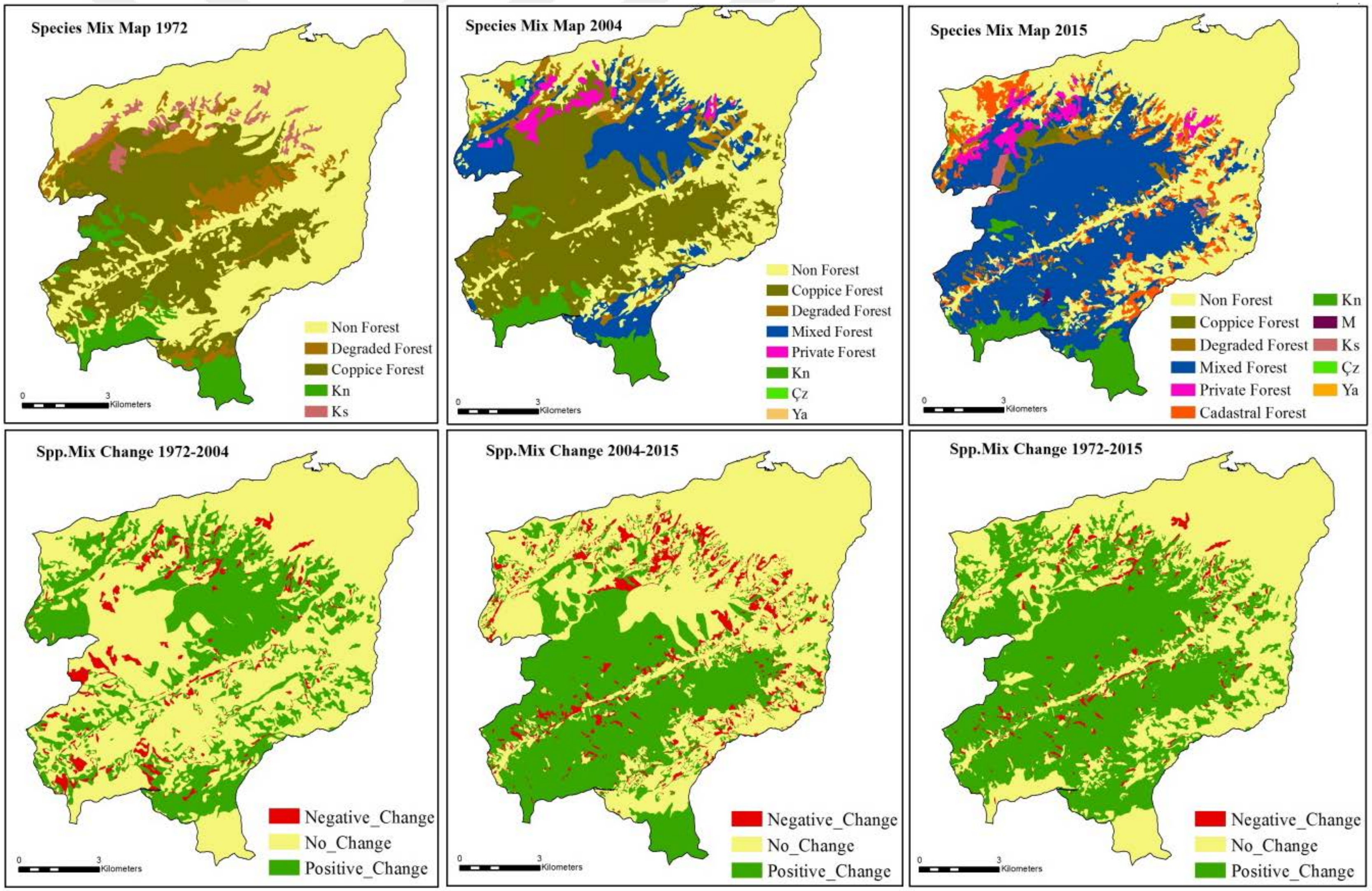

Figure 4. Species mix map of 1972, 2004 and 2015 in Gölcük PU (Kn:*Fagus orientalis*; M: *Quercus spp*.; Ks:*Castanea sativa*; Çz:*Pinus brutia*; Ya: *Robinia pseudoacacia*)

Table 8. Change matrix for tree species mix between 1972 and 2004 in Gölcük PU (ha)

		2004								
		Non Forest	**Degra. For.**	**Copp. For.**	**Mixed For.**	**Kn**	**Çz**	**Ya**	**Private For.**	**Total**
1972	**Non Forest**	4498	425	885	523	34	21	3	60	6451
	Degraded Forest	50	137	314	302	12	6	12	12	845
	Coppice Forest	118	30	2765	911	23	-	-	98	3945
	Kn	4	1	181	18	541	-	-	-	746
	Ks	52	21	57	117	-	-	-	75	321
	Grand Tot.	4723	614	4202	1871	611	27	15	245	12308

Table 9. Change matrix for tree species mix between 2004 and 2015 in Gölcük PU (ha)

		2015											
		Non Fo.	**Ca. For.**	**De. For.**	**Co. For.**	**Mix Fo.**	**Kn**	**M**	**Ks**	**Çz**	**Ya**	**Pri. For.**	**Total**
2004	**Non Forest**	4193	260	101	2	142	7	-	2	1	4	11	4723
	Degra. For.	228	146	76	-	145	-	-	-	3	2	14	614
	Coppice Fo.	242	215	123	142	3350	18	11	82	-	2	18	4202
	Mixed Forest	143	251	48	-	1258	91	-	5	-	-	76	1871
	Kn	3	-	1	-	73	534	-	-	-	-	-	611
	Çz	4	19	1	-	0	-	-	-	3	-	-	27
	Ya	1	3	0	-	2	-	-	-	-	9	-	15
	Private For.	8	11	2	2	39	-	-	-	-	-	182	245
	Total	4821	905	351	146	5009	650	11	89	7	17	301	12308

Table 10. Change matrix for tree species mix between 1972 and 2015 in Gölcük PU (ha)

		2015											
		Non Fo.	**Ca. For.**	**De. For.**	**Co. For.**	**Mi. For.**	**Kn**	**M**	**Ks**	**Çz**	**Ya**	**Pri. For.**	**Total**
1972	**Non Forest**	4568	716	172	6	851	31	-	13	3	2	87	6451
	Degraded Forest	63	59	117	22	504	47	-	-	4	16	14	845
	Coppice Forest	109	90	56	113	3338	52	7	72	-	-	109	3945
	Kn	4	-	2	-	217	519	4	-	-	-	-	746
	Ks	78	40	4	5	100	-	-	3	-	-	92	321
	Total	4821	905	351	146	5009	650	11	89	7	17	301	12308

In the pivot table obtained for 1972 and 2015, the degraded forest consists of 844 ha in 1972 which reduced to 351 ha in 2015. In contrary to that, the non-forest area of 6450 ha in 1972 decreased to 4821 ha in 2015. The degraded forest converted to 62 ha of non-forest and 503 ha of mixed forest in 2015 whereas 172 ha of non-forest just converted to degraded forest, 716 to cadastral forest and 851 ha to mixed forest. Moreover, there is a significant change which shall be considered that is the change of coppice practice. As a result of this 3338 ha of coppice is changed to the mixed forest in 2015.

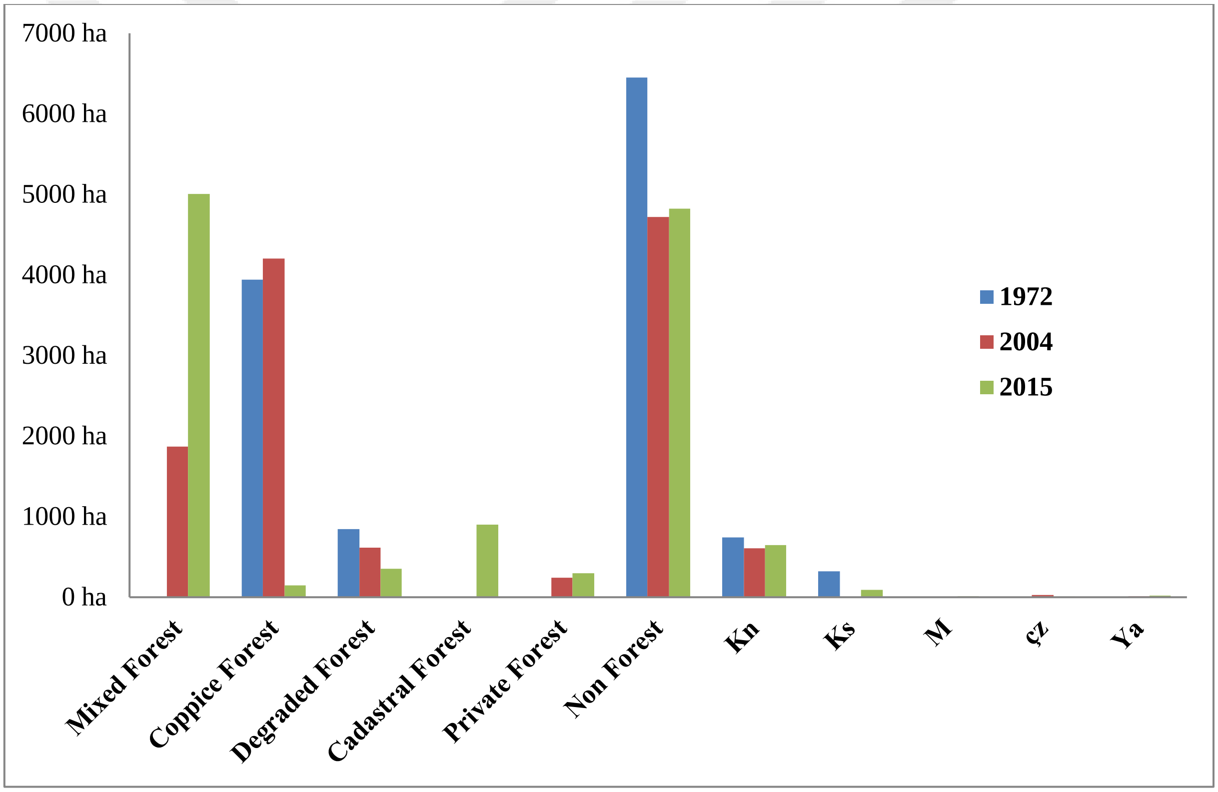

Figure 5. The changes in species mix for the periods of 1972, 2004 and 2015 in Gölcük PU

The trend of species mix in 1972, 20014 and 2015 were represented in Figure 7. Over 43 years, coppice forest changed to mixed high forest, degraded and non-forest decreased, beech pure stand remained prominent among other pure stands of oak, chestnut and black locust. Whereas, in 2015 some addition of cadastral forest and private forest can be seen.

3.3. Changes in Development Stage

Besides the land cover changes, dynamics in terms of developmental stage were further analyzed (Figure 6). Development stage change map shows large amount of positive change showing between 1972 and 2015, and 1972 and 2004.

In the pivot table obtained for 1972 and 2004. In 1972 the degraded forest was 845 ha which decreased to 614 ha in 2004 whereas; the non-forest area in 1972 was 6450 ha which decreased to 4722 ha. 348 ha non forest area change to “ab” stage. 885 ha of non-forest change to coppice forest. 314 ha of degraded forest changed to coppice forest and 300 ha change to “ab”. On the other hand, 35 ha “d” stage turned to “ab” and “b”, probably for the reason of regeneration. 872 of coppice forest change to “ab”. 118 “abd” changed to “K”.

In 2004 the degraded forest was 614 ha which decreased to 351 ha in 2015 whereas; the non-forest area in 2004 was 4722 ha which increased to 4821 ha. 628 ha of forest converted to non-forest. Similarly, 529 ha of non-forest convert to the forest. 260 ha of non forest changed to cadastral forest and 101 ha to degraded forest. 228 ha of degraded forest changed to non-forest. 242 ha of coppice forest change to non-forest and 215 ha to cadastral forest. 1462 ha of coppice forest turned to “b” and 1801 to “bc”. 299 ha and 867 ha “ab” turned to “b” and “bc”.

In the pivot table obtained for 1972 and 2015, in 1972 the degraded forest was 844 ha which decreased to 451 ha in 2015 whereas, the non-forest area in 1972 was 6450 ha which decreased to 4821 ha. Here, we understood that Gölcük forests is not composed of large trees because, “d” development stage has only 28 ha. 716 ha of non-forest changed to cadastral and 553 ha to “bc” stage. Similarly, 274 ha of degraded forest changed to “bc”. The most evident change was 1328 ha of coppice changing to “b” and 1968 ha to “bc” stage.

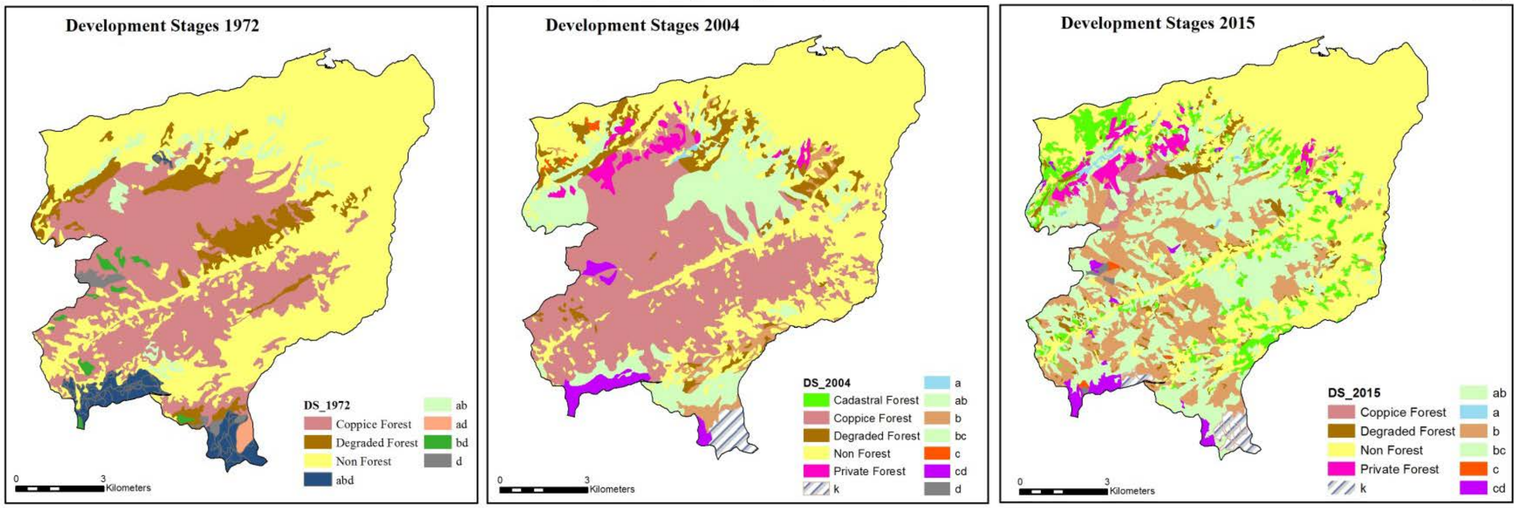

Figure 6. Development stage maps of 1972, 2004 and 2015 in Gölcük PU.

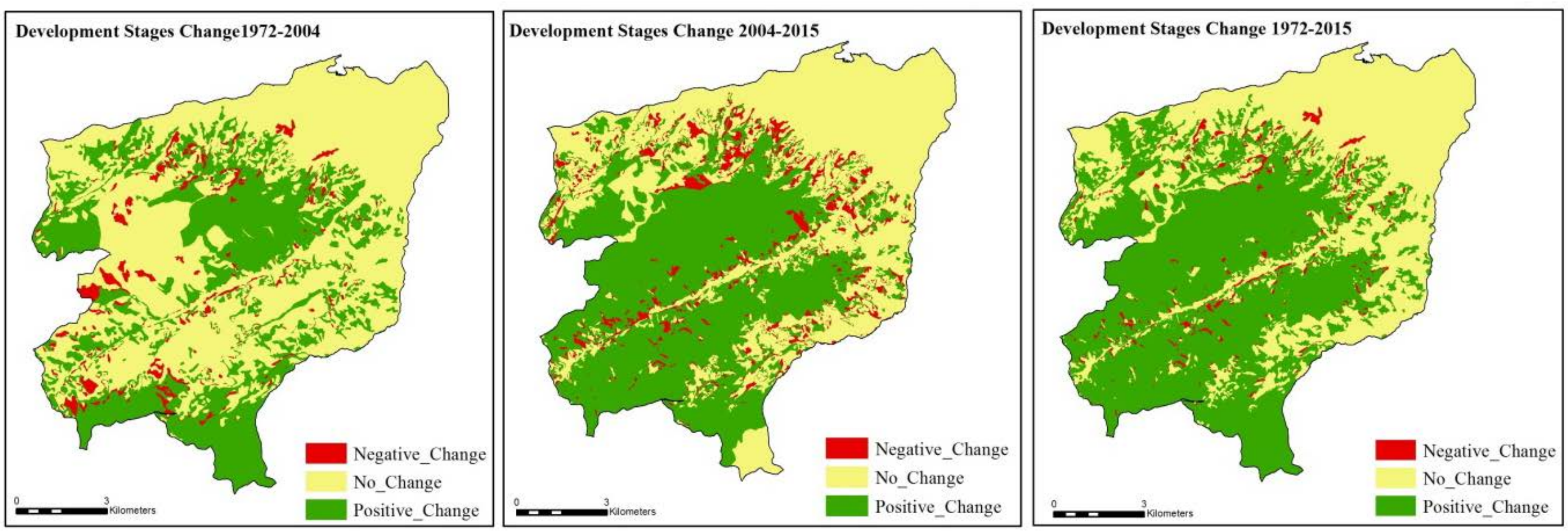

Figure 7. Development stage change maps of 1972, 2004 and 2015 in Gölcük PU.

Table 11. Change matrix for development stages between 1972 and 2004 in Gölcük PU (ha).

		2004											
		Non Fo.	**De. For.**	**Co. For.**	**a**	**ab**	**b**	**bc**	**c**	**cd**	**k**	**Pri. For.**	**Total**
1972	**Non Forest**	4498	425	885	3	348	150	50	21	9	-	60	6451
	Degraded For.	50	137	314	12	300	14	-	6	-	-	12	845
	Coppice Forest	118	30	2765	-	872	44	4	-	14	-	98	3945
	ab	51	21	84	-	104	13	14	-	-	-	68	354
	abd	4	-	49	-	6	33	93	-	157	118	7	467
	ad	-	-	-	-	-	2	-	-	-	51	-	53
	bd	1	1	73	-	9	2	-	-	12	-	-	97
	d	-	-	32	-	4	31	-	-	28	-	-	95
	Total	4723	614	4202	15	1643	289	161	27	220	169	245	12308

Table 12. Change matrix for development stages mix between 2004 and 2015 in Gölcük PU (ha).

		2015													
		Non F.	**Ca. For.**	**D. Fo.**	**Co. For.**	**a**	**ab**	**b**	**bc**	**c**	**cd**	**d**	**k**	**P. For.**	**Total**
2004	**Non Forest**	4193	260	101	2	2	15	51	85	-	2	-	-	11	4723
	Degra. For.	228	146	76	-	28	24	11	83	-	3	-	-	14	614
	Coppi. For.	242	215	123	142	5	173	1462	1801	1	19	1	-	18	4202
	a	1	3	-	-	-	10	-	2	-	-	-	-	-	15
	ab	102	176	45	-	9	75	299	867	-	13	-	-	56	1643
	b	32	70	3	-	-	1	31	130	-	2	-	1	19	289
	bc	10	5	1	-	-	1	24	104	8	8	-	2	-	161
	c	4	19	1	-	-	-	-	-	-	3	-	-	-	27
	cd	1	-	-	-	-	-	7	23	9	119	27	34	-	220
	k	-	-	-	-	-	-	7	22	-	2	-	139	-	169
	Private For.	8	11	2	2	-	1	7	31	-	1	-	-	182	245
	Total	4821	905	351	146	44	299	1899	3148	19	172	28	175	301	12308

Table 13. Change matrix for development stages mix between 1972 and 2015 in Gölcük PU (ha).

		2015													
		N. For.	**Ca. For.**	**D. For.**	**Co. Fo.**	**a**	**ab**	**b**	**bc**	**c**	**cd**	**d**	**k**	**P. For.**	**Total**
1972	**Non Forest**	4568	716	172	6	11	46	274	553	-	17	-	-	87	6451
	Degrad. For.	63	59	117	22	29	93	163	274	-	10	-	-	14	845
	Coppice For.	109	90	56	113	4	146	1328	1968	1	17	5	-	109	3945
	ab	78	37	4	5	-	9	30	98	4	2	-	-	85	354
	abd	2	3	2	-	-	-	60	143	7	110	5	129	7	467
	ad	-	-	-	-	-	-	8	-	-	-	-	46	-	53
	bd	1	-	-	-	-	4	26	56	-	7	3	-	-	97
	d	-	-	-	-	-	-	9	56	7	8	15	-	-	95
	Total	4821	905	351	146	44	299	1899	3148	19	172	28	175	301	12308

3.4. Changes in Crown Closure

Gölcük forests were also analyzed in terms of crown closure. Results show that large amount of positive change showing between 1972, 2004 and 2015. Whereas the map from 2004-2015 shows the major negative change. This evident negative change from 2004-2015 indicates code 0 that is degraded forest or less than 10% cover. The percentage cover should also be taken into account for regeneration. Regeneration took place in the area so this negative change is healthy as it is also indicating towards the new trees growing which have less foliage due to early stages. The no change majorly belonging to code 4 and 5 which are the non-forest and private forest and cadastral forest. Degraded crown closure of forest is reduced and changed to non-forest class in crown closure (Figure 7).

Similarly, the pivot table obtained for 1972 and 2004 shows that 614 ha of degraded crown closure exist in 2004, which were 844 in 1972. The degraded forest which has changed to the non-forest is 50 ha in 2015. 1770.8 ha forest having crown closure 1, changed into 3, 2111 ha of forest having crown closure 2 changed into 3. The total ha of non-forest existing in 1972 was 6450 which has reduced by 2004 to 4722 ha (Table 14).

As 614 ha of degraded crown closure exist in 2004, which was 351 ha in 2015. So the reduction of degraded crown closure shows that the regeneration took place and the canopy cover change thus reducing the 0 code closures. 725.2 Ha of crown closure 3 changed to non-forest and 374 ha of degraded forest changed to non-forest. The degraded forest which has changed to the non-forest is 374 ha in 2015. The total ha of non-forest existing in 2004 was 4722 ha which has increased by 2015 to 5725 ha (Table 15). Similarly, 614 ha of degraded crown closure exist in 2015, which were 844 in 1972. 803.2 ha of non-forest changed to crown closure 3 and 508.8 ha of degraded forest also changed to crown closure 3. 182 ha of crown closure 2 forest changed to non-forest. The degraded forest which has changed to the non-forest is 121 ha in 2015. The total ha of non-forest existing in 1972 was 6450 which has decreased by 2015 to 5725 ha (Table 16).

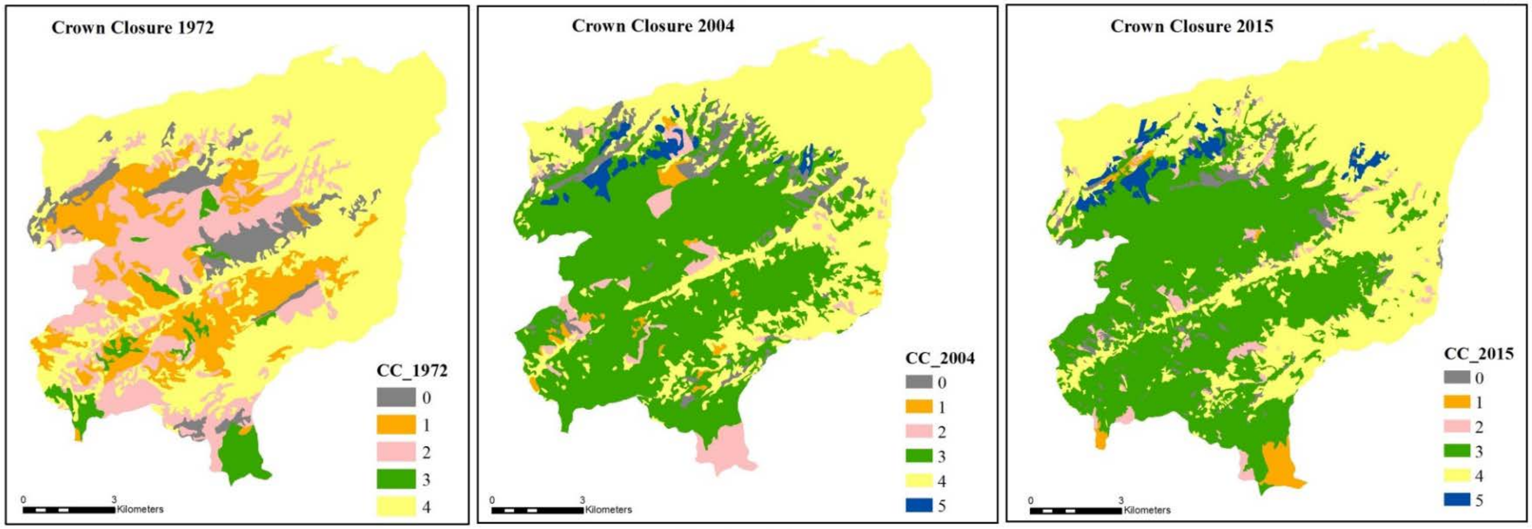

Figure 8. Crown closure maps of 1972, 2004 and 2005 in Gölcük PU.

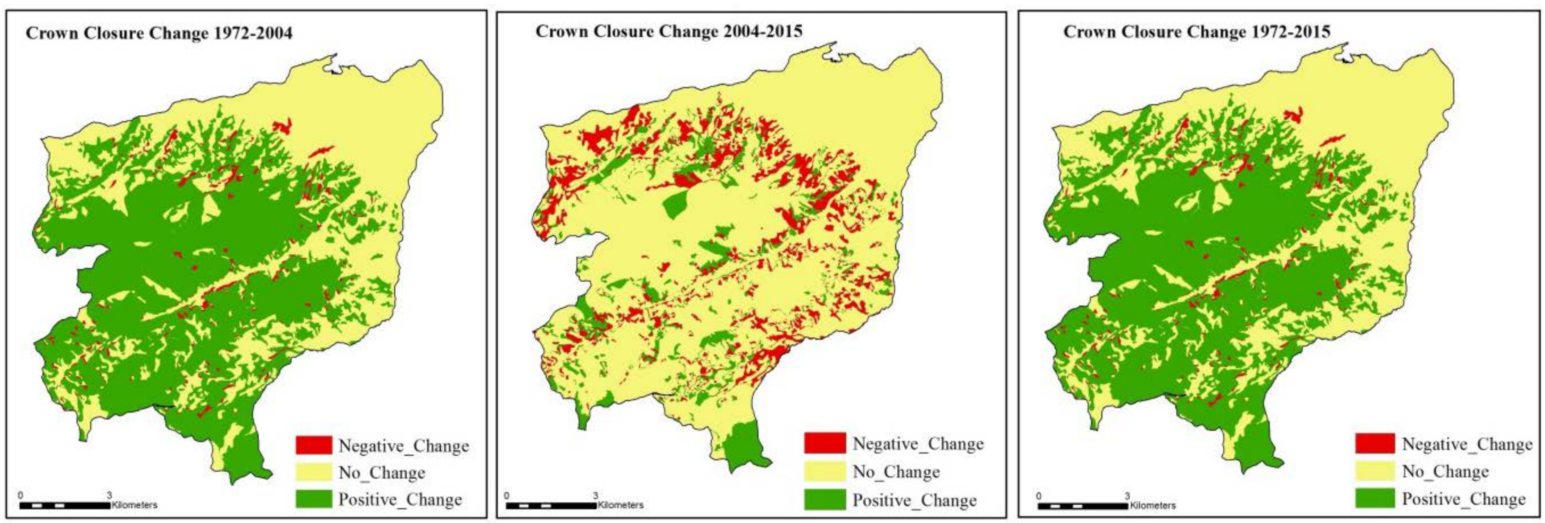

Figure 9. Crown closure change maps of 1972, 2004 and 2005 in Gölcük PU.

Table 14. Change matrix for crown closure between 1972 and 2004 in Gölcük PU (ha).

		2004						
		Non Forest	**Degraded Forest**	**1 (%11-40)**	**2 (%41-70)**	**3 (%>70)**	**Private Forest**	**Total**
1972	**Non Forest**	4498.3	424.8	80.1	151.9	1235.4	60.1	6450.7
	Degraded Forest	50.5	137.1	44.9	36.7	563.6	11.9	844.6
	1 (%11-40)	74.6	15.0	13.6	54.7	1770.8	92.4	2021.0
	2 (%41-70)	95.7	36.2	13.9	138.8	2111.4	80.3	2476.3
	3 (%>70)	3.8	0.9	6.2	185.0	319.3	-	515.2
	Total	4722.8	614.1	158.6	567.1	6000.6	244.6	12307.8

Table 15. Change matrix for crown closure between 2004 and 2015 in Gölcük PU (ha).

		2015						
		Non Forest	**Degraded For.**	**1 (%11-40)**	**2 (%41-70)**	**3 (%>70)**	**Private Forest**	**Total**
2004	**Non Forest**	4453.0	101.1	1.2	22.4	134.0	11.1	4722.8
	Degraded Forest	374.0	76.0	24.2	45.5	80.1	14.4	614.1
	1 (%11-40)	38.8	47.0	-	7.3	64.4	1.1	158.6
	2 (%41-70)	115.4	16.0	120.2	43.0	268.3	4.4	567.1
	3 (%>70)	725.2	109.8	25.3	227.3	4824.5	88.4	6000.6
	Private Forest	19.4	1.7	0.0	2.1	39.5	182.0	244.6
	Total	5725.8	351.5	170.9	347.5	5410.8	301.3	12307.8

Table 16. Change matrix for crown closure between 1972 and 2015 in Gölcük PU (ha).

		2015						
		Non Forest	**Degraded For.**	**1 (%11-40)**	**2 (%41-70)**	**3 (%>70)**	**Private Forest**	**Total**
1972	**Non Forest**	5284.2	172.1	7.4	96.8	803.2	87.0	6450.7
	Degraded Forest	121.4	117.0	25.1	58.1	508.8	14.1	844.6
	1 (%11-40)	133.5	33.0	8.1	94.3	1645.0	107.1	2021.0
	2 (%41-70)	182.0	26.4	0.1	82.2	2092.6	93.1	2476.3
	3 (%>70)	4.7	2.9	130.2	16.2	361.1	-	515.2
	Total	5725.8	351.5	170.9	347.5	5410.8	301.3	12307.8

3.5. Spatial Analysis

The spatial analysis of the landscape pattern indicated that the total number of patches increased from 118 to 279 between 1972 and 2004 and then jumped to 634 in 2015 as all patch types were taken into account (Table 17). Mean Patch Size (MPS) decreased from 596 ha to 335 ha in the same period. Area Weighted Shape Index (AWSI) increased from 22 to 41. The patch size coefficient of variation (PSCV) increased from 1261 to 2998.

The number of patches was almost doubled in non forest and degraded forests from 49 to 116 and 23 to 56 respectively between 1972 qnd 2004. On the other hand the same indices was decreased in Beech and Chestnut high forests.

These changes showed that landscape fragmentation increased and the forest has become more susceptible to harsh disturbances.

Table 17. Species analyses using some indices in 1972, 2004 and 2015 for Gölcük PU.

Forest cover/Land cover	**Class area** (ha)			**Number of patches (#)**			**Mean patch size (ha)**			**Area weighted mean shape index**			**Patch size coefficient of variation (%)**		
	1972	**2004**	**2015**	**1972**	**2004**	**2015**	**1972**	**2004**	**2015**	**1972**	**2004**	**2015**	**1972**	**2004**	**2015**
Non Forest	6451	4723	4821	49	116	153	132	41	32	8	8	10	657	891	1104
Cadastral Forest	-	-	905	-	-	175	-	-	5	-	-	3	-	-	234
Degraded Forest	845	614	351	23	56	161	37	11	2	3	3	2	157	172	250
Coppice Forest	3945	4202	146	11	39	1	359	108	146	7	6	5	205	561	-
Mixed Forest	-	1871	5009	-	42	93	-	45	54	-	4	9	-	309	814
Kn	746	611	650	14	6	12	53	102	54	2	2	2	167	117	200
M	-	-	11	-	-	1	-	-	11	-	-	2	-	-	-
Ks	321	-	89	21	-	13	15	-	7	2	-	2	76	-	160
Çz	-	27	7	-	5	2	-	5	3	-	2	2	-	85	5
Ya	-	15	17	-	1	3	-	15	6	-	2	3	-	-	114
Private Forest	-	245	301	-	14	20	-	17	15	-	2	2	-	110	119
Total	12308	12308	12308	118	279	634	596	344	335	22	29	41	1261	2246	2998

3.6 Changes in Forest Functions

Forest functions maps were obtained based on the forest management plans designed in 1972, 1994 and 2015 (GDF, 1972; GDF, 2004; GDF, 2015). The map shows that in 1972 only one function called economic function exists. On the other hand, the non-economic value from forest included social health, recreation, resting area, aesthetic, tourism, and education was mentioned and told that those functions were provided by forest. However, forests were not allocated non-economic values. The economic value was based on the maximum production of wood in accordance with rotation time and soil index. The green color represents the forest product production i.e. maximum wood production and yellow represent the non-forest (Figure 10).

The map of 2004 shows that the main functions is still the economic which includes forest products productions. Forest products productions aims the highest quantity of wood production. The sociocultural function represented by only aesthetics including aesthetic appearance (visual quality i.e. silhouette, mosaic and panoramic effect). Other areas are non-forest, which is not a subject of discussion.

Similarly, the forest function map of 2015 is obtained. The main functions include economic, ecologic and non-forest which is not a subject of discussion. The economic function includes forest products productions. Forest products productions include the highest quantity of wood production in different kinds such as sawwood, pole wood or firewood Here, non timber forest product (herbal products) as chestnut appears in the last period. The ecologic function includes only soil protection in the high slopes, generally over 60% of forest areas.

Forests allocated to wood production was first increased from 5857,2 ha in 1972 to 7318,8 ha in 2004 under the influence of increase in forest lands. Then, decreased to 3669,2 ha in 2015. In the middle period (2004), 21.7 ha forest area was allocated for esthetics. On the other hand, while 219.4 ha forest area was allocated for chestnut production as non wood forest products, 2439.9 ha forest are was alooctaed for soil conservation in 2015.

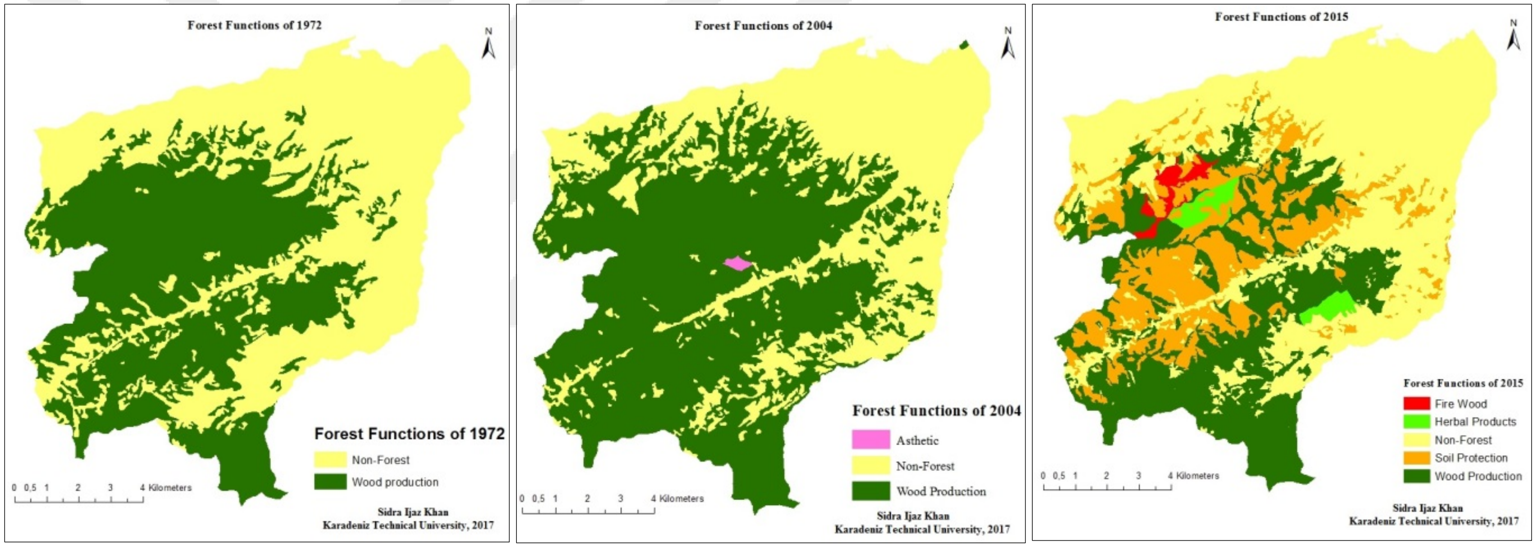

Figure 10. Forest functions maps of 1972, 2004 and 2015 in Gölcük PU.

4. DISCUSSION

4.1. Spatiotemporal Changes

The quantitative evidence of the forest dynamics presented here showed that there had been drastic changes in the temporal and spatial patterns of the stand parameters, productive forest areas, and especially on the species mix. Over 43 year's LULCC changes included cadastral forest, a mixed class of agriculture and residential area emerged in 2015 which indicates the new types of land use class introduced in the area according to new use. The most evident change is the high forest which increased approximately up to 3000 ha from 1972 to 2015. Coppice forests were decreased due to the change in policy by directorate general in 2004 where the coppice forest were replaced by high forest. Degraded forests were progressively decreased. Private forests were appeared in the last two periods. etc. The trend of species mix shows that coppice forest changed to mixed high forest, degraded and non-forest decreased, beech pure stand remained prominent among other pure stands of oak, chestnut and black locust. Possible reasons behind this change could be migration by rural population towards the city center, less dependent on fuelwood and management practices. In 2004 the Forest Directorate decided to convert Turkish forest from coppice to mixed and pure stands.

Demographic dynamics of Gölcük also was not negatively effected forest improvement by immigration of large quantities of population to Gölcük city or industrial regions of the territory. Rural population of Gölcük has increased by nearly 100000 from 1970 to 2015. Although there was a slight decrease in 2000 with the effect of Marmara eartquake, total population of Gölcük increased from 50708 to 152607 in the last four decades (Table 18) (SIS 2017).

Table 18. Demographic change in Gölcük PU

Urban/Rural	1970	1980	1990	2000	2010	2015
Urban	29774	45950	64911	55790	-	-
Rural	20934	27038	46497	51825	-	-
Total	50708	72988	111408	107615	131450	152607

These favorable changes are also the reflection of ecosystem based multi objective planning approach and allocating less areas to timber production especially within the last 20 years. For this reason the forest administration decreased maintenance activities especially the last few years, although there were scheduled interventions like regeneration and thinning according to forest management plan. It stands out that, while 113331 m^3 wood material produced according to forest management plans between 2004 and 2008, it decreased to 81608 m^3 between 2009 and 2013 as a result of conservative approach (Table 19).

Table 19. Wood production values for the Gölcük PU in recent years

Cutting Year	Regeneration (m^3)	Thinning (m^3)	Salvage Cutting (m^3)	Rehabilitation (m^3)	Total (m^3)
2004-2008	9752	47746	1703	54130	113331
2009-2013	6648	27222	298	47435	81608
Total	16400	75018	2001	101565	194939

Obtained results from this study are quite comparable to similar other research results. Kadıoğulları et al., (2008) reported that, based on stand-type maps, the forest cover in the Torul Forest Enterprise had increased from 42.95% in 1984 to 51.20% in 2005. This amounts to a rate of forest improvement of 0.92% annually (Kadıoğulları, et al., 2008). Another study from northeastern Turkey found an average forest improvement rate of 0.40% annually (1972-2005) for the Yalnızçam and Uğurlu forest planning units (Kadıoğulları, 2013). Furthermore, a study in the western part of Turkey reported an average forest improvement rate of 0.44% annually from 1972 to 1993 (Başkent and Kadıoğulları, 2007). In contrast, in the Rize Forest Enterprise in northeastern Turkey, cumulative forest disturbances between 1984 and 2007 were responsible for a forest disturbance rate of 0.20% annually (Günlü et al., 2009).

Moreover, Çakır et al. (2008) studied spatiotemporal analysis a large scale analysis of the spatiotemporal structure of Istanbul, a highly urbanized city in Turkey, from 1971 to 2002 using forest cover type maps analysed with geographical information systems (GIS) and a spatial statistics programme. The quantitative evidence indicated that increasing population and expanding urbanization caused drastic changes to the temporal and spatial dynamics of land use/land cover pattern in Istanbul. There was a net increase of 5387.3 ha in total forested areas (1 per cent) due to mainly reforestation activities even though the population increased three times over a 31-year period. Increase in number of patches and decrease in mean patch size together demonstrated that the landscape developed into a more fragmented structure that would negatively affect biodiversity and the resilience of the ecosystems. In conclusion, plain increase in forest areas may not always be a favourable situation. The quality, composition and the configuration of forest landscape should also be analysed to present the dynamics of ecosystem in terms of ecological and economical sustainability over a longer time and larger area.

4.2 Implications of International Conventions to Management Planning Approach

From 1972 till 1991 the Gölcük forest management was planned according to two series called Ayvaşa and Naldöken and operated on the basis of the province. According to the plan of 1972, both series have similar forest functions and divided into two management unit A and B. A management unit consists of beech species for maximum wood production and B is coppice forest. The non-economic value from forest included social health, recreation, resting area, aesthetic, tourism, and education and navigation purposes. But these general functions just remained as a written part of the plan instead of clear separation and allocation in the map and actual study area (GDF, 1972). The latter situation is more or less the same for all other planning units in Turkey. On the other hand, during the time of second plan (2004), generally, the forest functions were forest products production, nature protection erosion prevention, climate regulation, community health, hydrologic, nature protection, national defense, scientific, aesthetic, and recreational functions throught the Turkey.

In 1975 after Helsinki conference, the functions from the sustainable management of European forests were categorized as economic, ecology and social function which is further explained. The economic function included wood raw material production which encompasses log, pole, industrial wood, paper wood, fiber wood, chip, and firewood. Whereas, wood product production function included, herbal products, animal products, water and mineral products. Similarly, the ecology function compromised of erosion prevention, climate regulation, and nature protection. The social function included hydrologic, community health, national defense, aesthetic, scientific and recreational functions (GDF, 2004).

The 2004 Gölcük management planning was done while keeping in view the Helsinki conference, which Turkey became a member. The conference introduced the concept of forest functions such as ecological, social and economic while practicing sustainable forest management. After becoming parties with UNCCD UNCBD AND UNFCCC the 2015 forest management plan has been designed accordingly. With this perspective, national strategy on climate change and national climate change action plan were adopted in 2010 and 2011. The main adopted points includes, increasing sink areas and preventing land degradation implementing an action plan on forestry rehabilitation and national afforestation campaign. So national action plan the multi-use forest management planning with a focus on forest values and functions are highlighted. But there are no clear direct proofs of international agreements/binding in the plan itself rather it links to the national action plan which is made with context to these signed agreements (GDF, 1972; GDF, 2004; GDF, 2015).

The national forestry objectives defined in 2015 plans were administrative and business purposes, and silvicultural purposes. In 2015 Gölcük economic functions are still majorly encompasses production of forest products in the forest planning unit. Besides timber production, non wood forest product as chestnut come into prominence in that year. In addition, a a great number of forest areas were allocated to soil protection value. The mentioned diversified changes in the last period is the reflection of and in accordance with the "Forestry Management Regulation 2008" where, functions were defined as economic, ecological and social. In these regulations, ecological function of forests includes erosion control, nature conservation, conservation of forest, climate protection, nature park, soil protection and socio-cultural function which are further categorized as community health, ecotourism, hydrologic, water resources protection, community, aesthetic appearance (Visual Quality: Silhouette, Mosaic and Panoramic Effect), recreation (Picnic, Recreation, Festival, Yayla, etc.) and ecotourism and recreation, national defense. The forests were separated for economic functioning such as wood raw material which is economic value and the production of non-wood products due to the demand of the national and international economy of these products continuously. Main products such as sawwood, pole wood, industrial wood, fiber and cellulose, poles and rods and firewood. Whereas, the non-wood forest products (by-products) are of plant and animal origin, and water and minerals. The ecological function includes protective and environmental functions of forests (protection of soil resources, protection of water resources, prevention of flood damage, carbon accumulation, air pollution prevention, air cleanliness, etc.). To protect and erosion, to regulate the water regime, to reduce the effects of desertification and drought, to reduce crop and productivity losses of agricultural areas in sub-basins and to ensure safety, to prevent damage to infrastructure and settlements by means of irrigation, energy production, and drinking water. The main purpose is to protect the erosion (soil protection) function (water and prevention of wind erosion, avalanche, rock and stone rolling), climatic (Climate Protection) (GDF, 2008; GDF, 2015).

On the other hand, determined forest values by the forest managemet team seems does not reflect the demands of main stakeholders. A study conducted at Golcuk Planning Unit under a project of ALTEFOR “Alternatives models and robust decision-making for future forest management” helped examine the preferences of stakeholders in response to the forest values. The study area is also important for the provision of drinking water, thus the impacts of silvicultural prescriptions/models on water quality and water quantity need to be considered. Furthermore, the area is quite attractive for recreation and aesthetic values with currently operational 30 small sized promenade areas, because of the close proximity to the industrial area and large Metropole (e.g., İstanbul, Adapazarı, and Bursa). Besides Chestnut, mushroom is also an important non-wood forest products within the study area and the associated actors have limited influence in the management of forests. The interests of the actors within the case study generally match with the general interests within Turkish forest politics shown in Table 20.

Table 20. Interests of stakeholders towards Ecosystem services (ALTEFOR, 2017).

	Forest management(e.g. governmental actors)	**Timber and WFP Industries** (e.g., market actors)	**NGOs representing employment in forests** (e.g. cooperatives)	**NGOs representing eco-tourism and recreation**	**Water and soil protection**	**NGOs + Government actors representing nature conservation in forests**
Provisioning ES						
Wood provision	+++	+++	+++	-	-	+
NWFP **-** Chestnut	+	+++	+	+++	**0**	++
Supporting ES						
Biodiversity	++	---	-	++	++	+++
Regulating ES						
Carbon sequestration	+	--	-	**0**	**0**	+++
Climate regulation	+	**0**	**0**	**0**	**0**	+++
Water quality	++	-	-	-	+++	+++
Soil protection	++	---	---	+	+++	+++
Cultural ES						
Outdoor recreation	+	+	-	+++	-	+
Aesthetics	+	-	**0**	+++	-	+

Most actors from forestry suggest multiple use forest management at the whole area with a priority on timber production. Actors in regulating services have high concerns on harvesting activities that are considered detrimental to the water supply. Recreational forest users have no specific ideas about preferred forest management concepts but demand well-maintained landscapes within the forest. Timber processing companies appreciate the importance of other forest values such as biodiversity, water production, and nature protection although they give high priority to timber production (ALTEFOR, 2017).

Here, climate protection function and the integration of carbon sequestration to the management plans is also seen as an important step in the last period. This forest value can be seen as the reflection of climate change agreement and carbon processes.

The obligation arising from UNFCCC includes participation in the conference of the parties and the meeting of the parties, an establishment of the national focal point and related secretariats, preparation of national notification and preparation of national greenhouse gas inventory. The preparation of the national action plan for climate change, preparation of the national action plan for climate change, development and implementation of plans and regulations for adaptation, evaluation of emission reduction options, and increasing the awareness of education, courses and public opinion. The climate and surveys and observations of other related elements and technology development and transfer. In addition to the above obligations, Annex I countries are obliged to prepare an "Initial Report" and a "Prospective Progress Report" within the first year they are parties to the Kyoto Protocol. In addition, an infrastructure should be established, which is called the Emission Recording System and transfers all the important greenhouse gas-intensive enterprises' annual emissions records, transfer of the emission rights between enterprises. A further obligation for the countries listed on the Annex-B of the Kyoto Protocol and for all countries other than Annex-I is that of the designated National Authority, which is the competent institution to take advantage of the flexibility mechanisms and to monitor and monitor the functioning of these mechanisms after becoming a party to the Kyoto Protocol. Another important obligation imposed for Annex I countries under Article 5.1 of the Kyoto Protocol is the requirement that these countries establish 'National Inventory System. The calculation of greenhouse gases in accordance with the objectives and provisions of the UNFCCC and the existence of a single appointed body in this system; Institutional and legal regulations are required to ensure efficient management and accurate preparation of the annual inventory is required (MEU, 2010; URL-3 and MEF, 2011).

Within the context of the United Nations Framework Convention on Climate Change (UNFCCC) in 2001, parties were invited to recognize that Turkey has a special position in comparison to that of other countries listed in the Annex-1 and it was decided to exclude Turkey from the list of countries in the Annex-2 of the Convention. Following this decision, Turkey has become a party to the UNFCCC in 2004. Since Turkey was not listed in Annex-B of Kyoto Protocol to which Turkey became a Party in 2009, it does not have any quantification (MEU, 2010 and MEF, 2011).

On the other hand, Turkey presented its Intended Nationally Determined Contribution (INDC) towards achieving the ultimate objective of the United Nations Framework

Convention on Climate Change in accordance with decisions 1/CP.19 and 1/CP.20. With this perspective, National Strategy on Climate Change and National Climate Change Action Plan were adopted in 2010 and 2011 respectively. National Climate Change Action Plan consists of emission control and adaptation policies and measures which are being implemented in all relevant sectors. Plans and policies to be implemented for this INDC in forestry industry were "Increasing sink areas and preventing land degradation and Implementing Action Plan on Forestry Rehabilitation and National Afforestation Campaign" (MEF, 2011).

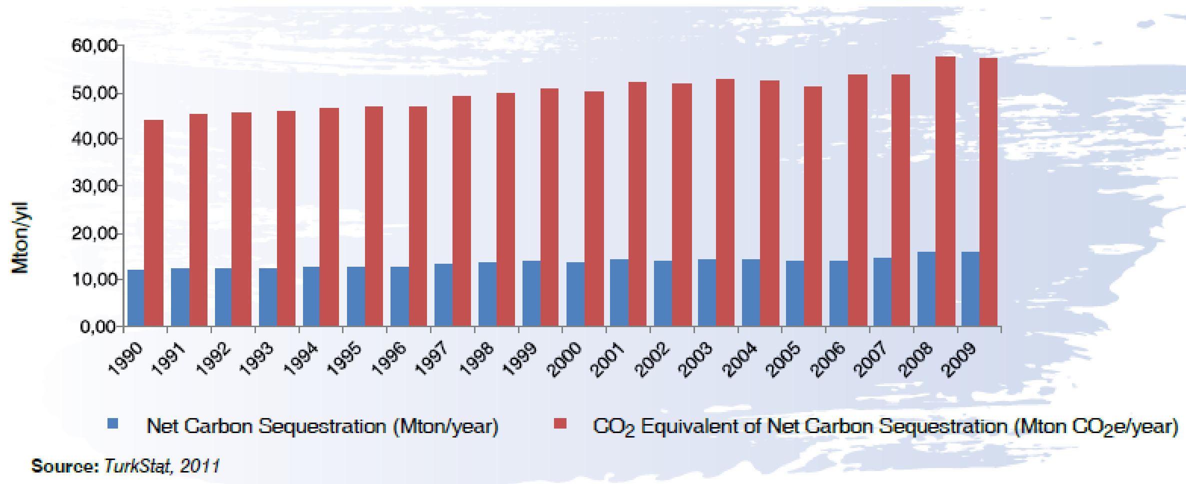

Figure 11. Turkey's Forest 1990-2009: Annual changes in the Carbon stock and CO_2 equivalent.

The potential of the annual carbon sequestration of Turkey's forests rises steadily due to increase in the forest cover. The net stock increment in 1990 was 12.02 M ton/year, reaching up to 15.64 Mton/year in 2009 leading to a similar increase in the carbon stock from 44.08 Mton/year to 57.36 Mton/year (MEF, 2011). In the national climate change action plan, the purposes and objectives of forestry and land use mentioned below clearly illustrate the integration of climate change into forest management (Table 21) (MEF, 2011).

Table 21. Purposes and objectives of forestry and land use (Source: MEF, 2011).

PURPOSE	OBJECTIVE
PURPOSE O1. Increase the amount of carbon sequestered in forests	OBJECTIVE O1.1. Increase the amount of carbon sequestered in forests by 15% of the 2007 value by 2020 (14,500 Gg in 2007, 16,700 Gg in 2020)
PURPOSE O2. Reduce deforestation and forest damage	OBJECTIVE O2.1. Reduce deforestation and forest damage by 20% of the 2007 values by 2020
PURPOSE O3. Limit the negative impact of land uses and changes such as forests, pastures, agriculture and settlements on climate change	OBJECTIVE O3.1. Integrate the climate change factor in land use and land use changes management strategies by 2015
	OBJECTIVE O3.2. Increase the amount of sequestered carbon as a result of agricultural forestry activities by 10% of the 2007 values by 2020
	OBJECTIVE O3.3. Identify the amount of sequestered carbon in pastures and meadows in 2012, and increase carbon stock 3% by 2020
	OBJECTIVE O3.4. Identify the existing carbon stock in wetlands in 2012, and maintain the level until 2020
	OBJECTIVE O3.5. Identify the quantity of carbon stored in settlement areas in 2012, and increase stored carbon 3% by 2020 through green planting
PURPOSE O4. Strengthen legal and institutional structure for combating climate change with regard to land use and forestry	OBJECTIVE O4.1. Make necessary legal arrangements for combating climate change with regard to land use and forestry by the end of 2013
	OBJECTIVE O4.2. Strengthen institutional capacity in institutions involved in land use and forestry on climate change by 2014

These processes such as Rio, Pan Europe, Forest Europe or GEF which are serving as guidelines in the forestry are adopted by the signatory parties. Turkey being party have adopted them in its national action plans which are ultimately adopted by management plans. Therefore, forest managemet plans seen as an important mechanism in calculating the carbon sequestration values as well as carbon loose from defostration and degradedation. In the plan of 2015, carbon storage and oxygen release calculations were indicated for the Gölcük planning unit. The total carbon store was 487575 tons and oxygen released was 34308 tons as shown in Table 22 and Table 23 (GDF, 2015).

Table 22. Carbon storage in Gölcük PU (GDF, 2015)

		Biomass (ton)				**Amount of Carbon**		
Tree Species Group	**Standing Volume (m3)**	**Above Ground**	**Below Ground**	**Litter**	**Total**	**In Total Biomass**	**In Soil**	**In Total Forest Ecosystem**
Hardwood	528561	425548	63831	195752	685131	308309	178819	487128
Softwood	659	374	75	180	629	283	164	447
Total	529220	425922	63906	195932	685760	308592	178983	487575

Table 23. Oxygen release in Gölcük PU (GDF, 2015)

		Biomass increment (ton)			
Tree Species Group	**Increment (m3)**	**Above Ground**	**Below Ground**	**Total**	**Oxygen release (ton)**
Hardwood	30291	24850	3727	28577	34292
Softwood	19	11	2	13	16
Total	30940	24861	3729	28590	34308

Turkey also tries to develop the integration of carbon storage process into forest management plans. For instance, a project called GEF-V “Integrated Approach to Management of Forests in Turkey, with Demonstration in High Conservation Value Forests in the Mediterranean Region” tries to implement forest-based GHG mitigation and carbon sequestration tools within landscape”. The benefits obtained from this project is the “implementation of emission mitigation and carbon sequestration practices in five target Forest Enterprise Directorates, thereby leading to emissions reductions of 44,871.46 tCO2-eq/y and increased sequestration equivalent to 11,561.04 tCO2-eq/y (URL-4).

In climate change mitigation, sustainable forest management and forest products play a vital role. The IPCC Fourth Assessment Report which underlined that “in the long term, sustainable management of forests will generate the largest sustained mitigation benefit”. In order to achieve such benefits, the aims of the sustainable forest management should be to maintain or increasing forest carbon stocks, while also producing an annual yield of timber, fiber or energy from the forest (GDF, 2008).

The six pan-European criteria for sustainable forest management as mentioned in the previous chapter and the basic points in forest Europe for forest management under climate change which focus on conservation of biological diversity in forest ecosystems and enhancement of protective functions in forest management (notably soil and water). So, the functions mentioned above clearly shows that forest values are diversified within the successive periods because of processes such as Rio or Pan-European and forest Europe which Turkey is signatory (GDF, 2008; URL-5, 2017).

Turkey also signed Biodiversity Convention in 1992 and ratified it in 1996 and it entered into force on 14 May 1997. The three main goals of the Convention on Biological Diversity (CBD) are the conservation of biological diversity, the sustainable use of biological resources and the fair and equitable sharing of the benefits to arising out of the utilization of genetic resources. The obligations under the UNCBD are not independent of each other, but some have direct or indirect implications. These obligations are to prepare national strategies, plans and programs for the conservation and sustainable use of biodiversity, to integrate plans and programs into relevant sector plans, identify the elements of importance in terms of biological diversity, identify and monitor priorities, to protect and manage biodiversity in-situ, establishing an ex-situ protection system to support on-site protection, to implement measures for the sustainable use of biological resources, to implement economic and social incentives to achieve the objectives of the Convention, support scientific and technical research and training, to provide the public with information and education, to evaluate and minimize environmental impacts, to regulate access to genetic resources and benefit-sharing, arranging access to technology, to support scientific and technical cooperation and organize the distribution of use and benefits of biotechnology. Turkey's National Biological Diversity Strategy and Action Plan (NBSAP) was prepared in 2001 under the coordinating role of the Ministry of Environment, with the intention that it should serve as a guide to implementing the Convention on Biological Diversity in harmony with other obligations and in addressing the problems caused by the loss of biological diversity. However, changing national and international conditions and trends made it necessary to revise the NBSAP of 2001. Consequently, the NBSAP was updated in 2007 through a participatory approach under the Project titled "Consultation for National Reporting, Participation in the National CHM and

Further Development of the NBSAP conducted with UNEP/GEF grant support. The updated NBSAP is intended to identify and assess Turkey's biological diversity, in brief, to determine an agreed strategy for conservation and to present decision-makers with proposals for action required for achieving the goals of biological diversity conservation in Turkey. The NBSAP should be regarded as a dynamic tool which may be renewed and updated as the goals are reached and the conditions change (MEF, 2007).

The objectives of the Turkey's forest biological diversity work programme are to apply the ecosystem approach to the management of all forest types; to reduce the threats to forest biological diversity and mitigate the impacts of processes that threaten it; to protect, improve and restore forest biological diversity; to promote the sustainable use of forest biological diversity; to regulate access to forest genetic resources and benefit-sharing; to develop a favorable institutional environment; to identify decisions that result in loss of forest biological diversity and the socioeconomic failures and defects that cause it; to build public education, participation and awareness; to develop the general classified cation and awareness; to develop the general classification of forests at different scales; to develop information and methods for the assessment of the situation and its trends; to develop understanding of the role of forest biological diversity and ecosystem operation; and to develop infrastructure for data and information for correct assessment and monitoring of global forest biological diversity. (MEF, 2007).

Biodiversity is tried to protect via strict forest values such as "nature conservation" with no intervention or some statuses such as "national park" or "Nature Park". In Turkey, only Calabrian pine stands are subject to clear cutting. And maximum green-up area could not exceed 25 ha. Considering the tree species such as Fagus orientalis, Castanea sativa, Oak spp. (Quercus petraea, Quercus robur, Quercus frainetto, Quercus infectoria, Quercus cerris, Quercus hartwissiana) in the study area, natural regeneration is obligatory according to Technical Principles of Silvicultural Applications Act (No: 298). This kind of regulations is stand to biodiversity conservation. Besides, silvicultural guideline (Technical principles of silvicultural applications, No: 298) is guaranteed to resume the same tree species after regeneration. In addition, silvicultural guidelines (Technical Principles of Silvicultural Applications, No: 298) require some stand level targets towards dead wood management on the field. For instance, in economically designated areas for wood production, 1-3 dead wood trees per ha is to be retained in all managed areas. When available, small areas of islands (<3ha) is promoted or left out for “aging islands”.

5. CONCLUSIONS AND SUGGESTIONS

Land cover and forest cover type changes have been a major topic in sustainable management of natural resources. Understanding forest dynamics is also critical for environmental concerns such as water production, soil loss and especially C balance. Land use and land cover change is generally known to be directly or indirectly affected by human-induced activities and population, socio-economic factors, forestry expansion, urbanization and patterns of agricultural activities. Thus, this study was designed to detect and document changes in major land use and forests cover types and analyze patterns of change in landscape of the study area focusing on forest fragmentation.

Gölcük forest management unit is a mostly state-owned forest located in the Marmara region of Turkey with an average general hectar of planning unit is 12307.8. Using GIS, digitizing, entering attributes, analyzing the land use, development stage, growing stock, forest value and canopy cover according to the criteria set in regulations (GDF, 2014) using management plan for 1972, 2004 and 2015 was carried out. Forest functions map were made according to the functions mentioned in the plans and Patch analysis Indexes such as number of patches, mean patch size and area weighted average shape index were evaluated. The quantitative evidences of land use/land cover dynamics showed that there were drastic changes in the temporal and spatial patterns of land use/land cover classes.The spatiotemporal analysis of forest revealed different types of maps such as the LULCC map shows that from 1972 until 2015 the degraded forest and agricultural area shrank thus resulting in an increase in forest area. The residential areas have greatly been increased replacing the agricultural land. 5491.5ha is the total forest area in 2004, while 5574.3 ha is the total forest area in 2015. Thus the result shows an increasing amount of forest area. The canopy cover map shows that degraded crown closure of forest is reduced and changed to non-forest class in crown closure. The degraded forest which has changed to the non-forest is 345.4 ha in 2015. The total ha of non-forest existing in 2004 was 3266.1 which have increased by 2015 to 4090.1 ha. The development stage map shows that 342.9 ha of degraded forest convert to the non-forest. The species mix map revealed that the degraded forest consists of 578.8 ha in 2004 which reduced to 303.8 ha in 2015. In contrary to that, the non-forest area of 3266.1 ha in 2004 increased to 4090.1 ha. So, the coppice forest is replaced by mixed forest and pure stands, the increase in forest cover in non-forest areas thus decreasing the non-forest area, and the reduction of the deforested forest. So the forest has gone healthier than before. The most evident change is the high forest which increased approximately up to 3000 ha from 1972 to 2015. The Canopy cover shows a large amount of positive change, and development stage also shows alarge amount of positive change. In 1972, 4566.63 ha total forest area whereas, in 2004, 12263 ha total forest area exist which increased to 6328.5 ha total forest area in 2015. The forest value maps shows general economic and non-economic functions in 1972 to aesthetic, firewood, herbal uses and soil erosion control functions map in 2004 and 2015. The patch analysis also shows the fragmentation of landscape which can be susceptible to the harsh environmental conditions. The main driving factors could be could be migration by rural population towards the city center, less dependent on fuelwood and management practices. As well as another fact0or is the change in policy in 2004 the Forest Directorate decided to convert Turkish forest from coppice to mixed and pure stands.

This study provided important information into the dynamics of forest ecosystems that occurred in forested area of Gölcük PU between 1972 and 2015. Understanding forest dynamics is critical to design the sustainable management of forest ecosystems as the temporal change of both composition and configuration of forest cover types are crucial factors of ecosystem conditions and functions. The rate and amount of land/forest cover type changes as a result of either the historical legacy of forest structure or ongoing threats or factors affecting the current pattern to shape are to be quantified to help better design future forest management actions and environmental policies for forest ecosystems. The patch analysis also shows the fragmentation of landscape which can be susceptible to the harsh environmental conditions.

From timber production and fuel wood consumption, the multi-use forest management planning started which led to the functional value of forest that is ecology, economic and social-cultural. The forest value maps clearly show the trend from past till the latest year of study that how the functions started dominating the map and made its position in the plan.

From general economic and non-economic in 1972 to aesthetic, firewood, herbal uses and soil erosion control in 2004 and 2015 can be seen.

We could not conduct a field survey to evaluate the current allocation and may propose a potential allocation/classification of areas into the associated forest/land-based values on the principles of ecosystem-based multiple use forest management (ecologic, economic and socio-cultural values/functions). Analyses socio-cultural, economic, environmental causes and consequences of the change particularly deforestation, reforestation or afforestation.

The ministerial conferences such as UNFCCC, UNCBD, UNCCD, GEF, Pan Europe/Rio, and Forest Europe are serving as guidelines in the forestry. These guidelines or criteria set in these conferences are adopted by the signatory parties. Turkey being party have adopted them in its national action plans which are ultimately being implemented to the planning unit. After 2008 signed agreements the national actions prepared served the basis for future planning which ensures the planning in accordance with international commitments for sustainable forest management. Thus Golcuk Forest Management Planning is fulfilling the agreement signed by Turkey yes and its forest cover is increasing and management practices have been devised under these binding which is showing a greener future of turkey’s forest. Turkey aims to contribute to the collective efforts to combat climate change, biological diversity and combating desertification in line with its national circumstances and capabilities.

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Sidra Ijaz khan currently doing her joint master's through Erasmus Mundus MEDFOR Scholarship Program from University of Padova, Italy and Karadeniz Technical University, Turkey. Sidra spent her winter semester at University of Valladolid, Spain and went on a short-term scholarship program to University of California, Berkeley. Sidra went on Global Under-GRADuate exchange program to Wilson College, USA in 2012. She became member of Wilson College Deans List for scoring highest GPA. She won Project Smile 2012 and 2013, Mentorship Program 2014 & Digital Story telling Program 2014 (micro grant programs by ECA and IREX). She served as Community Service Volunteer Coordinator of Lahore Youth Council at US Consulate General Lahore in 2013. Sidra founded her environmental student run volunteer society called "GREEN MINDS" back in 2011. Green Minds aim to engage young students for raising awareness about environmental problems and protection. Her Volunteer work also includes serving as Project Manager, "Youth Impact" for organising "Jasmine0423-Youth Leadership Expedition, 2015 and President "Sustainable Pakistan-Environment NGO" in 2013. She is member of PAUN-Lahore Chapter, Youth Parliment and Red Crescent Pakistan. Recently, at Xth Young Researcher Meeting on conservation & sustainable use of forest system, 2016 held at Valsain, Spain she got best communication Accesit award. Sidra recieved Best Speech Awards 2011,2013 & 2014 during her BS.Hons in Environmental Sciences from University of the Punjab. She has recieved various awards as a Facilitator, Debater and Anchor person.

Sidra's strongly believe in,

"Future Belongs to those who believe in the beauty of their dreams"