ECOLOGICAL PERSPECTIVE
Review Article

EKOLOJİK PERSPEKTİF
Derleme Makalesi

e-ISSN:2792-0062

2021-1-1 /29-36

EFFECTS OF CLIMATE CHANGE ON MAIN FOREST TREE SPECIES IN TURKEY: A REVIEW

İKLİM DEĞİŞİKLİĞİNİN TÜRKİYE'DEKİ ASLİ ORMAN AĞAÇ TÜRLERİ ÜZERİNE ETKİLERİ: BİR DEĞERLENDİRME

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Doi: https://doi.org/ 10.53463/ecopers.20210064
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ABSTRACT

Global warming and climate change threaten the future of the world. The effects of climate change, which expresses the increase in the amount of greenhouse gases released into the atmosphere, especially carbon dioxide, and the differences in precipitation, are now felt all over the world, from the highest peaks to the ocean depths, from the equator to the poles. While climate change creates negative effects on forests, it also causes destruction in the natural carbon cycle. Primary forest trees and forest areas, which directly contribute to the economy, are also of vital importance for people and other living things that are part of the ecosystem. The aim of this study is to review the effect of global climate change on main forest tree species through the climate change models of the future and present and to evaluate what kind of effects, problems and results emerge. As a result, it is seen that most of the main tree species will not be able to resist climate change, the distribution areas of the species will decrease and even all of them will face the danger of extinction.

Keywords: Climate change, modeling, forest tree, Turkey

ÖZET

Küresel ısınma ve iklim değişikliği dünyanın geleceğini tehdit etmektedir. Başta karbondioksit olmak üzere atmosfere salınan sera gazlarının miktarındaki artışı ve yağışlardaki farklılıkları ifade eden iklim değişikliğinin etkileri, artık en yüksek zirvelerden okyanus derinliklerine, ekvatordan kutuplara kadar tüm dünyada hissedilmektedir. İklim değişikliği ormanlar üzerinde olumsuz etkiler yaratırken, doğal karbon döngüsünde de tahribatlara neden olmaktadır. Ekonomiye doğrudan katkı sağlayan birinci sınıf orman ağaçları ve orman alanları, insanlar ve ekosistemin bir parçası olan diğer canlılar için de hayati öneme sahiptir. Bu çalışmanın amacı, küresel iklim değişikliğinin başlıca orman ağaç türleri üzerindeki etkisini, geleceğin ve günümüzün iklim değişikliği modelleri aracılığıyla araştırmak ve ne tür etki, sorun ve sonuçların ortaya çıktığını değerlendirmektir. Sonuç olarak, asli ağaç türlerinin çoğunun iklim değişikliğine uyum sağlayamayacağı, türlerin yayılış alanlarının azalacağı ve hatta birçoğunun yok olma tehlikesiyle karşı karşıya kalacağı görülmektedir.

Anahtar Kelimeler: İklim değişikliği, modelleme, orman ağaçları, Türkiye

1. INTRODUCTION

The main forest trees and forest areas, which contribute directly to the economy and whose value can be measured in money, also provide vital ecological services for people and other living things that are part of the ecosystem (OGM, 2009). Although it is known that forests, which are very important for the protection of biological diversity, have benefits for people both as wood and non-wood forest products, they also have benefits such as carbon bonding, oxygen generation, recreation and entertainment. Almost 300 million people in the world and 7 million people in Turkey lead a life directly dependent on forests and the recent global climate change has increased the importance of forests (Tolunay, 2013).

Many problems, like global warming, climate change, ozone depletion, acid rain, etc. that we call environmental problems to threaten humanity with each passing day. Deforestation lies at the root of most such environmental problems (Kırış & Toprak, 2009). Climate shows the trend of change naturally in all temporal measures, ranging from millions to tens of years in almost 4.5 billion years of earth history (Türkeş, 2008; Uzun & Örücü, 2020). Turkey is a peninsula surrounded by seas on three sides, it is one of the countries that will be most affected by global climate change with its complex climate structure and due to its topographic features (Öztürk, 2002). The most important problems caused by climate change can be listed as drought, floods and overflows, storms, heat or cold airwaves (Tolunay, 2013).

The aim of this study is to review the effect of global climate change on main forest tree species of Turkey through the climate change models of the future and present and to evaluate what kind of effects, problems and results emerge.

2. THE EFFECTS OF CLIMATE CHANGE ON FORESTS

Regarding climate change that may be seen in the future, scenarios are produced by various sources in which more greenhouse gas emissions are taken into account. The results that emerge when these are loaded into various mathematical climate models show that the changes that started in the climate will continue in the future (Öztürk, 2002).

The effects of climate change on Europe are listed as follows in the 6th Intergovernmental Panel on Climate Change (IPCC, 2021);

- Regardless of future global warming levels, temperatures in all European regions will rise at a rate that exceeds global average temperature changes, similar to past observations.
- The frequency and intensity of extreme heat, including maritime heat waves, has increased in recent years and is expected to continue to rise regardless of the greenhouse gas emission scenario. It is predicted that 2°C, which is the critical threshold for ecosystems and humans, will be exceeded.
- The frequency of cold and frost days will decrease in all GHG emission scenarios and across all time periods in this report, similar to past observations.
- Despite strong internal variability, the observed trends in European average and temperature extremes cannot be explained without taking into account anthropogenic factors. Before the 1980s, warming caused by greenhouse gases was partially offset by anthropogenic aerosol emissions. The reduced aerosol effect in recent years has led to an observable positive trend in shortwave radiation.
- The observations are of a seasonal and regional nature, consistent with the projected increase in winter precipitation in Northern Europe. It is expected that precipitation will decrease in the summer months in the regions extending to the north in the

Mediterranean. It is estimated that excessive precipitation and floods will increase at global warming levels exceeding 1.5°C in all regions except the Mediterranean.

- Regardless of global warming level, relative sea level in all European regions except the Baltic Sea will rise at a rate close to or exceeding the global mean sea level. The changes are expected to continue beyond 2100.
- Extreme sea-level events will become more frequent and more intense, leading to more coastal flooding. Shorelines on sandy shores will recede over the course of the 21st century.
- Strong decreases in glaciers, permafrost, snow cover size and seasonal duration of snow are observed at high latitudes/altitudes and will continue in a warming world.
- Numerous climatic influence factors have already changed simultaneously in recent years. With increasing global warming, the number of changes that cause climatic effects are expected to increase.

Also, Global warming effects on the Mediterranean region of Europe, where Turkey is situated, were evaluated in IPPC AR6. The observed increase in hydrological and agricultural and ecological droughts, expected increase in drought and fire weather conditions in global warming of 2°C and above. The predicted combination of mid-century and global climatic impacts (warming, extreme temperatures, increased drought and drought, decreased precipitation, increased fire weather, average and extreme sea levels, decreased snow cover and decreased wind speed) is at least 2°C and over warming. It is thought that the Turkish forests, which are sensitive to climatic changes, where the level of destruction is high due to agricultural land creation, fire and settlement, will differentiate in a possible climate change (temperature, precipitation extreme events, spread of pests and fires). Damage to forests, meadows and pastures that provide ecological balance and failure to take adequate measures in national parks will create major problems for our forests in the future (Öztürk, 2002).

There is a relationship of interest between forests and climate, that is, forests are affected by the climate, but also change the climate. All climate changes from the past to the present have led forests to expand, contract or relocate in the very long term, that is, to migrate. This orientation has been towards the south with the cooling of the climate and towards the north with the warming of the climate (Tolunay, 2013). It takes a lot of effort and resources to be 100% certain about how the forest ecosystem is changing due to climate change. Previous studies on this subject only show the incompleteness and inadequacy of current knowledge and efforts (Millar et al., 2007; Pilkey & Pilkey-Jarvis, 2007; Zeydanlı et al., 2011).

The important effects of climate change on forests are as follows (Lemprière et al., 2008; Tolunay, 2013; Williamson et al., 2009; Zeydanlı et al., 2011);

- Increase in the risk of forest fire in coastal areas and lowlands with the increase in temperature and drought,
- Increase in the risk of fire, which was not very high in the upper altitudes before, as a result of the increase in the germination status and the increase in the growth rate of the trees with the prolongation of the vegetation period at high altitudes,
- Floods and storms, the trees in the forests fall, break and dry out.
- Decreases in the germination and survival success of seedlings due to lack of water and drying out in plantation forests due to water shortage,
- The danger of extinction of our forests in the coastal areas due to sea level rises, due to seawater and salinization,
- Increased pressure on insect populations and trees as a result of the increase in hot days and the decrease in cold days,

- Plants that tend to do more photosynthesis with the increase of CO_2 need more water and nitrogen, phosphorus, potassium etc. need it,
- Since the rate and power of photosynthesis of each plant are different, with the increase of CO_2, plants that perform fast photosynthesis will consume the food of slow-acting plants, occupy their place, etc. causing problems.

3. RESULTS AND DISCUSSION

Considering the land use in Turkey; It is seen that approximately 52% of the country's total consists of forest and semi-natural areas (Figure 1; Table 1; Table 2).

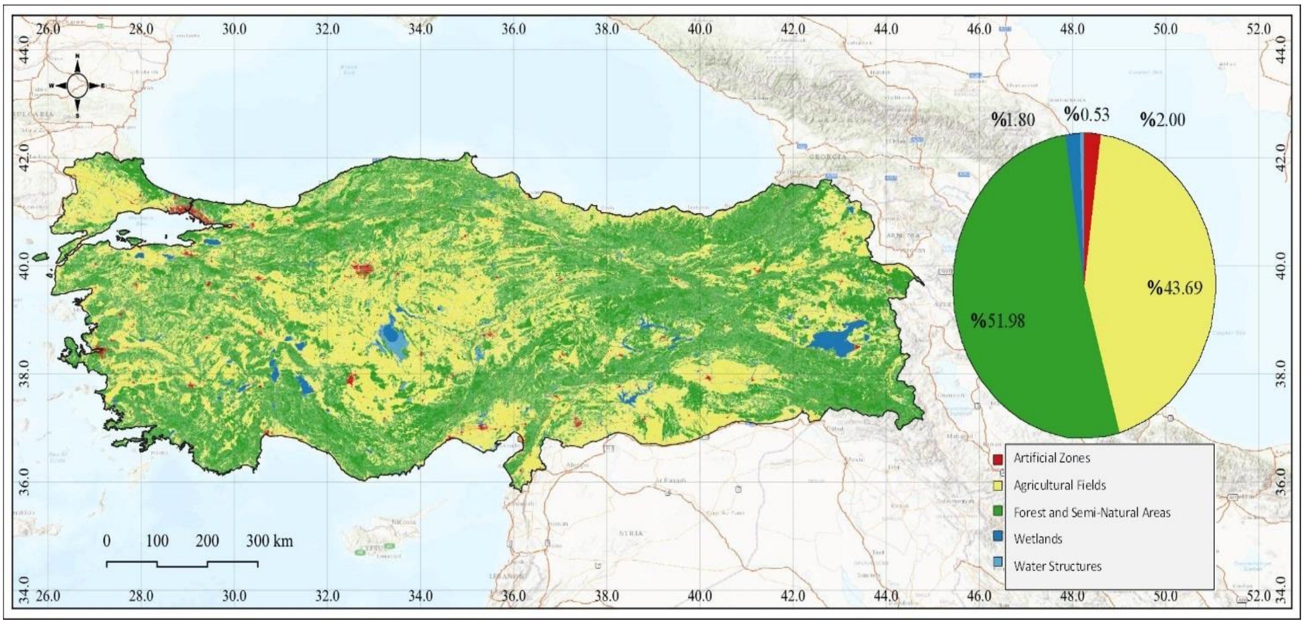

Figure 1. Land use status in Turkey according to CORINE 2018 data

Table 1. Areal values of land use in 2018 (ha)

Artificial Zones	Agricultural Fields	Forest and Semi-Natural Areas	Wetlands	Water Structures	Total (ha)
1.559.183	34.068.208	40.534.343	411.304	1.405.028	77.978.066

Table 2. Forest and semi-natural areas (ha)

Forests	Areas (ha)	%	Semi-Natural Areas	Areas (ha)	%
Coniferous	3.624.366	8.94	Plant Exchange Areas	7.758.199,419	19.14
Deciduous	5.370.545	13.25	Beaches and Sands	88.176,832	0.22
Mixed forests	2.526.389	6.23	Bare Cliffs	1.890.544,221	4.66
Natural Grasslands	8.873.394	21.89	Sparse Plant Areas	9.337.462,471	23.04
Shrubbery	164.306	0.0004	Burnt Areas	3.910,308	0.0096

In recent years, the effects of climate change on forest tree species in Turkey have been discussed in various studies.

Örücü (2021) calculated the current and future potential distribution areas of *Picea orientalis* in RCP 4.5 and RCP 8.5 scenarios for the years 2050 and 2070, using the CSSM4 climate model. Appropriate and very suitable distribution areas for today are calculated as 45,233 km^2, 65,042 km^2 in the 2070 RCP 4.5 scenario and 90,861 km^2 in the RCP 8.5 scenario. Contrary to many different species studies, *Picea orientalis* is expected to increase in the future distribution areas. Tüfekçioğlu et al. (2008) stated that temperature increases in the western parts of Eastern Black

Sea Region of Turkey will place more stress on spruce trees and possibly increase bark beetle attacks. They also mentioned that the fire may become a significant threat in the western part of the region and at the same time, an upward shift of 400-800 m will be observed in the spruce belt in the western part.

Sarıkaya & Örücü (2019) calculated the suitable areas as 31.114,8 km^2 and the most suitable areas as 17.605,1 km^2 as the current distribution area of *Castanea sativa*. In addition, according to the CCSM4 climate change scenario, significant losses were observed in the potential distribution areas of the species in the future. Gulcin et al. (2021) state that the most suitable distribution areas for *Carpinus betulus* in Turkey will decrease to a great extent, and even for the RCP 8.5 scenario, there will be no suitable areas for the distribution of the species between 2081-2100. Akyol & Orucu (2020) calculated the distribution areas of *Pinus pinea* in today's, 2050 and 2070 periods using the HadGEM2-ES climate model, according to the RCP 4.5 and RCP 8.5 scenarios. Prediction models under both climate change scenarios indicated that *P. pinea* would lose its habitat and shift its geographical distribution to the north and higher altitude areas.

Arslan & Örücü (2019) modeled potential distribution areas of *Pinus nigra* and *Pinus slyvestris* for 2050 and 2070. In the study, habitat suitability areas on RCP 4.5 and RCP 8.5 were determined digitally. As a result, it is seen that these species will suffer significant losses in their potential distribution areas in the future according to the CCSM4 scenario. Usta Baykal (2019) states that the habitat of *Abies nordmanniana* subsp. *equitrojani* will be a serious decrease as a result of the predicted model of 2050 climate variables.

Çoban et al. (2020) calculated the present and future estimated distribution areas of *Q. libani* by using RCP 4.5 and RCP 8.5 scenarios of CCSM4 model. They determined that suitable areas for the current distribution of *Quercus libani* cover 72,819 km^2, and depending on the CCSM4 climate model, the suitable area will decrease to 67,580 km2 according to the RCP 4.5 scenario or 63,390 km^2 according to the RCP 8.5 scenario by 2070 and this could lead to a reduction in the future population of the species, they said.

Babalık et al. (2021) modeled the distribution areas of *Quercus coccifera* according to climate change scenarios in RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 in 2050 and 2070. It is seen that there are losses in the potential distribution areas of the species in the future and it will gradually shrink in the scope of the CCSM4 climate change scenario. Arslan et al. (2021) calculated the species distribution of *Juniperus foetidissima* in the 2041-2060 and 2081-2100 periods according to SSP24.5 and SSP5 8.5 scenarios. As a result of the study, they obtained the findings that there will be a decrease in the distribution area of *J. foetidissima* under the pressure of climate change and that it will not be able to adapt. In another study, Özdemir et al. (2020) determined the potential distribution areas of *Juniperus excelsa* under the influence of climate change and estimated that the species will be affected by climate change and its distribution will decrease significantly as a result of the study.

Varol et al. (2021) studied the effects of climate change scenarios on *Fraxinus excelsior* by using the entropy method, and as a result, the SSP 245 and SSP 585 climate scenarios, respectively, revealed that the geographical distribution of *Fraxinus excelsior* in 2100 was 7.58% and 6.28%. Cantürk & Kulaç (2021) modeled the distribution areas of 3 *Tilia* species for 2040, 2060, 2080 and 2100 according to SSP 245 and SSP 585 scenarios. The results show that the distribution areas of all three *Tilia* species will change due to climate change and the loss area will be 43,5 km^2 (4%) for *T. tomentosa*, 9.953,6 km^2 (15%) for *T. platyphyllos* and 448 km^2 (19%) for *T. cordata*.

Koç et al. (2018) showed that *Taxus baccata* will find suitable conditions in the Bolkar Mountains region, pointing it out as an important refuge. They also found that the distribution of *Taxus* *baccata* in the Taurus Mountains will likely decrease further due to future climate change. Uzun et al. (2020) stated that suitable and very suitable areas of *Acer campestre* L. subsp. *campestre* in climate change models and scenarios are 45.408,07 km^2 for today. According to the scenarios, the distribution areas will decrease to 57% in the RCP 4.5 2041-2060 period, 60% in the RCP 4.5 2061-2080 period, 35% in the RCP 8.5 2041-2060 period, and 32% in the RCP 8.5 2061-2080 period. They stated that it would shift to the North East of Anatolia. López-Tirado et al. (2021) studied *Cedrus libani* in two different time periods and scenarios in their study covering Lebanon, Syria and Turkey. While the global habitat suitability area will be more limited in 2070 due to altitude shifts, it will expand relative to the present in the predicted scenarios. Dağtekin et al. (2020) stated that *Fagus orientalis* will face a dramatic range narrowing in the future and will prefer the mountainous regions of the Caucasus for its distribution. Sakallı (2017) concluded that *Alnus* species will potentially migrate northward in the northern hemisphere in the future.

4. CONCLUSIONS

Most of the forest tree species in Turkey, which are not able to migrate quickly and effectively, will not be able to keep up with the speed of climate change and provide the necessary adaptation and displacement. It has been stated in many studies that due to the increase in temperature with climate change, the species will tend to higher altitudes and north. In addition to carrying out conservation-use studies, carrying out studies that will help them move to higher altitudes will help reduce losses and accelerate adaptation.

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