3rd INTERNATIONAL CONGRESS ON ENGINEERING AND LIFE SCIENCE

ICELIS

20-22 SEPTEMBER 2023

TRABZON-TURKIYE

3RD INTERNATIONAL CONGRESS ON ENGINEERING AND LIFE SCIENCE

ForesTR «THE BALANCE OF THE LIFE: CARBON»

THE BALANCE OF THE LIFE CARBON

PROCEEDINGS BOOK

20-22 September 2023 **Trabzon – Türkiye** **icelis.net**

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3RD INTERNATIONAL CONGRESS ON ENGINEERING AND LIFE SCIENCE

ForesTR "The Balance of The life: Carbon"

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Editors

Prof. Dr. Sezgin AYAN

Assoc. Prof. Dr. Ercan OKTAN

Assoc. Prof. Dr. Bülent TURGUT

Republic of Türkiye

Karadeniz Technical University - 2023

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CHAIR'S PREFACE

Dear Participants,

I am very happy and honored to successfully complete the 3rd International Congress on Engineering and Life Science with you under the roof of our university, Karadeniz Technical University.

Climate change, which is shown as the primary problem of the whole world and therefore of humanity, is triggered as a result of global warming. One of the main reasons for global warming is the excess of carbon gas in the atmosphere. For this reason, the main theme of the congress was determined as "The Balance of The Life: Carbon". Since the existence of the world, nature has been in balance. However, this balance has been disrupted by the rapid population growth and rapid industrialization processes of humanity. The process of reducing carbon emissions in order to repair the disturbed balance has become the most important agenda of today with the implementation of the Paris agreement. However, it has been seen throughout the process that simply reducing carbon emissions will not be sufficient. It has become clear that systems that will capture and store carbon are needed to balance carbon emissions. In this context, projects in researching carbon capture and storage need to be deepened. There is an urgent need to develop research and practices on carbon capture and storage functions, especially in forest ecosystems, and to introduce relevant regulations.

Combating global climate change is not only the responsibility of natural scientists such as foresters, but is an international problem that concerns the whole world and can only be solved with interdisciplinary solidarity. Therefore, international cooperation is inevitable. In this context, our university cooperated with S. Seifullin Kazakh Agro Technical University, Bodenculture University, Technical University of Moldova, Ibn Zohr University, Atyrau University, University of Guilan, Ibn Tofail University, Academic Center for Education, Culture and Research, and Ss. Cyril and Methodius University of Skopje in organizing the congress.

At the congress, researchers from 14 different countries presented 65 papers. In addition, in the afternoon session on the last day, a panel was held with the participation of officials from the General Directorate of Forestry, Climate Change Directorate, and TAGEM institutions.

Hereby, I respectfully thank you all for your invaluable contributions, hoping that the papers presented in the congress will carry the knowledge of all decision makers, especially my young colleagues who will shape the world in the future, one step further...

Sincerely yours

Assoc. Prof. Dr. Ercan OKTAN

Chair

HONORARY CHAIR'S PREFACE

Dear Scientists,

Karadeniz Technical University is a globally recognized university with a rich history of 68 years, competent academic staff, and a pioneering and innovative approach. Since 1955, it has provided education at high standards that produce over 250,000 graduates who compete successfully with their contemporaries. Many other universities have been established under its umbrella, and its expert staff have contributed to various places for educational purposes. As of today, our university has 33,000 students enrolled in 81 undergraduate and 35 associate degree programs in 12 faculties, 1 school, and 8 vocational schools. It also offers graduate education in 85 master's and 55 doctoral programs in 6 graduate schools. In addition, Karadeniz Technical University embodies globally accredited disciplines and quality-focused research centers in various fields. It continues to keep pace with the contemporary scientific world, continuously improving itself with innovations and scientific activities. As an example, our university has successfully completed its journey of establishment that began in 1955 and solidified its strong position within the higher education system as a "Research University" during the 2021-2022 academic year. In line with this title, Karadeniz Technical University, with its accumulated knowledge from the past and a rich staff, organizes many scientific activities and hosts numerous meetings.

Scientific conferences, one of the most important means for disseminating scientific research, also enable scientists to experience different cultures and environments and foster interaction among scientists. In this context, the 3rd International Congress on Engineering and Life Science with the theme "ForesTR: The Balance of The Life: Carbon" has been hosted by our university this year. As a member of the KTU family, I would like to express that we are pleased to host many scientists presenting papers on such a crucial topic within the field of science.

Hereby, I would like to take this opportunity to thank all the scientists who contributed to the organization of the congress, the invited speakers, all the scientists who participated either in person or online, partner universities, and sponsor companies on behalf of myself and our university.

Kind Regards

Prof. Dr. Hamdullah ÇUVALCI

Rector of Karadeniz Technical University

Honorary Chair

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Effective Soil and Plant Management Practices for Increasing Soil Organic-Carbon Stocks

Taşkın Öztaş

Atatürk University, Faculty of Agriculture, Department of Soil Science & Plant Nutrition, Erzurum/TÜRKİYE

***Correspondence**:* toztas@atauni.edu.tr

Abstract: Due to its multifunctional characteristics; soil organic matter has great importance not only for soil fertility by providing many plant nutrients, increasing plant available water and microbial activity, but also for structural improvement of soil by creating stable aggregates. However, the existence of this valuable resource is rapidly decreasing in Turkish soils, as in many other geographical regions of the World, mainly due to land use/land cover changes and high rates of soil erosion. In terms of drought and desertification, which are the most obvious negative effects of climate change, Türkiye is among the high-risk countries. One of the most important threats to soil functions, which are directly related to climate change-related crop production, is the loss of soil organic matter. Soil degradation due to organic matter loss that threaten the food, energy and water security of human beings in today's world, carries the risk of becoming more prominent and destructive on the axis of global-scale climate change and oppressive and unsustainable management practices on natural resources. However, it is clear that with the sustainable management of soil, which is known as the biggest organic carbon stock pool of terrestrial ecosystems, it plays a key role in minimizing the negative effects of climate change. The carbon storage capacity of soil depends on the local climate and existing land cover at the upper scale, but it also affected by solum depth, soil parent material, soil moisture and soil temperature regime, and the most importantly by soil and plant management practices. In other words, the factor that creates variability and has the opportunity to change is the human-induced soil/plant management factor. Increasing organic-C stocks in the soil is directly related to the balancing of land degradation and the effectiveness of the implementation of sustainable land and forest management strategies. In this context; minimizing erosion losses for all land use types and preventing misuse of lands, and especially in agricultural areas where organic carbon loss is manageable, dissemination of ecosystem-oriented - regenerative agriculture and climate-friendly agricultural techniques, application of reduced, minimum or zero tillage systems, adding plant residues and organic inputs into the soil have very important places. This paper describes the effective ways of increasing soil organic carbon stocks in soil with different aspects.

Keywords: Sustainable soil management, Organic-C stocks, Ecosystem oriented agriculture.

KEYNOTE SPEECH https://doi.org/10.61326/icelis.2023.58

How Forest Management Can Improve Carbon Sequestration, Carbon Stock and Other Ecosystem Services? A Focus on Mediterranean Environment

Ugo Chiavetta

CREA - Research Centre for Forestry and Wood, Rome/ITALY

***Correspondence**:* ugo.chiavetta@crea.gov.it

Abstract: Forests play a crucial role in mitigating climate change by sequestering carbon and providing various ecosystem services. This contribute explores the relationship between forest management practices and their impacts on carbon sequestration, carbon stock, and other ecosystem services, with a specific focus on the unique challenges and opportunities presented by Mediterranean environments. Drawing from a synthesis of existing research, I discuss the effectiveness of different forest management strategies in enhancing carbon sequestration and carbon stock while considering the broader ecosystem services provided by Mediterranean forests. I also include a case study on thinning in peri-urban forest stand, highlighting its potential to enhance carbon sequestration and ecosystem services in Mediterranean peri-urban areas. I underline the importance of sustainable forest management practices in mitigating climate change and supporting biodiversity conservation in this ecologically sensitive region. Furthermore, we identify key knowledge gaps and research priorities to guide future efforts in optimizing forest management for both carbon sequestration and ecosystem resilience in Mediterranean environments.

Keywords: Climate change, Forest ecosystems, Mediterranean forests, Mitigating.

KEYNOTE SPEECH https://doi.org/10.61326/icelis.2023.59

The Roadmap to Achieving Climate Neutrality in Türkiye: A Comprehensive Analysis of Long-Term Forestry Strategies

Yusuf Serengil

İstanbul University-Cerrahpaşa, İstanbul/TÜRKİYE

***Correspondence**:* serengil@iuc.edu.tr

Abstract: In 2021, Türkiye ratified the Paris Agreement and committed to achieving climate neutrality by 2053. As mandated by the agreement, Türkiye submitted its first Nationally Determined Contribution (NDC) and has been conducting simulations to identify alternatives to establish its Long-Term Strategy (LTS). Our study focused on the LULUCF (Land Use, Land Use Change, and Forestry) sector of Türkiye, mainly focusing on forestry. Our analysis shows that the forests in Türkiye offset approximately 8-10% of the country's total greenhouse gas emissions in 2021, down from over 20% in 2014. This reduction in offset percentage is due to a drop in the removal rate of forests over the last ten years. To achieve climate neutrality, this trend of reduction must be reversed. Recent inventory data shows that forest management is the central activity, with afforestation and other land use activities contributing less than 1%. However, when analyzing their effectiveness, it is important to consider the co-benefits of mitigation policies and measures. Our study concluded that Türkiye should prioritize forest management, including wildfire prevention and improved use of wood products, by investing in research and innovation. The forest products industry should also enhance the added value of wood products and embrace circularity to reduce raw material demand. By reducing the harvest rate, the carbon stock and increment of forests can be enhanced. Acceleration is needed towards achieving sectoral targets to achieve a climate-smart forestry perspective.

Keywords: Climate neutrality, Long term forestry strategy, Climate smart forestry.

1. INTRODUCTION

The Paris Agreement (PA) has a goal to limit global warming to well below 2, preferably to 1.5°C, compared to pre-industrial levels by the end of the century, according to the latest Intergovernmental Panel on Climate Change (IPCC) Working Group 1 report, the world is on track to exceed the 1.5 °C global warming level before 2040[1]. To limit the warming to 1.5 °C, only 400-500 GtCO2 of the carbon budget is available from 2020, while current annual emissions are around 40 GtCO2. As the carbon budget for 1.5°C is rapidly shrinking, developing countries may urge developed countries to work towards achieving net-negative emissions (Mohan et al., 2021).

The PA also underlines that to achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate-neutral world by mid-century. To this end, Article 4.19 of the Paris Agreement points out that countries must prepare and submit long-term climate strategies (LTSs or LT-LEDs) that carry through to mid-century or 2050 to the Secretariat of the UNFCCC[2].

According to United Nations Framework Convention on Climate Change (UNFCCC), net zero emissions are achieved when anthropogenic removals balance anthropogenic emissions of GHG to the atmosphere over a specified period. The IPCC (2021) defines carbon neutrality as the condition in which anthropogenic CO_2 emissions associated with a subject are balanced by anthropogenic CO_2 removals (Place et al., 2022). Therefore, becoming 'climate neutral' means reducing greenhouse gas emissions as much as possible but compensating for any remaining emissions. This is how a net-zero emissions balance can be achieved (Figure 1).

[1] https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/
[2] https://unfccc.int/process-and-meetings/the-paris-agreement

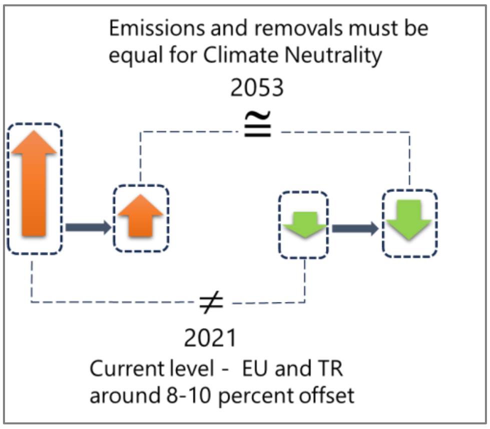

Figure 1. The schematic representation of climate neutrality. The green arrows represent removals (C sequestration by ecosystems). The emissions must equal removals for climate neutrality (net zero) at the target year. According to the most recent GHG inventory (2023) the removals offset around 8 percent of the emissions.

Türkiye ratified the Paris Agreement in the fall of 2021 and submitted its first Nationally Determined Contribution (NDC) target in 2022 during the 27th Conference of Parties (COP27). In 2023, Türkiye presented its detailed NDC document. The NDC aims to increase the capacity of forests to absorb carbon dioxide by implementing sustainable forest management practices, afforestation and reforestation, restoration, and long-term planning by rejuvenating existing forest areas. The initiative also encourages nature and technology-based solutions that enhance sink capacity, such as afforestation, rural agricultural land protection, and grassland improvement. Additionally, the Plan focuses on preventing, controlling, and reducing desertification and land degradation. For adaptation, the Ecosystem-Based Adaptation (EBA) Strategy seeks to promote agro-forestry[3].

To tackle the urgent issue of climate change, countries are presently submitting long-term climate strategies to the UNFCCC process. These strategies incorporate the potential use of 'negative emissions technologies' (NETs) in the future. NETs encompass various interventions that remove carbon from the atmosphere, such as large-scale terrestrial sequestration in forests, wetlands, and soils and using carbon capture and storage technologies (Jacobs et al., 2023).

Türkiye will launch its 2030 Climate Change Action Plan in 2023 and submit its LTS to the UNFCCC secretariat in 2024. The LTS will put forward Türkiye's policy decisions in forestry and land use for the coming decades.

Our paper focused on the land use sector, specifically forestry, and the various mitigation options available to Türkiye. We presented and discussed these options in detail, highlighting their potential impact and feasibility.

2. THE INTERNATIONAL LTS CONTEXT

United Nations Strategic Plan for Forests 2030[4] is one of the documents to highlight the mid-term global strategies. The Plan mentions the following goals and priorities:

i. *Reverse the loss of forest cover worldwide through sustainable forest management,*

ii. *Enhance forest-based economic, social, and environmental benefits, including by improving the livelihoods of forest-dependent people,*

iii. *Increase the area of protected forests significantly worldwide and other areas of sustainably managed forests, as well as the proportion of forest products from sustainably managed forests,*

[3] https://unfccc.int/documents/627743
[4] https://www.un.org/esa/forests/documents/un-strategic-plan-for-forests-2030/index.html

iv. *Mobilize significantly increased new and additional financial resources from all sources for the implementation of sustainable forest management and strengthen scientific and technical cooperation and partnerships,*

v. *Promote governance frameworks to implement sustainable forest management, including through the United Nations Forest instrument, and enhance the contribution of forests to the 2030 Agenda for Sustainable Development.*

vi. *Enhance cooperation, coordination, coherence and synergies on forest-related issues at all levels, including within the United Nations system and across member organizations of the Collaborative Partnership on Forests, as well as across sectors and relevant stakeholders.*

On the other hand, the EU forest strategy for 2030 aims to *set a vision and concrete actions to improve the quantity and quality of EU forests and strengthen their protection, restoration and resilience. The strategy aims to adapt Europe's forests to the new conditions, weather extremes and high uncertainty brought about by climate change. This is a precondition for forests to continue delivering their socio-economic functions, and to ensure vibrant rural areas with thriving populations.*

These global and regional strategies toward 2030 focus on two main pillars:

- Protection, restoration, and resilience - achieve Zero Net Deforestation from national and global perspectives, improve the quantity and quality of forests, and adapt to new conditions, weather extremes and high uncertainty that climate change brings.
- Circularity, efficiency, and sustainability of the forestry sector - developing skills and empowering people for sustainable forest-based bioeconomy (Green jobs)

When we get back to Türkiye, the CCDR[5] of World Bank published in 2022 was the first whole sectorial assessment of the Türkiye's long-term strategic mitigation options. The report highlighted the below findings:

Türkiye is highly vulnerable to the impacts of climate change and other environmental hazards due to its geographic, climatic, and socioeconomic conditions. Therefore, it is crucial for Türkiye to prioritize adaptation and resilience. The recent war in Ukraine has led to energy supply disruptions and price increases, which pose significant risks for countries like Türkiye that heavily rely on fossil fuel imports. This highlights the urgent need for climate action to ensure energy security and affordability.

To achieve its development and climate goals, Türkiye needs to adopt a resilient and net-zero development pathway (RNZP). However, this requires significant deviation from current trends and major policy changes.

The report also emphasized the need for investment in adequate sectors and activities. With these investments, Türkiye's economy will get the lowest negative impacts and gain momentum.

3. MATERIALS AND METHODS

To evaluate the forestry sector for the mitigation capacity we looked at the details of the categories and subcategories (Figure 2).

We used the same methodology as the Land Use Land Use Change and Forestry (LULUCF) sector GHG inventory of Türkiye based on the IPCC (2006) Guidelines. We also used the most recent data from the Activity Reports of the General Directorate of Forestry. The data sources we used were:

- National Inventory Report (NIR) of Türkiye 2023,
- General Directorate of Forestry, 2022 Action Plan,
- LULUCF section of the Country Climate and Development Report (CCDR) of Türkiye by the World Bank, 2022,
- FAO Forest Products Database (https://www.fao.org/faostat/en/#data/FO)

[5] https://www.worldbank.org/en/country/turkey/brief/key-highlights-country-climate-and-development-report-for-turkiye

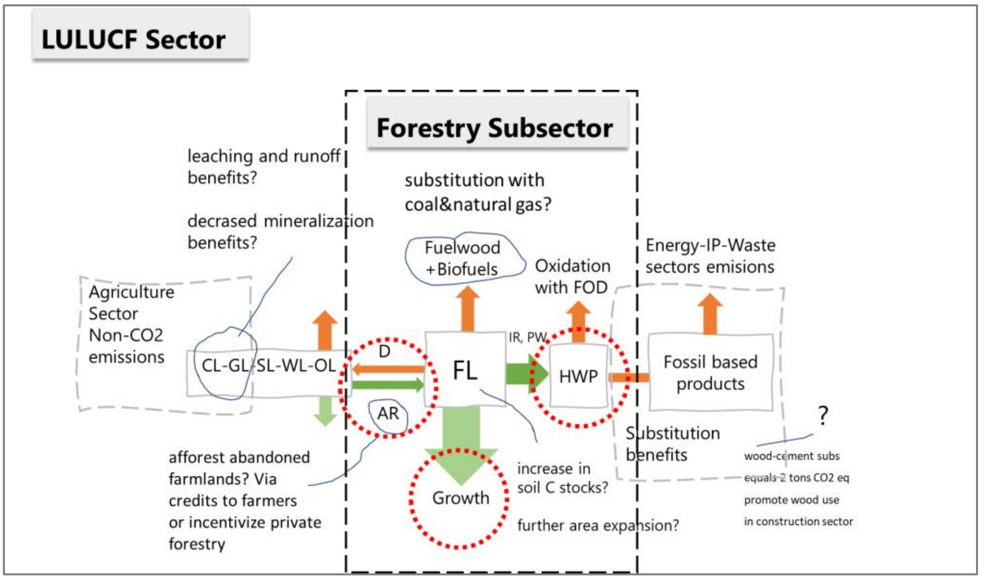

Figure 2. The forestry sector as part of the LULUCF sector. The potential mitigation categories are given in red dotted circles.

4. RESULTS AND DISCUSSION

4.1. Results

According to the latest GHG inventory report, Türkiye's emissions have increased to 564.39 MtCO2e, while removals have decreased to 47.15 MtCO2e. This reduction in the land sector is due to two main factors: the large mega-fires in 2021 and an increased harvest rate in forestlands. Compared to the 1990 figures, the removals have decreased by 29.12 percent, from 66.51 MtCO2e to 47.15 MtCO2e, while emissions have increased by 61.10 percent during the same period (Figure 3). The GHG inventory indicates that Türkiye is not on track to achieve the peak of emissions and removals during the 2030s.

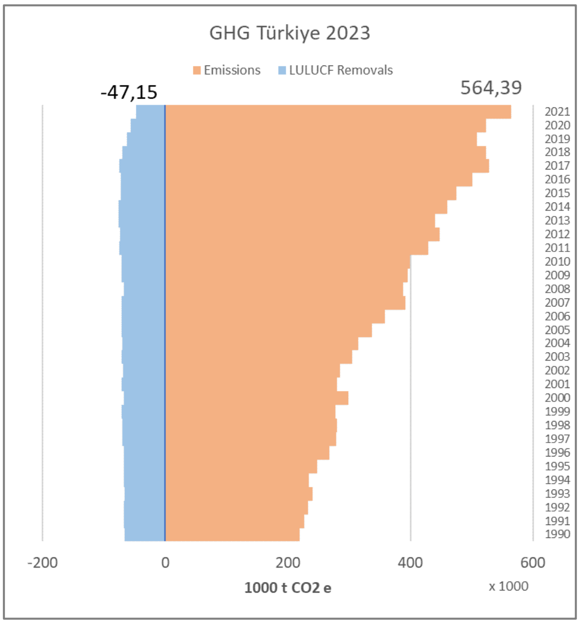

Figure 3. The emission and removal series of Türkiye for the 1990-2021 period according to the latest GHG inventory (2023) submitted to the UNFCCC.

Türkiye's LULUCF sector saw most of its removals in 2021 fall under the Forestland (FL) category. A total of 33.94 MtCO2e removals (44.066 FL-FL + 340 L-FL = 44.41 MtCO2e total removals) was accounted for in 2021. These figures show that the overwhelmingly major category of the LULUCF sector is forestlands remaining forestlands (FL-FL). The share of afforestation/reforestation adds less than 1 percent to the total removals.

It's worth mentioning that while the Harvested Wood Products (HWP) category is considered a removal category, it represents delayed emissions since it involves a transition from forestland to the atmosphere Figure 4).

The inventory also reveals that land uses (croplands, grasslands, wetlands, settlement, otherland) other than FL are all emissions.

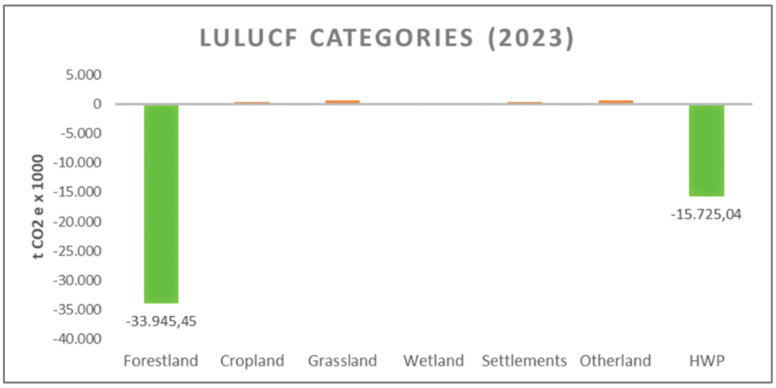

Figure 4. The share of LULUCF sector emission and removal categories according to the latest GHG inventory (2023) submitted to the UNFCCC. Green represents negative emissions (removals), while orange represents emissions.

The reduction of LULUCF sector removals as compared to 1990 occurred during the 2015-2021 period, as seen in Figure 5. The increase in the HWP during the same period indicates that the reduced removals are related to the harvest rate.

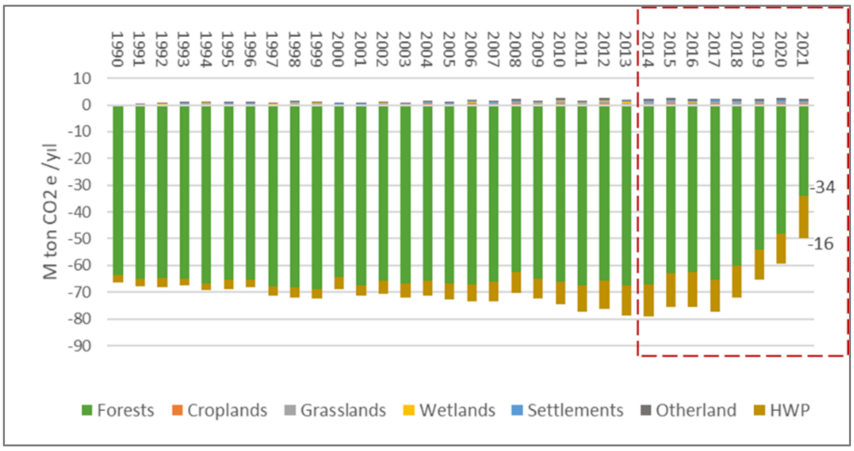

Figure 5. The time series of LULUCF sector removals for the 1990-2021 period. The percentage of other land uses has witnessed a notable increase, while the removal of forestland category has experienced a significant decline in recent years.

4.2. Discussion

Climate neutrality requires the reduction of emissions as well as the increase in removals. The latest GHG inventory figures show that Türkiye is performing the opposite at the current state. To enhance the removals, Türkiye must leave its current forestry policies and move towards a new tract that prioritizes ecosystem services, particularly carbon. EU has launched new forestry approaches as part of the 2030 Forest Strategy under the Green Deal. The Union forestry specialists are also seeking ways to enhance biogenic removals (Aggestam & Giurca, 2021; Lier et al., 2021; Lovrić et al., 2023;

Winkel et al., 2022). Climate-smart forestry (Weatherall et al., 2022) and closer-to-nature forestry[6] are the recent approaches the EU forestry policy is trying to move on.

On the other hand, the use of wood material is expanding in all sectors, and more raw wood material is needed to boost wood's substitution benefits towards fossil-based products (Jonsson et al., 2021; Schulte et al., 2023). The forest ecosystems can grow fast to accumulate carbon in biomass and soil but can also provide wood material to enhance substitution benefits. However, this requires very sophisticated forest management.

The latest figures in the GHG inventory of Türkiye indicate that:

- Türkiye must invest in forest management to increase its removals.
- The land categories other than FL should become emission-negative. They are all emitting at the current state.
- Investing in HWP may enable delayed emissions if the fuelwood use ratio drops further,
- Afforestation/reforestation, grassland rehabilitation, improved cropland management, wetland restoration, and greened settlements do not have large mitigation potentials but should be supported to enhance the sector. These categories are also significant for their co-benefits, such as increased productivity and resilience. There may be a good potential for afforestation of unstocked lands and also potential of afforestation of abandoned croplands.
- Disturbances, especially forest fires, must be appropriately managed to reduce emissions. Particularly, the disastrous wildfires must be disabled by using new technologies and prevention measures.
- Controlling urban expansion (sprawl) towards croplands, unstocked forestlands, and grasslands can reduce emissions caused by land use changes.

Among these mitigation measures and strategies, the focus must be on the forest management category. To increase the FL category removals, the average net increment of the forests should get into an increasing trend. According to the latest figures extracted from the action plans of the General Directorate of Forestry, the per-hectare stock and increment values are in decline while harvesting is increasing. The productive forests' weighted average stock and increment were 121.70 m3/ha and 3.35 m3/ha in 2022, respectively. The production has increased to 2.36 m3/ha in 2021 and then reduced to 2.19 m3/ha in 2022 (Figure 6). The harvest rate has been 65.37 percent of the increment by 2022. However, it should be noted that more than 10 percent of the forests are protected, and increment is not distributed evenly throughout the country. Thus, the utilization rate could be considerably high in some regions of the country, which might be suppressing the increment rate.

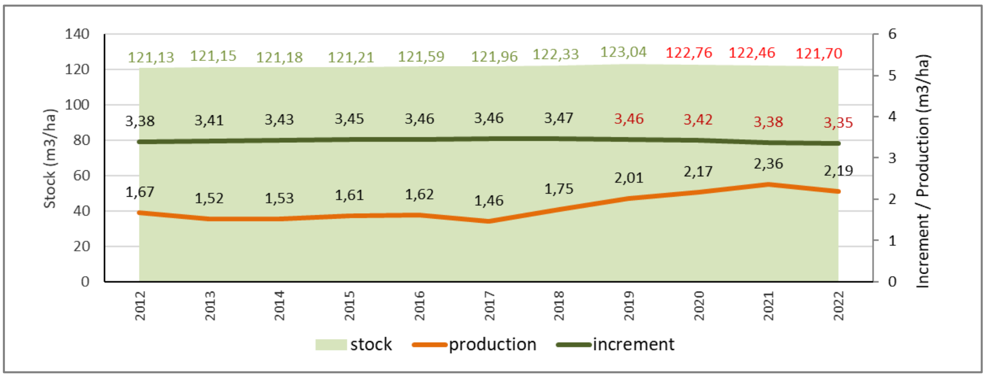

Figure 6. The time series of increment rates, stock, and harvest in productive forests. The decline in the increment rate parallels the decline in the LULUCF sector removals in recent years.

[6] https://efi.int/publications-bank/closer-nature-forest-management

To achieve increases in FL removals, Türkiye must turn the declining trend of increment to the opposite direction (Figure 7) to reach an average net increment rate somewhere around 3.6-4.0 to reach a removal rate of around 80-120 MtCO2 e by 2050.

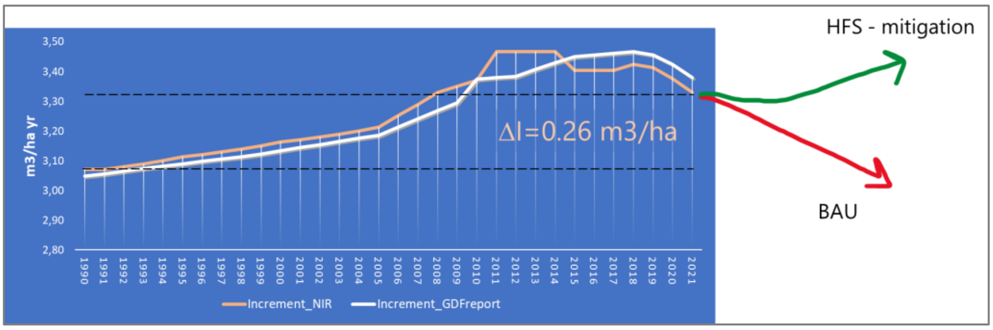

Figure 7. Time series of increment rates according to GDF activity reports and GHG inventory reports. The difference is caused by the slight difference in calculating the average. Türkiye must enhance the increment rate in a High Forest Scenario (HFS) as compared to Business as Usual (BAU).

5. CONCLUSION

Türkiye is on the eve of its green transformation by submitting its first NDC document, Climate Change Action Plan for 2030, and LTS. A roadmap in forestry and the Land Sector is needed in this preparation period. The roadmap with a set of strategies will guide the land sector decisions in the coming decades.

According to the results above, a 0.5 m^3/ha yr increase in the average net increment rate for productive forests supported by afforestation/restoration and wildfire prevention would move Türkiye on track for climate neutrality at a year beyond 2050. However, enhancing removals is only a part of the LTS. The emissions must reach the peak point and start declining around early 2030 to reach the target in the 2050s. Türkiye's Climate Neutrality target year, 2053, is only three years later than the EU. To align with the target, the removals will reach somewhere near one hundred million tons of CO_2 equivalent by the 2050s. Türkiye must start investing in biogenic removals since the growth of the forests is taking time. The biogenic mitigation options must be fully implemented for their cost effectiveness and co-benefits before other costly options, such as Carbon Capture and Storage (CCS).

Funding restoration (afforestation, rehabilitation etc.), circularity, innovation/technology, and high added value is necessary for the whole land sector. Good practices, including NBSs in all land uses, especially in urban areas, have limited mitigation potential but are critical to enhancing climate adaptation.

In conclusion, increasing the productivity (stock and increment) of forests as part of climate-smart forestry is the key to climate mitigation.

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ORAL PRESENTATION https://doi.org/10.61326/icelis.2023.1

The Role of Wooden Consumptions in Climate Change Mitigation - Case Study: Forest-Dwelling Community of Nodeh, Razvanshahr, Gilan, Iran

Nastaran Zolfi[1], Ramin Naghdi[1], Mehrdad Nikooy[1], Hamid Reza Afrand Sorkhani[2]✉

[1]University of Guilan, Faculty of Natural Resources, Department of Forestry, Somehsara/IRAN

[2]University of Tehran, Faculty of Natural Resources, Department of Forestry and Forest Economics, Karaj/IRAN

✉***Correspondence**: afrand@ut.ac.ir*

Abstract: The Law on Nationalization of Forests (1963) in Iran did not officially recognize the border line of village, which was used to provide livestock grazing, fuelwood and construction wood, but it prescribed some provision for villagers' consumptions. On the other hand, in addition to the benefits of carbon sequestration inside the forest, forests also store significant benefits outside the forest by providing harvested wood products for construction and fuel; Therefore, it becomes important, investigation of attitude, participation and indigenous knowledge of forest dwellers in using these products. In this research, utilization of wood products in Nodeh village investigated by using questionnaire and interview tools. The results showed that 52.3% of the residents are engaged in Livestock farming and 95.5% of their monthly income is above the poverty line. Only 4.5% of the interviewees sell the collected fuelwood and charcoal in retail form. This is while 100% of products such as fence base, construction wood and lop are just harvested for personal consumptions. The production of the mentioned products has decreased in recent years and their harvest has also decreased. The main attitude of the society, of course to wrong, is that the use of iron and concrete materials and fossil fuel instead of wood products helps to climate change mitigation. Participation to reduce emissions and cooperation in government forest protection projects is estimated at a medium to high level. 100% of the interviewees are well aware about effect of climate change on the reduction of forest products, but 77.3% of them believe that forests cannot mitigate these effects well. Finally, although the interest of local community participation for mitigation measures is evaluated in well level but due to the emerging phenomenon of climate change and the weakness of its literature, indigenous knowledge and the attitude of forest dwellers is not correct in this field, and it seems necessary promoting of attitude and increasing of knowledge.

Keywords: Rural consumptions, Timber forest products, Fuelwood, Construction-wood, Carbon store, Reduce emission, Carbon substitution.

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Manufacturing of Aluminum-Based Alloy Y-Axis of Laser Machines and Investigation of the Impact on Carbon Footprint

Gökan Yılmaz

Durmazlar Machinery Inc., Uludağ University, Bursa/TÜRKİYE

***Correspondence**: gyilmaz@durmazlar.com.tr*

Abstract: Nowadays, the rapid development of technology increase fiber laser cutting machine's cutting dynamics day by day, these dynamics, such as speed, acceleration, and jerk, refer to the quantitative measures used to describe the motion of an object. In order to enhance these dynamics, it is imperative to modify the design of the motion mechanism. We can employ more powerful electrical or magnetic motor for motion system however dimensional constraints limits this implementation. The aim of this study evolves mechanical design and manufacturing material of Y axis. "Y axis" significant part of the machine which assembly "fiber cutting head" resemblance bridge over the machine main body. Steel alloys predominantly recognize as preferred manufacturing alloy material for this part on account of manufacturing in addition processing of steel parts comparatively effortless than aluminum-based alloys additionally welding and assembly process require more knowledge than production of steel alloys-based material. Aluminum is an economically viable and lightweight metal with the ability to undergo heat treatment and withstand relatively high levels of stress. It ranks among the easily produced high-performance materials, thereby contributing to reduced manufacturing and maintenance costs. Aluminum production process known higher level carbon dioxide emission. "Aluminum Institute reported 11.2 t CO_2/t Al through primary aluminum production and 0.2 t CO_2/t Al through secondary aluminum production." "World Steel Association, in the year 2020 data's when examining the average emissions per unit of steel produced in 2020, it is each metric ton of steel contributed to the release of approximately 1.89 t CO_2/t into the atmosphere." Based on the presented data, it is evident that the carbon dioxide emissions associated with the production of 1 ton of aluminum are approximately six times higher than the carbon dioxide emissions from steel production. The incorporation of an aluminum-based Y-axis in the machinery has led to a notable reduction in weight. Consequently, the two servo motors responsible for actuating this component will consume less electrical current during its operation throughout the machinery's operational lifespan. This decrease in electrical power consumption is expected to translate into a discernible advantage in terms of CO_2 emissions over a specific timeframe, thereby will make aluminum bridge a probably more environmentally favorable choice. This article provides of how to enhance of machine dynamics with using aluminum based "Y axis" in addition that such as carbon footprint, manufacturing process. Upon the conclusion of the research, a comprehensive analysis will be provided regarding the advantages and disadvantages of employing an aluminum "Y axis" rather than a steel "Y axis" in terms of design considerations.

Keywords: Laser cutting machine, Carbon footprint, Manufacturing methods, Material and metallurgy.

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Spatial Pattern of Trees in *Parrotia persica-Carpinus betulus* and *Parrotia persica-Quercus castaneifolia* Types in Chafrood Forests, Guilan, Iran

Hassan Pourbabaei, Saman Pourabasi Shiraz, Amer Mirzazadeh✉

University of Guilan, Faculty of Natural Resources, Department of Forestry, Somehsara/IRAN

✉***Correspondence****:* mirzazadehamer@gmail.com

Abstract: The aim of this study was to determine the trees spatial pattern in *Parrotia persica – Carpinus betulus* and *Parrotia persica – Quercus castaneifolia* types in Chafrood forests, Western Guilan. For doing the purpose, one- hectare (100 m×100 m) plot was established in each type. Diameters at breast height (DBH) of all trees > 7.5 cm were measured, azimuth angle and distance of trees was also recorded in the plot. Spatial pattern was analyzed using Ripley's K- function. Our results indicated that spatial pattern of trees to a distance of 19 m was clumped distribution, and higher from this distance was a random pattern in *Parrotia persica – Carpinus betulus* type. In addition, in *Parrotia persica – Quercus castaneifolia* type, clumped distribution pattern was found within 37 m distance, and after this distance found random pattern. Awareness of spatial pattern of forest trees is effective on the design of suitable management pattern for protection, reforestation of forest stands, and determining inventory method in forest ecosystems.

Keywords: *Parrotia persica - Carpinus betulus*, *Parrotia persica - Quercus castaneifolia*, Ripley's K function, Spatial pattern, Guilan Chafrood.

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Investigation of Carbon Sequestration Model according to Independent Variables of DBH and Height in *Populus deltoides* Plantation, Case Study: West, Center and East of Gilan Province, Iran

Tooba Abedi[1]✉, Roya Abedi[2], Hadi Modaberi[1], Hassan Pourbabaei[3]

[1]*Environmental Research Institute, Academic Center for Education, Culture and Research, Tahran/IRAN*
[2]*University of Tabriz, Ahar Faculty of Agriculture and Natural Resources, Tabriz/IRAN*
[3]*University of Guilan, Faculty of Natural Resources, Department of Forestry, Somehsara/IRAN*
✉***Correspondence***: t.abedi@acecr.ac.ir

Abstract: *Populus deltuides* W. Bartram ex Marshall is one of the most important economically (wood production), environmentally (biomass production and carbon sequestration), and fast growing species in plantations. Therefore, the purpose of this study was to investigate DBH, height and carbon sequestration models according to the age using Stem Analysis Method in poplar plantations of Guilan province, Iran. Thirty trees were randomly selected in different diameter classes, fell down and the discs were obtained in order to stem analysis. The annual rings of discs counted, age at different tree heights obtained, and the annual rings diameter were measured to determine annual diameter and volume growth. Biomass was measured and finally, regression analysis performed by the relationship between DBH and height by carbon in age based on the highest coefficient of determination and minimum standard error. The results showed that the model of carbon sequestration was $C = 3.3d^{0.29} + 0.002H^{2.42}$ (R^2=99, SE=0.31) in the west, $C = 1.51(d^{0.8} + H^{0.97})$ (R^2=0.98, SE=2.16) in the center and $C = 1.29(d^{0.07} + H^{0.89})$ (R^2=0.82, SE=3.80) in the east poplar plantation of Guilan Province.

Keywords: Carbon model, Plantation, *Populus deltoides*, Stem analysis.

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Investigation of Carbon Stock Changes in Forests of Uludağ National Park

***Birsen Durkaya*[1], *Asiye Karaevli Yüksel*[2], *Sinan Kaptan*[1✉], *Ali Durkaya*[1]**

[1]*Bartın University, Department of Forest Engineering, Bartın/TÜRKİYE*

[2]*Bartın University, Graduate School, Bartın/TÜRKİYE*

✉***Correspondence**:* skaptan@bartin.edu.tr

Abstract: In this study, it was aimed to evaluate the temporal changes in the amount of carbon stock held in the stands of Uludağ National Park with the help of biomass equations (BE) and biomass expansion factor (BEF) methods. For this purpose, the changes in the amount of stand carbon stock for the 1994-2012 and 2014-2033 plan periods of Uludağ National Park were tried to be determined by using BE and BEF methods. Previously determined biomass equations (BE) were used for the species represented in the types of biomass to make biomass and carbon calculations using the biomass equations method. For species that do not have biomass equations, calculations were made by averaging the biomass amounts given by coniferous tree species and broadleaf tree species according to diameters from the existing biomass equations. It was calculated that in the 1994-2012 plan period in Uludağ National Park, 447,265.46 tons of total carbon was stored by the BE method and 346,131.39 tons by the BEF method in all stand types. In the 2014-2023 plan period, the carbon stored in all stands was calculated as 483.917.06 tons by BE method and as 313.331.79 tons by BEF method. According to BE and BEF calculations; It showed that the amount of carbon stored in the forests of Uludağ National Park decreased in coniferous and broad-leaved forests during the 20-year period from 1994 to 2014, while it increased in mixed forests. The most important deficiency encountered in the study is the inability to calculate the carbon storage amounts precisely because of the lack of biomass equations for broad-leaved species.

Keywords: Forest biomass, Carbon, Allometric biomass equations, Biomass expansion factor (BEF), Uludağ National Park.

ORAL PRESENTATION https://doi.org/10.61326/icelis.2023.9

Investigation of the Effects of Global Warming on Carbon Storage Capacity of Pure and Mixed Forests of Zonguldak-Dirgine Region by Using Climate Change Scenarios

Halil Barış Özel[1]✉, Tuğrul Varol[1], Uğur Cantürk[2], Burak Amaç[3], Güllizar Özyurt[4]

[1]*Bartın University, Faculty of Forestry, Bartın/TÜRKİYE*
[2]*Düzce University, Faculty of Forestry, Düzce/TÜRKİYE*
[3]*Dirgine Forest Enterprises Directorate, Zonguldak/TÜRKİYE*
[4]*Bartın University, Graduate School, YÖK 100/2000 Sustainability Forestry Doctora Programme, Bartın/TÜRKİYE*
✉***Correspondence***: halilbarisozel@gmail.com

Abstract: The negative effects of global warming, which is the most important environmental problem particularly during last two decades, continue to negatively affect all social life and the future of the world's natural resources. Increasing the carbon storage level is very important in mitigating the effects of this global problem. In this regard, it is necessary to protect the existence of natural resources with high carbon storage capabilities as well as creating awareness of social environmental cleaning. Forests are at the forefront of these important natural resources. Forests, which naturally have the ability to renew themselves, have different carbon storage abilities at every age and growth stage. However, the problem of global warming, the effectiveness of which is increasing rapidly, negatively affects this important feature of forest resources in terms of carbon storage. In this research, the possible changes in the carbon storage capacities of the forests in Dirgine province, which is located in the Western Black Sea Region, which is one of the regions with productive high forest resources which has very valuable pure and mixed forest resources, due to the effects of global warming, were investigated by using climate change models. For this purpose, Shared Socio-economic Pathways (SSPs) presented in the 2021 IPCC sixth evaluation report (AR6) for the years 2040, 2060, 2080, and 2100 in the WorldClim database, using 19 different bioclimatic variables, including altitude, and aspect, according to 245 and 585 global climate change scenarios. Modeling was done with Maximum Entropy software using topographic variable. As a result of the model applications, the annual mean temperature, the maximum temperature in the warmest months, the mean temperature in the driest period, the mean temperature in the warmest period and seasonal precipitation were determined as the bioclimatic variables that have the most important effects on the change in the carbon storage capacity of pure and mixed stands in the research area. According to these model applications, the carbon storage capacity of pure forest will decrease by 13.6% in 2040, 23.8% in 2060, 34.7% in 2080 and 41.3% in 2100. Depending on the effects of global warming, it has been determined that it will weaken by 11.5% in 2040, 20.7% in 2060, 30.8% in 2080 and 37.9% in 2100 in the mixed forest resources in the Dirgine province.

Keywords: Global warming, Climate change scenarios, Bioclimatic variables, Dirgine, Pure forest, Mixed forest.

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Analysis of the State of Degradation of the Endemic Argan Tree (*Argania spinosa* (L.) Skeels) in Morocco

Said Laaribya✉

Ibn Tofail University, Laboratory of Territories, Environment, and Development, Kenitra/MOROCCO

✉***Correspondence****:* said.laaribya1@uit.ac.ma

Abstract: The argan grove is one of Morocco's most emblematic and endemic forest ecosystems, covering an estimated 871,210 hectares. Despite the low average density of its stands, the exceptional qualities of the argan tree (*Argania spinosa* (L.) Skeels) have made it a focus of attention for scientists, local communities, foresters, tourists and others. The aim of the study is to present a spatial remote sensing diagnosis of the forestry situation. The methodology adopted focused on the use of spatial remote sensing using high-resolution satellite images and field checks, which is proving to be a highly valuable tool, providing a synthetic overview and highly accurate spatial measurements. An analysis of the dynamics of argan areas reveals several indicators of degradation. Indeed, in addition to human activities, the de-densification of stands and the reduction in cover, the argan forest provides only a limited quantity of ecosystem services and retains only limited biological diversity. The urgent need to conserve the argan tree plantation urges the public authorities to take the necessary steps to reverse the degradation of this endemic specie in Morocco.

Keywords: GIS, Remote sensing, Vegetation indices, Degradation, Argan tree.

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Estimation of Urban Forest Carbon Stocks Considering Future Land-Use Change Scenarios: Case of Izmir City Core

Ufuk Özkan*✉, *Remzi Eker

İzmir Katip Çelebi University, Faculty of Forestry, Department of Forest Engineering, İzmir/TÜRKİYE

✉***Correspondence***: ufuk.ozkan@ikc.edu.tr

Abstract: Urban forests play a crucial role in mitigating climate change by sequestering and storing carbon dioxide (CO_2) from the atmosphere. However, rapid urbanization and land-use changes have threatened these fragile ecosystems. Therefore, in-depth assessment of their carbon stocks under future scenarios is required with proper methods. This study focuses on the İzmir City Core as an exemplary case to estimate the potential impact of land-use changes on urban forest carbon stocks. It was aimed to simulate future land-use change based on past urban development trends according to CORINE maps, demographic projections, and policy implementations. Future land-use changes simulations were made with GeoSOS-FLUS software by considering two scenarios: I) assuming current land-use change trend would be same in future, and II) assuming current urban forest would be protected. The analysis reveals important variations in urban forest carbon stocks across different land-use scenarios. These findings underscore the significance of adopting environmentally sensitive land-use policies for preserving and enhancing urban forests' carbon sequestration capacity. Additionally, the study highlights the importance of urban forest quality and its potential role in climate change adaptation and urban resilience. Moreover, it emphasizes the value of using innovative technologies and methodologies to accurately estimate urban forest carbon stocks in the face of dynamic land-use changes. In conclusion, this study provides valuable insights into the estimation of urban forest carbon stocks under various land-use changes scenarios within the İzmir City Core. The findings offer a foundation for evidence-based policymaking, fostering sustainable urban planning, and promoting the importance of urban forest conservation in combating climate change.

Keywords: Carbon stock, GeoSOS-FLUS, Future land-use, Urban forest.

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Health Risk Assessment due to Some Potentially Toxic Elements in Sepiolite Mineral

Şeref Turhan, Aybaba Hançerlioğulları✉, Aslı Kurnaz
Kastamonu University, Science Faculty, Kastamonu/TÜRKİYE
✉***Correspondence***: aybabah@gmail.com

Abstract: Potentially toxic elements (PTEs) can cause several health problems. Sepiolite is a clay mineral containing hydrated magnesium silicate and widely utilized in agriculture, food, detergent, pharmaceutical, cosmetics, paint, paper, fertilizer, construction, etc. The aim of this study is to assess the health risks that may arise from some PTEs present in the sepiolite mineral contained in the products we use in our daily lives. For this purpose, first of all, some PTEs contained in the sepiolite mineral were analyzed by EDXRF technique, and then non-carcinogenic and carcinogenic risks were estimated based on the analysis results. According to the average concentration (mg/kg), PTEs analyzed in sepiolite samples were ordered as Al (5457) > Fe (3832) > Ti (361) > Mn (65) > V (42) > Zr (25) > Ni (24) > Cr (16) > Zn (12) > Co (9) > Cu (8) > As (5) > Pb (5) > Cd (4). The values of hazard quotient and hazard index estimated for non-carcinogenic risk and the incremental lifetime cancer risk and cancer risk index estimated for carcinogenic risk caused by PTEs in sepiolite samples were within the acceptable limit and the safe range except for the Beylikova quarry.

Keywords: Sepiolite, Potentially toxic element, Hazard index, Cancer risk.

1. INTRODUCTION

Today, various chemical, biological, and physical pollutants arising as a result of rapid population growth, industrialization, and excessive mining activities have become a major problem that adversely affects people, animals, plants, organisms, and ecosystems all over the world (Abbaslou & Bakhtiari, 2017; Tyagi et al., 2022; Kolawole et al., 2023). Contamination of agricultural soils, water resources, and food crops with potentially toxic elements (PTEs) as chemical pollutants remains a major environmental issue at the global due to their persistence in the environment, their tendency to bioaccumulate in the food chain, and their toxicity to humans, animals and plants (Rinklebe et al., 2019; Liu et al., 2020; Pham et al., 2022; Belanović et al., 2023; Agbasi et al., 2023). The main sources of PTEs are human activities such as chemical and metallurgical industries, mining, agriculture, combustion from vehicle emissions, power plants, and coal burning, etc. lithogenic sources such as volcanic eruptions and weathering of element-containing rocks (Marín et al., 2022). The availability of PTE and its toxicity effects on human health and other organisms depend on its chemical properties (Rinklebe et al., 2019). PTEs are generally classified as carcinogens and non-carcinogens. Carcinogenic PTEs contain arsenic (As), mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr), nickel (Ni), etc. (Agbasi et al., 2023). Non-carcinogenic PTEs such as Cu (copper), Fe (iron), Co (cobalt), Zn (zinc), and Mn (manganese) have functional roles and are essential for biochemical and physiological functions in humans (Niede & Benbi, 2022). Exposure to PTEs can cause serious health diseases such as cardiovascular problems, insomnia, insanity, cancer, Alzheimer, anemia, abdominal discomfort, depression, headache, constipation, cramping in the abdomen, exhaustion, irritability, etc. (Jaishankar et al., 2014; Golia et al., 2021; Niede & Benbi, 2022; Agbasi et al., 2023). Mining activities containing exploration, construction, operation (grinding the rock and ores, etc.) maintenance, expansion, abandonment, and dumping the waste into a tailing or holding pond may have negative impacts on the environment such as erosion, deforestation, contamination, and alteration of soil profiles, and an increase in dust and emissions (Haddaway et al., 2019). Türkiye has the largest mineral resources in the world and is an important industrial mineral (boron, sepiolite, feldspar, barite, marble, pumice, bentonite, gypsum, etc.). The proven sepiolite reserves of the world are approximately 80 million tons. The main raw sepiolite production is from quarries in Spain, followed by China, the United States, and Türkiye (Wang et al., 2018).

Sepiolite ($Mg_8Si_{12}O_{30}(OH)_4(OH_2)_4 \cdot 8H_2O$), which occurs naturally as a result of geological processes on Earth, is a natural fibrous magnesium-rich silicate clay mineral (He et al., 2020). Sepiolite is widely used in industrial applications such as agricultural carries, adhesives, industrial floor absorbents, drilling fluids, animal feed bonds, paint and coatings, paper, pharmaceuticals, polishes, suspension fertilizers, and raw materials in the ceramics and cement industry as it has superior absorbent, rheological and catalytic properties due to its unique crystalline tubular structure (Álvarez et al., 2011). Considering the mining of sepiolite and the widespread use of the sepiolite mineral in a wide variety of consumer products, it is inevitable that quarry workers, the general population, and the environment will be exposed to PTEs contained in sepiolite. Thus, there is a necessity for a study involving data on PTEs in sepiolite, which is associated with health risk concerns. Moreover, many previous studies investigated the mineralogical and radiometric characterization of sepiolite minerals and the removal of PTEs (or heavy metals) or radioactive elements in various environmental samples by using sepiolites (Doğan et al., 2008; Donat, 2009; Işık et al., 2010; Kadir et al., 2016; Suárez et al., 2016; Kocaoba, 2019; Hançerlioğulları et al., 2019; Bashir et al., 2020; He et al., 2020; Hamid et al., 2021; Tekin & Açıkel, 2023; Wang et al., 2023). However, there has never been a comprehensive study linking PTE levels in sepiolite minerals to human health risks for adults. This study particularly aims to (1) determine the levels of fourteen PTEs in thirty sepiolite samples collected from three quarries located in the Central Anatolian Region of Türkiye by using an energy dispersive X-ray fluorescence (EDXRF) spectrometry to estimate the potential environmental risk due to concentrations of PTEs in sepiolites and (2) evaluate the associated health risk for adults by estimating the non-carcinogenic (hazard quotient and hazard index) and carcinogenic (incremental lifetime cancer risk and cancer risk) index. By this way, this study represents the first attempt to raise the awareness of sepiolite consumers and mine workers about the presence of PTEs accompanying the sepiolite mineral and to establish a database on the distributions of PTEs in the three sepiolite quarries.

2. MATERIALS AND METHODS

2.1. Sample Collection and Preparation

A total of thirty sepiolite samples were collected randomly from sepiolite open quarries (SQs) located in Polatlı-Ankara (SQ1), Beylikova-Eskişehir (SQ2), and Sivrihisar-Eskişehir (SQ3) in Central Anatolia of Türkiye as shown in Figure 1 (Hançerlioğulları et al., 2019). Sepiolite samples were taken from the upper layers of each quarry, that is, from a depth of 0-5 cm. Each sepiolite sample placed in polyethylene bags was brought to the sample preparation laboratory. After the samples were kept in the open air in the laboratory for a while, they were dried in a furnace at 110 °C for 5-10 h to remove moisture. The dry samples were grounded and powdered to make them fit the calibrated powder geometry in the EDXRF spectrometer (Turhan et al., 2020; Altıkulaç et al., 2022). Each powder sample was homogenized with an agate pestle and made ready for elemental analysis (Turhan et al., 2020). The X-ray emission underlying the XRF technique is simple, systematic, relatively independent of the chemical state, and has uniform excitation and absorption based on an atomic number. Interference in the X-ray peak in the spectrum can be easily corrected, thus ensuring high accuracy and sensitivity easily. Wavelength and energy dispersive X-ray fluorescence spectrometers are utilized for qualitative and quantitative multi-element analysis in a sample of geological, archaeological, industrial, food, biological, and environmental and require minimal sample preparation compared to other chemical analytical analysis techniques (Oyedotun, 2018; Tyagi et al., 2022; Qingyu et al., 2023). Determination of PTEs in the sepiolite samples was carried out using an EDXRF spectrometer (Spectro Xepos, Ametek) equipped with an anode X-ray tube (50 W, 60 kV) consisting of a dual thick Pd/Co mixture. Detailed information on the spectrometer and analysis processes was given in detail in the study done by Turhan et al. (2020). The EDXRF has many different excitation conditions that guarantee the best detection of all elements from Na to U (Turhan et al., 2020). The spectral resolution of the system is lower than 155 eV. The EDXRF spectrometer has twelve automatic sampling devices and software to analyze samples at the same time. It uses sophisticated calibration techniques such as "no-standard" calibration, often based on the basic parameters method. Soil-certified reference material (NIST SRM 2709) was used for quality assurance of the EDXRF system (Turhan et al., 2020). Sample containers prepared for each sepiolite sample were placed in an automatic sampler and the analysis procedures were completed by counting for two hours. The total uncertainty of the analytical procedure is between 2% and 16%. The XRF spectrum of each sepiolite sample was assessed with the help of the software installed in the system.

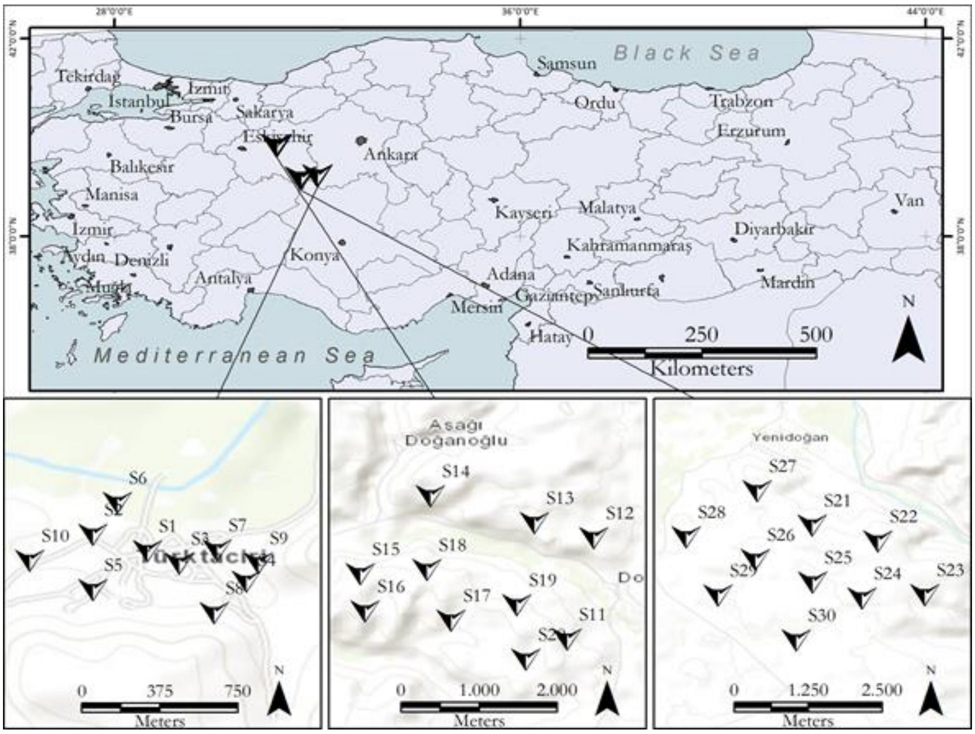

Figure 1. Locations of sampling points and sepiolite quarries (Hançerlioğulları et al., 2019).

2.2. Potential Health Risk Evaluation

Potential health risk evaluation is the process of estimating the nature and probability of adverse health effects on people who may be exposed to hazards in polluted or contaminated environmental media. Health risks of pollutants often include carcinogens and non-carcinogenic risks. This study accepted the potential health risk evaluation model recommended by the USEPA. The Ingestion of soil and dust is a potential way of exposure to environmental chemicals for both adults and children (USEPA, 2011). The cumulative non-carcinogenic risk and carcinogenic risk are represented by hazard index (HI) and carcinogenic risk (CR), respectively. The average daily dose (ADD) was calculated for adults as follows (Tyagi et al., 2022; Shentu et al., 2023):

$$\text{ADD (mg/kg/day)} = \frac{\text{C}\times\text{IR}\times\text{FE}\times\text{ED}\times10^{-6}}{\text{BM}\times\text{AT}} \quad (1)$$

where C is the PTE concentration in sepiolite samples (mg/kg); IR is the ingestion rate of soil and dust (100 mg/day) given for adults in Final Report prepared by USEPA (2011); ED is the average exposure duration of adults (79 y); FE is the frequency of exposure (365 day/y); BM is the average body weight of adults (77 kg) and AT is the average exposure time (79 y x 365 day/y) (TÜİK, 2022). Then, based on ADD value, the hazard quotient (HQ) for non-carcinogenic risk (HI) was calculated using the following equation (Tyagi et al., 2022; Shentu et al., 2023):

$$HQ = \frac{ADD}{R_fD} \quad (2)$$

$$HI = \sum_{i=1}^{n} HQ_i \quad (3)$$

where R_fD is the PTE oral reference dose and 1, 2, …, n are the individual PTE in the sepiolite samples. The RfD value for Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Sr, Cd, Ba and Pb was taken as 0.1, 0.009, 0.003, 0.14, 0.007, 0.0003, 0.02, 0.005, 0.3, 0.0003, 0.6, 0.0005, 0.2 and 0.0035 mg/kg/day, respectively (USEPA, 2012). For non-carcinogenic risk, values of HQ and HI > 1 indicate high potential adverse health effects (Tyagi et al., 2022; Shentu et al., 2023). Based on ADD value, the incremental lifetime cancer risk (ILCR) for carcinogenic risk (CR) was calculated for Cr, Ni, As, Cd, and Pb by using the following equation (Tyagi et al., 2022; Shentu et al., 2023):

$$ILCR = ADD \times SF \quad (4)$$

$$CR = \sum_{i=1}^{n} ILCR_i \quad (5)$$

where SF is the slope factor and is taken as 0.5, 1.7, 1.5, 6.1 and 0.0085 per mg/kg/day for Cr, Ni, As, Cd and Pb, respectively (USEPA, 2012). The safe range of CR risk is suggested as 10^{-6} < CR > 10^{-4}. However, CR > 10^{-4} indicates cancer risk and needs some sort of intervention and remediation (Shentu et al., 2023).

3. RESULTS AND DISCUSSION

3.1. Potentially Toxic Element Content of Sepiolites

Some descriptive statistical data (average, median, standard deviation, etc.) on the concentrations of PTEs analyzed in all sepiolite samples is given in Table 1. PTE concentration distributions in sepiolite quarries and Earth's crust average of PTE are presented in Table 2. It can be seen from Tables 1 and 2 that the concentrations of the PTEs in sepiolite samples vary depending on the geological and geochemical structure of the location of the quarries. According to the average values, the levels of PTEs analyzed in the sepiolite samples are ranked as Al > Fe > Ti > Mn > V > Zr > Ni > Cr > Zn > Co > Cu > As > Pb > Cd. According to the average values of PTEs, except for As and Cu, the sepiolite quarries are ranked in descending order as follows: SQ2 > SQ3 > SQ1.

Table 1. Some descriptive statistical data on concentration of PTEs in sepiolite samples.

PTE	PTE concentration (mg/kg)								N
	Average	Median	SD	SE	Kurtosis	Skewness	Min	Max	
Al	5456.5	2269.5	5201.3	949.6	-1.0	0.9	1281.0	15390.0	30
Ti	361.0	161.2	315.3	57.6	-1.0	0.9	109.6	942.7	30
V	42.0	21.6	31.2	5.7	-1.4	0.4	3.5	104.4	30
Cr	15.5	5.3	16.6	3.0	-0.2	1.1	1.8	54.8	30
Mn	65.2	43.7	40.4	7.4	-0.6	1.0	19.6	158.2	30
Fe	3831.5	1655.5	3451.8	630.2	-1.1	0.9	942.7	9853.0	30
Co	8.6	6.2	6.9	1.3	-1.0	0.7	2.1	22.6	30
Ni	23.7	10.5	21.0	3.8	-1.1	0.9	7.4	61.0	30
Cu	7.8	4.9	5.5	1.0	-1.0	0.8	2.6	18.2	30
Zn	11.8	7.8	6.7	1.2	-1.3	0.7	5.2	24.9	30
As	5.3	4.0	4.4	0.8	-1.0	0.7	0.8	13.4	30
Zr	25.3	26.9	3.0	1.0	-1.7	-0.4	21.3	29.2	10
Cd	3.7	3.4	1.0	0.3	-0.7	0.3	2.1	5.4	10
Pb	5.3	5.5	1.4	0.3	1.9	-1.3	1.4	7.2	26

SE: standard error; SD: standard deviation.

Table 2. The average and range (min-max) of concentrations of PTEs in sepiolite quarries.

PTE	Concentration (mg/kg)						
	SQ1		SQ2		SQ3		Earth's crust
	Average	Range	Average	Range	Average	Range	
Al	1808.7	1281-273	12432.3	8141-15390	2128.4	1690-2700	80500
Ti	136.5	109.6-153.3	786.2	524.2-942.7	160.2	124-226.8	4500
V	26.6	3.5-75.9	68.1	47.5-85.4	31.2	11.5-104.4	90
Cr	4.4	2.6-6.1	37.2	25.3-54.8	4.9	1.8-10.5	83
Mn	37.7	19.6-45.7	117.6	70.2-158.2	40.2	26.2-47.0	1000

Table 2. (continued)

PTE	Concentration (mg/kg)						
	SQ1		SQ2		SQ3		Earth's crust
	Average	**Range**	**Average**	**Range**	**Average**	**Range**	
Fe	1432.9	942.7-1962.0	8457.5	4824-9853	1604.2	1245-2305	46500
Co	4.0	2.1-10.0	17.2	11.1-22.6	4.5	2.4-10.8	18
Ni	9.0	7.4-10.9	52.0	34.8-61.0	10.1	8.4-12.6	58
Cu	4.2	2.6-6.2	15.2	10.9-18.2	4.1	2.7-5.9	47
Zn	8.0	5.2-21.5	18.9	12.7-24.9	8.4	6.1-21.8	83
As	2.6	1.4-4.7	11.1	7.8-13.4	2.4	0.8-5.3	1.7
Zr	< 1.0	25.3	21.3-29.2	< 1.0	170		
Cd	< 2.0	3.7	2.1-5.4	< 2.0	0.13		
Pb	4.6	1.9-6.1	6.1	5.1-7.2	5.1	1.4-7.1	16

It can be seen from Table 1 that the concentrations of Al in all samples varied from 1281 to 15390 mg/kg with an average value of 5457 mg/kg. From Table 2, the highest average concentration (HAC) value of Al was analyzed in the sepiolite samples (S17) from the SQ2 quarry while the lowest average concentration (LAC) value was in the sepiolite samples (S2) from the SQ1 quarry. The average Al concentration is significantly lower than the earth's crust average of 80500 mg/kg (Yaroshevsky, 2006). The concentrations of Fe in all samples varied from 943 to 9853 mg/kg with an average value of 3832 mg/kg. The HAC value of Fe was analyzed in the sepiolite samples (S12) from the SQ2 quarry while the LAC value was in the sepiolite samples (S9) from the SQ1 quarry. The average Fe concentration is significantly lower than the earth's crust average of 46500 mg/kg (Yaroshevsky, 2006). The concentrations of Sr in all samples varied from 135 to 2129 mg/kg with an average value of 1183 mg/kg. The HAC value of Sr was analyzed in the sepiolite samples (S1) from the SQ1 quarry while the LAC value was in the sepiolite samples (S11) from the SQ2 quarry. The concentrations of Ti in all samples varied from 110 to 943 mg/kg with an average value of 361 mg/kg. The HAC value of Ti was analyzed in the sepiolite samples (S12) from the SQ2 quarry while the LAC value was in the sepiolite samples (S9) from the SQ1 quarry. The average Ti concentration is significantly lower than the earth's crust average of 4500 mg/kg (Yaroshevsky, 2006). The concentrations of Mn in all samples varied from 20 to 158 mg/kg with an average value of 65 mg/kg. The HAC value of Mn was analyzed in the sepiolite samples (S20) from the SQ2 quarry while the LAC value was in the sepiolite samples (S9) from the SQ1 quarry. The average Mn concentration significantly is lower than the earth's crust average of 1000 mg/kg (Yaroshevsky, 2006). The concentrations of V in all samples varied from 4 to 104 mg/kg with an average value of 42 mg/kg. The HAC value of V was analyzed in the sepiolite samples (S28) from the SQ3 quarry while the LAC value was in the sepiolite samples (S2) from the SQ1 quarry. The average V concentration is lower than the earth's crust average of 90 mg/kg (Yaroshevsky, 2006). The concentration of Zr analyzed only in sepiolite samples collected from the SQ2 quarry varied from 21 to 29 mg/kg with an average value of 25 mg/kg. The HAC value of Zr was analyzed in the sepiolite samples (S13) from the SQ2 quarry while the LAC value was in the sepiolite samples (S18) from the SQ2 quarry. The average Zr concentration is significantly lower than the earth's crust average of 170 mg/kg (Yaroshevsky, 2006). The concentrations of Cr in all samples varied from 2 to 55 mg/kg with an average value of 83 mg/kg. The HAC value of Cr was analyzed in the sepiolite samples (S14) from the SQ2 quarry while the LAC value was in the sepiolite samples (S23) from the SQ3 quarry. The average Cr concentration is lower than the earth's crust average of 83 mg/kg (Yaroshevsky, 2006). The concentrations of Zn in all samples varied from 5 to 25 mg/kg with an average value of 12 mg/kg. The HAC value of Zn was analyzed in the sepiolite samples (S12) from the SQ2 quarry while the LAC value was in the sepiolite samples (S10) from the SQ1 quarry. The average Zn concentration is lower than the earth's crust average of 83 mg/kg (Yaroshevsky, 2006). The concentrations of Co in all samples varied from 2 to 23 mg/kg with an average value of 9 mg/kg. The HAC value of Co was analyzed in the sepiolite samples (S12) from the SQ2 quarry while the LAC value was in the sepiolite samples (S4) from the SQ1 quarry. The average Co concentration is lower than the earth's crust average of 18 mg/kg (Yaroshevsky, 2006). The concentrations of Cu in all samples varied from 3 to 18 mg/kg with an average value of 8 mg/kg. The HAC value of Cu was analyzed in the sepiolite samples (S15) from the SQ2 quarry while the LAC value was in the sepiolite samples (S1) from the SQ1 quarry. According to the average values of Cu, the sepiolite quarries are ranked in descending order as follows: SQ2 > SQ1 > SQ3. The average Cu concentration is lower than the earth's crust average of 47 mg/kg (Yaroshevsky, 2006). The concentrations of As in all samples varied from 1 to 13.4 mg/kg with an average value of 5 mg/kg. The HAC value of As was analyzed in the sepiolite samples (S19) from the SQ2 quarry while the LAC value was in the sepiolite samples (S26) from the SQ3 quarry. According to the average values of As the sepiolite quarries are ranked in descending order as follows: SQ2 > SQ1 > SQ3. The average As concentration is approximately three times higher than the earth's crust average of 1.7 mg/kg (Yaroshevsky, 2006). The concentration of Pb analyzed only in 26 sepiolite samples varied from 1.4 to 7 mg/kg with an average value of 5 mg/kg. The HAC value of Pb was analyzed in the sepiolite samples (S15) from the SQ2 quarry while the LAC value was in the sepiolite samples (S21) from the SQ3 quarry. The average Pb concentration is lower than the earth's crust average of 16 mg/kg (Yaroshevsky, 2006). The concentration of Cd analyzed only in sepiolite samples collected from the SQ2 quarry varied from 2 to 5 mg/kg with an average value of 4 mg/kg. The HAC value of Zr was analyzed in the sepiolite samples (S18) from the SQ2 quarry while the LAC value was in the sepiolite samples (S16) from the SQ2 quarry. The average Cd concentration is significantly higher than the earth's crust average of 0.13 mg/kg (Yaroshevsky, 2006).

3.2. Human Health Risk Evaluation

The values of the average daily dose, health quotient, hazard index, incremental lifetime cancer risk, and cancer risk estimated for PTEs analyzed in the investigated sepiolite samples are summarized in Table 3. The ADD values varied from 4.8×10^{-6} mg/kg/day (Cd) to 7.1×10^{-3} (Al) mg/kg/day. The average ADD values of the PTEs decreased in the following order: Al < Fe < Ti < Mn < V < Zr < Ni < Cr < Zn < Co < Cu < As < Pb < Cd. The HQ values estimated for the PTEs in the investigated sepiolite samples varied from 0.0001 (Zn) to 0.7109 (Fe). The average HQ values of the PTES were found in the descending order of Fe < Al < Co < As < Cd < Cr < V < Cu < Pb < Ni < Mn < Zn. The HQ values estimated for adults revealed that there is no individual PTE posed a significant non-carcinogenic risk (HQ < 1). The combined non-carcinogenic health risk HI values estimated for all samples varied from 0.2 to 2.2 with an average of 0.9. Although the average HI values were below the safe limit of 1, HI values calculated for sepiolite samples (33% of the total sample) from the SQ2 quarry varied from 1.2 to 2.2 with an average of 1.9, implying a non-negligible risk to adults.

Table 3. Non-carcinogenic and carcinogenic risks to adults from PTEs in sepiolite samples.

PTE		ADD (mg/kg/day)	HQ	ILCR
Al	Average	7.1×10^{-3}	7.1×10^{-2}	-
	Range	1.7×10^{-3} - 2.0×10^{-2}	1.7×10^{-2} - 2.0×10^{-1}	-
V	Average	5.4×10^{-5}	6.1×10^{-3}	-
	Range	4.5×10^{-6} - 1.4×10^{-4}	5.1×10^{-4} - 1.5×10^{-2}	-
Cr	Average	2.0×10^{-5}	6.7×10^{-3}	1.0×10^{-5}
	Range	2.3×10^{-6} - 7.1×10^{-5}	7.8×10^{-4} - 2.4×10^{-2}	1.2×10^{-6} - 3.6×10^{-5}
Mn	Average	8.5×10^{-5}	6.0×10^{-4}	-
	Range	2.5×10^{-5} - 2.1×10^{-4}	1.8×10^{-4} - 1.5×10^{-3}	-
Fe	Average	5.0×10^{-3}	7.1×10^{-1}	-
	Range	1.2×10^{-3} - 1.3×10^{-2}	1.7×10^{-1} - 1.8	-
Co	Average	1.1×10^{-5}	3.7×10^{-2}	-
	Range	2.7×10^{-6} - 2.9×10^{-5}	9.1×10^{-3} - 9.8×10^{-2}	-
Ni	Average	3.1×10^{-5}	1.5×10^{-3}	5.2×10^{-5}
	Range	9.6×10^{-6} - 7.9×10^{-5}	4.8×10^{-4} - 4.0×10^{-3}	1.6×10^{-5} - 1.3×10^{-4}
Cu	Average	1.0×10^{-5}	2.0×10^{-3}	-
	Range	3.4×10^{-6} - 2.4×10^{-5}	6.8×10^{-4} - 4.7×10^{-3}	-
Zn	Average	1.5×10^{-5}	5.1×10^{-5}	-
	Range	6.8×10^{-6} - 3.2×10^{-5}	2.3×10^{-5} - 1.1×10^{-4}	-

Table 3. (continued)

PTE		ADD (mg/kg/day)	HQ	ILCR
As	Average	6.9×10^{-6}	2.3×10^{-2}	1.0×10^{-5}
	Range	1.0×10^{-6} - 1.7×10^{-5}	3.5×10^{-3} - 5.8×10^{-2}	1.6×10^{-6} - 2.6×10^{-5}
Zr	Average	3.3×10^{-5}	-	-
	Range	2.8×10^{-5} - 3.8×10^{-5}	-	-
Cd	Average	4.8×10^{-6}	9.6×10^{-3}	2.9×10^{-5}
	Range	2.7×10^{-6} - 7.0×10^{-6}	5.5×10^{-3} - 1.4×10^{-2}	1.7×10^{-5} - 4.3×10^{-5}
Pb	Average	6.9×10^{-6}	2.0×10^{-3}	5.9×10^{-8}
	Range	1.8×10^{-6} - 9.4×10^{-6}	5.2×10^{-4} - 2.7×10^{-3}	1.5×10^{-8} - 7.9×10^{-8}
HI=∑HQ	Average		0.9	
	Range		0.2-2.2	
CR=∑ILCR	Average			8.3×10^{-5}
	Range			2.4×10^{-5} - 2.3×10^{-4}

The average ILCR estimated for Ni, As, Cd, Cr and Pb in the sepiolite samples varied from 5.9×10^{-8} to 5.2×10^{-5}. The average values for ILCR were found in the order of Ni > Cd > As > Cr > Pb. The values of the carcinogenic risk index were within the safe index range of 10^{-6} to 10^{-4}. However, the combined carcinogenic health risk CR values estimated for all samples varied from 2.4×10^{-5} to 2.3×10^{-4} with an average of 8.3×10^{-5}. Although the average CR was within the safe limit, the CR values for 33% of the total samples collected from SQ2 exceeded the safety limit.

4. CONCLUSION

In this study, for the first time, (1) the concentrations of PTEs (Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Zr, Cd, and Pb) in sepiolite samples from three selected commercial quarries located in the Central Anatolian region of Türkiye were analyzed, and (2) potential non-carcinogenic and carcinogenic health risk caused by PTEs contained in the investigated sepiolite samples was evaluated. Analysis results revealed that the average concentration of As and Cd in sepiolite samples was higher than the Earth's crust averages. Potential health risk evaluation results indicated that some PTEs in sepiolite samples from the SQ2 quarry may pose carcinogenic and non-carcinogenic risks to adults and quarry workers. Therefore, at least, it should be necessary to take necessary precautions such as not breathing dust to eliminate situations that may threaten the health of the quarry workers. In conclusion, this study highlighted the status of potentially toxic elements, enrichment factors, and risk characterization in sepiolite minerals. The data are information that can create awareness for both those who use sepiolite-added products and those who work in the quarries.

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Design and Optimization of PV/T Solar Collector System Suitable for Local Climate Conditions in Türkiye - İran

***Rezvan Rezaeizadeh*[1], *İlknur Şahin*[2], *Aybaba Hançerlioğulları*[3]✉**

[1]*Guilan University, Science Faculty, Rasht/IRAN*

[2]*Kastamonu University, Central Research Laboratory, Kastamonu/TÜRKİYE*

[3]*Kastamonu University, Science Faculty, Kastamonu/TÜRKİYE*

✉***Correspondence****:* aybabah@gmail.com

Abstract: This study implements this concept by using a new roof-mounted PV multi-reflection panel, which not only increases the power output of the PV panel, but most importantly, the aesthetic aspect is a major barrier to large-scale uptake of PV/T. We developed it by considering the production planning of the industrial, expecting our model to determine each optimum production level. This model is based on a mixed binary-continuous linear optimization problem. The flow variables are continuous and the decision variables can be sales and purchases in the markets and gas purchases. We extracted the extra earnings and generate by comparing the situations that interact with the electricity markets and those that do not. In this study, it is aimed to develop an alternative system to the inefficient conventional building energy production and space heating systems, which are widely used in Türkiye, and to ensure that the developed technology has wide usage areas. The reason of rapid development of photovoltaic/thermal (PV/T) solar collector technologies, which are not yet known in the world and not used in R&D industrial applications, is to provide solutions to the industrial and social difficulties in the field of energy with Türkiye and İran, which has a close climate, by providing commercial value. In this way, it contributes to the industrial and economic development of both countries by creating new employment opportunities. Thus, private investment in innovative research in the field of solar and other renewable energy systems contribute to the reduction of carbon emissions by the two neighbouring powerful states and to the solution of problems related to energy security, climate change and increased energy consumption. In the study, more heat than heated PV panels using the high thermal conductivity of the fluids, which achieved 14% improvement in electricity production with the withdrawal of Fe_2O_4 nanofluid. Since the amount of heat absorbed in the thermal system is high, there is an increase in the average 10.4% temperature (ΔT) hot fluid temperature compared to the base fluid water was obtained in Fe_2O_4 nanofluid. For this reason, it is to integrate a power-generating PV panel and a solar thermal heating panel within the same collection surface.

Keywords: PV/T Systems, Optimization, Climate change, Türkiye, İran.

1. INTRODUCTION

The most common systems used to convert solar energy into thermal energy, water has traditionally been used as liquid. In this study, we obtained nanofluids, a new thermal nanofluid with high basic temperature, using conventional water and doped nanoparticles to achieve better efficiency. Magnetic nanoparticles are formed when groups of magnetic nanoparticles with diameters ranging from 50 to 200 nanometers come together. Magnetic nanoparticle assemblies are made up of a collection of nanoparticles that have each been extracted and isolated independently by a team of researchers (Swese & Hançerlioğulları, 2022). These specific purposes are as follows; to perform the design, modeling/simulation and optimization of the proposed photovoltaic thermal (PV/T) solar collector system; to design, build and test the PV/ThermoGen prototype; building integration and system performance studies and testing in building/climatic contexts; to make economic, social, environmental and thermodynamic analyzes of the PV/ThermoGen system (Shahsavar et al., 2021). In this study, focusing on the electro-mechanical production industry of advanced PV/T solar panels, studies carried out on the development of new methodological methods for the efficiency of existing asset management practices of the infrastructure of this industry and the optimal improvement of new technological systems. For this reason, it is to integrate a power-generating PV panel and a solar thermal heating panel within the same collection surface. In this research, it was implemented using a new roof-mounted PV multi-reflection panel, which not only increases the power output of the PV panel, but most importantly, the aesthetic aspect is a major barrier to large-scale uptake of PV/T of Türkiye-İran, Europe, some Asian countries, especially. Advanced innovation companies around the world have recently focused on both useful and ergonomic systems for renewable energy systems (Ghadiri et al., 2015). By applying a multi-reflective absorption concept and integrating it with solar and air source heat pump, the proposed technology provides a building integrated solar system with high efficiency and aesthetically appealing (Khanlari et al., 2019). For photovoltaic (PV) systems, simulation of some parameters carried out by engineering analysis and machine learning algorithm to improve deep neural network and maximum power point efficiency. Solar Photovoltaic (PV) systems are one of the most promising renewable energy sources that convert solar energy into electrical energy in an environmentally compatible manner. However, these systems have low efficiency and high relative costs. To overcome these disadvantages, the load requirement, there is a need for a grid-connected PV energy system to meet the requirements. In line with this information, I develop a new and efficient algorithm in PV/T Systems. The amount of electricity produced in Türkiye, which is one of the developing countries, does not meet the energy requirement. We need more than half of our energy needs in a state connected to neighbouring countries (Russia, Bulgaria, İran, etc.). Hard coal, lignite, oil and natural gas are the only important domestic energy sources. Approximately 97% of the grid electricity in Türkiye is produced from fossil fuels, which emit harmful CO_2 gases into the atmosphere.

2. MATERIALS AND METHODS

2.1. Preparation of the Hybrid Nanofluid

The Fe_2O_4 nanoparticle used in this study that is obtained from Nanography Nano Technology Science and Consultancy Ltd. Company. Physical parameters such as particle size, shape and purity of nanoparticles and pure water were listed in Table 1. The particle ratios Fe_2O_4 0.6% by weight, while the ratio of nanoparticles by weight in hybrid nanofluid is 1%. The nanoparticles first dispersed in pure water by mechanical mixing. Various techniques are used to prevent precipitation problems and to obtain a homogeneous fluid (Lämmle et al., 2017). In this study, 0.2% surfactant Triton X-100 added to the solution with nanoparticle concentration of 1%. For homogeneous distribution of Fe_2O_4 nanoparticle in the base fluid (pure water), the obtained hybrid nanofluid was kept in an ultrasonic bath for 5 hours.

Table 1. Thermo-physical properties of nanoparticles and pure water (40 °C).

Material	**Particle Morphology**	**Colour**	**Purity (%)**	**Particle Size (nm)**	**Density (kg/m^3)**	**Specific Heat (J/Kg K)**	**Thermal Conductivity (W/m K)**
Pure Water	/	/	/	/	995	4250	0.620
Fe_2O_4	Spherical	Black	97.45	17	5300	702.3	75

2.2. Measurement of the Thermophysical Properties

The relationships between base fluid and hybrid nanofluid for different thermal physical properties were calculated. The specific heat value of the hybrid nanofluid was calculated as follows;

$$Cp_{hna} = \frac{\rho_{Fe_2O_4} Cp_{Fe_2O_4} + (1-\Phi)\rho_{pure\,water} C_{Ppure\,water}}{\rho_{hna}} \tag{1}$$

where Cp_{hna} is the specific heat of the hybrid nanofluid, $\rho_{Fe_3 2}$ is the density of Fe_2O_4 nanoparticles, $\rho_{Fe_2O_4}$ is the density of Fe_2O_4 nanoparticles, $\rho_{pure\,water}$ is the density of the base liquid, ρ_{hna} is the density of the hybrid nanofluid, $Cp_{Fe_2O_4}$ is the specific heat of. The calculated thermos-physical properties of the hybrid nanofluid are given in Table 2.

Table 2. Thermo-physical properties of hybrid nanofluid.

Hybrid Nanofluid	Density (kg/m^3)	Specific Heat (J/Kg K)	Thermal Conductivity (W/m K)
(Fe_2O_4)/Water	5.326	702.3	120.3

The necessary theoretical analysis was carried out using the data, recorded as experimental results. The heat production of PV/T panels can be expressed as follows:

$$\dot{Q}_{PVT} = \dot{m}_{PVT} c_p (T_{PVT,o} - T_{PVT,i}) \tag{2}$$

3. RESULTS AND DISCUSSION

We carried out in the climatic conditions average of Türkiye as experimental study. The maximum surface temperature difference is 14ºC. As a result of the experiments, it was observed that the cooling of the panel reached to a significant degree. In the PV/T system, the cooling amount increased by using different fluid, water, and hybrid nanofluid. In addition, 14% improvement in energy output was calculated in the hybrid state (Fe_2O_4+Water) compared to conventional water (Sandnes & Rekstad, 2002).

Figure 1 give to variation of inlet and outlet temperatures of serpentine with time, according to the type of fluid used in the cooling circuit (Sözen et al., 2020). Mains water primarily used as the cooling fluid in the experiments carried out according to the values measured at certain times of the day. Firstly, calculation of heat absorbed by cooling system have been made, and coolant able to remove maximum heat identified.

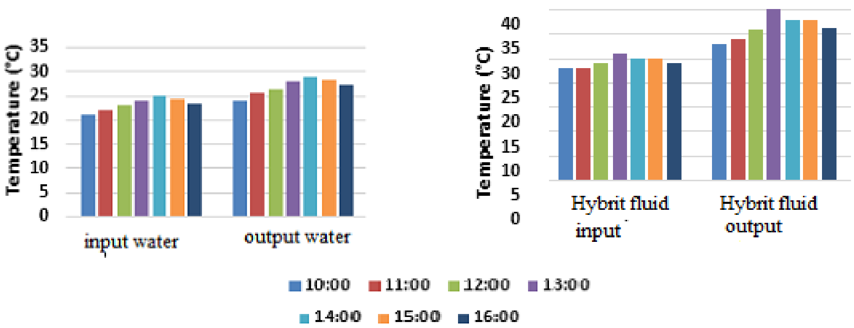

Figure 1. Input/output compare of temperature –time (water and hybrid fluid).

4. CONCLUSION

Considering the climatic conditions and energy needs of Türkiye and İran, successful development of the proposed system has significant economic impact and help global investment achieve the target of reducing emissions as required by both Turkish and Iranian governments (Michael & Iniyan, 2015). Hybrid PV modules with thermal units (PV/T) are heat-releasing systems that are installed together with a solar cell. The system also allows excess heat to be stored for other purposes, so that the benefits of solar energy are greatly harnessed (Maadi et al., 2017). In addition to increasing the electricity production performance of PV systems, the importance of PV/T systems is to obtain thermally hot fluid from the system. The importance of the PV/T system has also increased due to the wide application area of the produced hot fluid, which can be used as an energy source in heat pumps in industrial drying systems and for heating rooms/areas and green houses. In this study, it can be concluded that the hybrid nanofluid containing nanometer-sized Fe_2O_4 particles is aimed to replace pure water with properties such as high thermal conductivity and heat transfer coefficient. Therefore, weight, energy and production cost be reduced.

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The Effects of Electric Vehicles on the Carbon Footprint in Türkiye

Ahmet Nur[1✉]***, Nur Sabah Nur***[2]

[1]*Adıyaman University, Department of Electrical-Electronics Engineering, Adıyaman/TÜRKİYE*

[2]*İstanbul University, Department of Geography, İstanbul/TÜRKİYE*

✉***Correspondence***: anur@adiyaman.edu.tr

Abstract: While human beings carry out many activities to continue their lives, they also pollute the nature in which they live. The negative effects of the result of this natural pollution are also first experienced by human beings. One of the negative effects that has become increasingly important in recent years is global warming. With the industrial revolution, carbon dioxide (CO_2) gas, the amount of which has increased exponentially every year, is the biggest component of the greenhouse gas that causes global warming. Combustion is the most important factor in air pollution. Combustion events can be of natural origin such as forest fires, vegetation fires, volcanoes. Combustion events can also be caused by domestic heating, industrial activities, and motor vehicle use. The carbon footprint is used to indicate the amount of greenhouse gases released into the atmosphere in terms of carbon dioxide equivalent. As a result of the activities of individuals and organizations, such as energy consumption and transportation, direct or indirect carbon emissions occur. In many countries of the world and in Türkiye, the most increasing footprint is caused by carbon. Countries sign agreements with organizations such as the Kyoto Protocol to reduce the impact of greenhouse gases. To reduce fuel consumption and reduce the gases released by fossil fuel vehicles to the environment, vehicles with electric vehicle technology have started to take their place on the roads today. In this study, information about internal combustion engine vehicles and electric vehicles is given. Then, the effects of electric vehicles on the carbon footprint in Türkiye are examined and suggestions are made.

Keywords: Türkiye, Carbon Footprint, Electric Vehicle.

1. INTRODUCTION

According to the United Nations Economic Commission for Europe (UNECE), some many different reasons and sectors cause CO_2 emissions into the atmosphere. Among these, transportation sector activities are one of the issues that require effective public intervention to reduce CO_2 emissions. The transportation sector is one of the sectors that needs precautions due to climate change and sets targets accordingly (Aslan, 2022). Currently, the transportation sector accounts for 27% of total greenhouse gas emissions in the European Union (EU). The transportation sector, as seen in Figure 1, is one of the main sources of greenhouse gas pollution (Sendek-Matysiak, 2019).

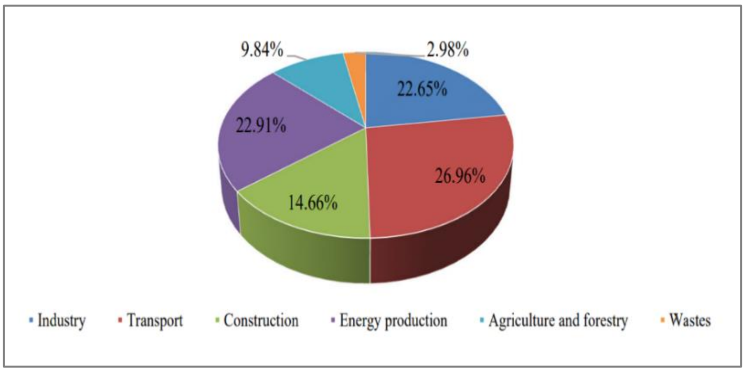

Figure 1. Distribution of factors causing greenhouse gas emission in the EU (2016).

According to the Intergovernmental Panel on Climate Change (IPCC), a reduction in global greenhouse gas emissions by up to half of 1990 levels is expected by 2050. Road transportation, which contributes highly to carbon emissions within the transportation sector, is a priority target in mitigating climate change. To fulfill this purpose, recommendations have been prepared by the ministers of transportation of many countries to reduce carbon emissions from the road sector and increase fuel efficiency (Altenburg et al., 2012). Some of those;

- Investing in innovative automobile technologies and advanced engine management systems
- Increasing the use of electric vehicles
- Prevent traffic congestion and encourage the use of multiple modes of transport
- Creating an improved transportation infrastructure with Intelligent Transportation Systems (ITS)
- Informing transportation sector consumers about issues such as eco-driving and public transportation
- Encouraging low carbon emission vehicles with tax exemptions and incentive policies
- Discouraging vehicles that cause intense carbon

2. ELECTRIC VEHICLES

When the vehicle technologies used as land vehicles are examined, it is seen that three different vehicle technologies are used according to the engine drive method and the energy source used. These are internal combustion engine vehicles, battery electric vehicles, and hybrid electric vehicles. Internal combustion engines are used in conventional vehicles, also called traditional vehicles. Fossil fuels such as gasoline, diesel, and LPG (Liquefied Petroleum Gas) are consumed as fuel. Thus, engine drive is provided by the fuel energy obtained from the fuel tank. The advantages of these vehicles are that they have an infrastructure, are affordable, have long driving distances, can store a high volume of liquid fuel in the fuel tank, and can access fuel easily and in a short time. The disadvantages of vehicles with internal combustion engines are that they require fossil fuels, have high CO_2 emissions, have mechanism noise, and the efficiency of the engine is below 30% (Özdemir Öztürk, 2022).

In battery electric vehicles, the electrical energy provided by the battery is converted into mechanical energy and transferred to the wheels, thus providing movement. Electric battery-powered vehicles do not have internal combustion engines but consist of a battery for energy storage, an electric motor for the propulsion system, a generator, mechanical transmission and power control systems. In electric battery-powered vehicles, the energy required for engine drive is provided only by battery packs (Archer, 2014). As seen in Figure 2, there are two types of battery electric vehicles. The main difference between these two types is the size of the electric motor and the location of the electric motor. The most common type today is the central engine. The hub motor type is used in smaller vehicles (Nur, 2017).

Hybrid electric vehicles contain an internal combustion engine, an electric motor that works independently of each other, and a battery storage system that can be charged from an external energy source. Hybrid electric vehicles can use only the electric engine, only the internal combustion engine, or both, taking into account energy efficiency while driving. This results in less fuel consumption and an economic advantage. In some vehicles, the battery can even be charged by generating electricity through regenerative braking. Another main advantage of hybrid electric vehicles is that they provide very low greenhouse gas emissions and noise levels (Brant & Leitman, 2008).

Hybrid electric vehicles can be classified under two headings, series and parallel, in terms of power transfer principles, as shown in Figure 3 (Nur, 2017). In a series hybrid electric vehicles, the energy obtained from the internal combustion engine is converted into electrical energy with the help of a generator, and the engine is driven. Series hybrid electric vehicles enable the vehicle to move forward with only a single energy converter. The internal combustion engine runs the generator, enabling the electric motor to power the battery and preventing the battery from falling below a certain charge level. The power that enables the vehicle to move is provided by the electric motor. In parallel hybrid electric vehicles, energy is transferred between the electric motor and the internal combustion engine together or separately. In parallel hybrid electric vehicles, multiple energy sources enable the vehicle to move forward. In these vehicles, the internal combustion engine and the electric motor are connected in parallel (Ustabaş, 2014).

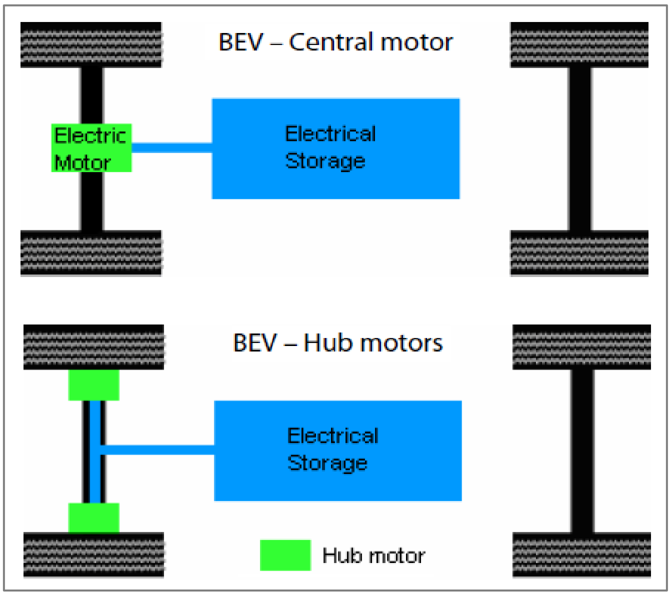

Figure 2. Types of battery electric vehicles.

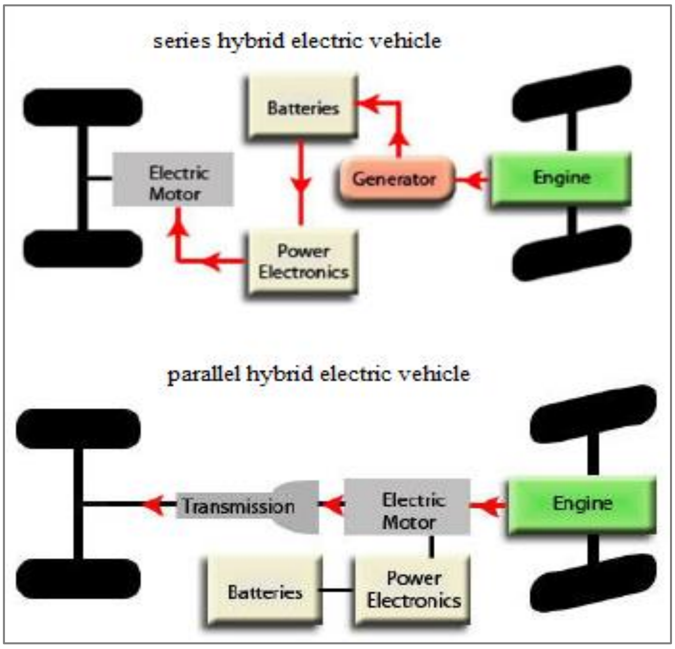

Figure 3. Types of hybrid electric vehicles.

Plug-in Hybrid Electric Vehicles (PHEV) are in the category of hybrid electric vehicles and have a larger battery and can reach a longer range since they can be charged externally (Kotter, 2013). In addition, since plug-in hybrid electric vehicles can be charged externally, they are more advantageous in terms of fuel economy than internally charged hybrid vehicles. The grouping of electric vehicles is briefly shown in Figure 4 (Sanguesa et al., 2021).

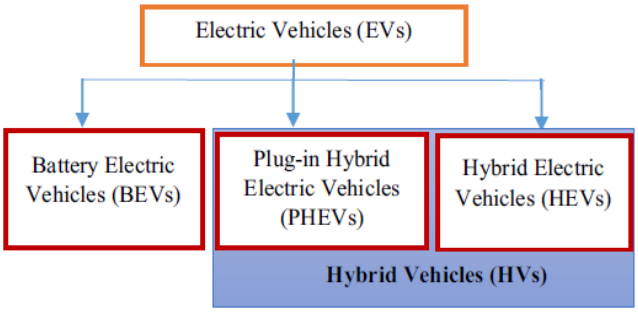

Figure 4. Electric vehicles classification.

3. THE EFFECT OF VEHICLES ON CARBON FOOTPRINT IN TÜRKİYE

As in most international countries, approximately 20% of global greenhouse gas emissions in Türkiye originate from the transportation sector. The largest producers of greenhouse gas emissions in the transportation sector in Türkiye are motor road vehicles. The motor vehicles that produce the most emissions are cars, sports utility vehicles, pickup trucks, mini vans, and light duty trucks. These vehicles account for more than half of the greenhouse gas emissions from the transportation sector (Tören & Mollahasanoğlu, 2022).

In Table 1, the carbon emission values of the number of motor vehicles in Türkiye between 1990 and 2021 are given in 5-year periods. The most important reason for fossil fuel emissions that cause air pollution and climate change is the use of these fuels by motor vehicles used in the transportation sector. Therefore, the numerical data in Table 1 is important for climate change, global warming, air pollution, and is also closely related to human health (TURKSTAT, 2021)

Table 1. Number of motor vehicles in traffic in Türkiye and CO_2 emissions.

Year	Number of Motor Vehicles	CO2 Emission (thousand tonnes)
1990	3.750.678	26,25
1995	5.922.859	33,180
2000	8.320.449	35,49
2005	11.145.826	41,03
2010	15.095.603	44,38
2015	19.994.472	74,27
2021	25.249.119	89,32

The distribution of cars registered in Türkiye by fuel type is given in Table 2. In Türkiye, automobiles generally consume gasoline, diesel and LPG fuels. In 2004, 75% of the cars registered to traffic in Türkiye used gasoline. In 2021, the most common fuel used in registered cars is diesel with 38%, followed by LPG with 36% and gasoline with 25%. As can be seen in Table 2, one of the feasible alternative methods to reduce harmful gases that cause environmental and air pollution is the widespread use of electric and hybrid vehicles. Table 2 shows that the interest in electric and hybrid vehicles in Türkiye has increased noticeably in recent years, although it is much less compared to other countries. This increase is mainly caused by the rise in oil prices and increased environmental awareness. For such reasons, it is estimated that the number of electric and hybrid vehicles will increase even more in the coming periods. Among the most obvious reasons why electric vehicles will become widespread today are their zero carbon emission value and their environmental friendliness (TURKSTAT, 2022).

Table 2. Distribution of cars registered to traffic in Türkiye according to the type of fuel.

Year	Total	Gasoline	(%)	Diesel	(%)	LPG	(%)	Electric and Hybrid	(%)
2004	5400440	4062486	75.2	252629	4.7	793081	14.7	-	-
2005	5772745	3883101	67.3	394617	6.8	259327	21.8	-	-
2006	6140992	3838598	62.5	583794	9.5	1522790	24.8	-	-
2007	6472156	3714973	57.4	763946	11.8	1826126	28.2	-	-
2008	6796629	3531763	52.0	947727	13.9	2214661	32.6	-	-
2009	7093964	3373875	47.6	1111822	15.7	2525449	35.6	-	-
2010	7544871	3191964	42.3	1381631	18.3	2900034	38.4	-	-
2011	8113111	3036129	37.4	1756034	21.6	3259288	40.2	47	0.0
2012	8648875	2929216	33.9	2101206	24.3	3569143	41.3	228	0.0
2013	9283923	2888610	31.1	2497209	26.9	3852336	41.5	436	0.0
2014	9857915	2855078	29.0	2882885	29.2	4076730	41.4	525	0.0
2015	10589337	2927720	27.6	3345951	31.6	4272044	40.3	889	0.0
2016	11317998	3031744	26.8	3803772	33.6	4439631	39.2	1160	0.0
2017	12035978	3120407	25.9	4256305	35.4	4616842	38.4	1685	0.0
2018	12398190	3089626	24.9	4568665	36.8	4695717	37.9	5367	0.0
2019	12503049	3020017	24.2	4769714	38.1	4661707	37.3	15053	0.1
2020	13099041	3201894	24.4	5014356	38.3	4810018	36.7	36487	0.3
2021	13706065	3495172	25.5	5158803	37.6	4923275	35.9	92949	0.7

Reducing greenhouse emissions in the transportation sector differs from other sectors in that it only considers tailpipe or direct emissions. For example, reducing exhaust emissions of road vehicles is dominant in EU policies. According to the EU Community regulation, CO_2 emissions per km for new cars have been determined as 130 gCO_2/km as of 2015. As of 2021, new vehicles must produce CO_2 emissions per km below 95 gCO_2/km. The EU aims to reduce CO_2 emissions to 59 gCO_2/km in 2030 with legal regulations. For Türkiye, the average CO_2 emissions of new vehicles until 2013 were low compared to the EU. In 2017, the average CO_2 emission values of EU countries and Türkiye, which have heavier and stronger fleets, were close to each other. Since there are no obligations for vehicle manufacturers in Türkiye, CO_2 emissions from motor vehicles are expected to decrease over the years and at a similar rate in previous years (approximately 2.5 gCO_2/km per year). Thus, by 2030, the average CO_2 emissions of the new vehicle fleet will be approximately 50% higher than the CO_2 emissions average of the EU's new vehicle fleet (Logan et al., 2021). Figure 5 shows the average CO_2 emission levels of new vehicles in Türkiye and the EU according to the New European Driving Cycle (NEDC) between 2007 and 2030 (Guliyev, 2022).

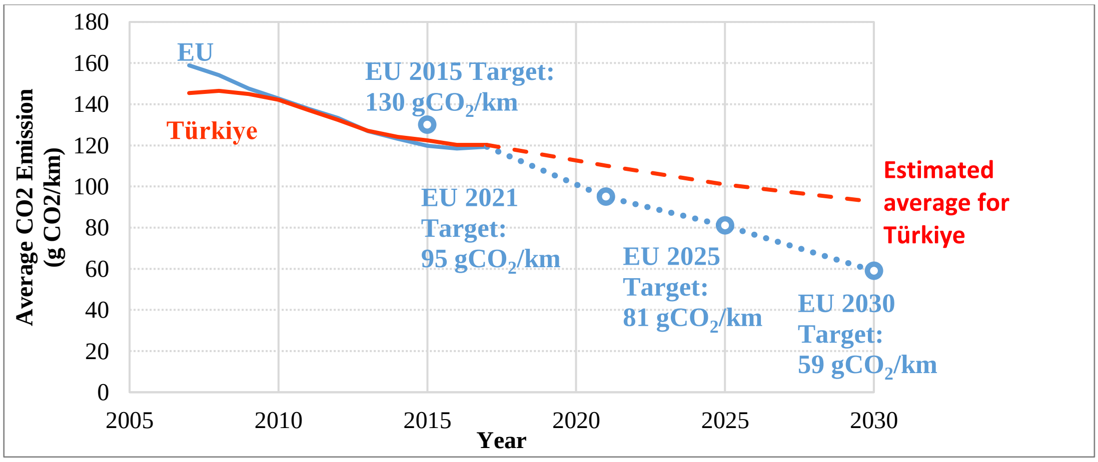

Figure 5. Average CO_2 emission levels of newly registered vehicles in Türkiye and the EU.

These tables have mobilized many countries to produce zero-emission electric cars. The dreams of producing a local and national car in our country for a long time have finally come true with zero emissions with Türkiye's Automobile Enterprise Group (TOGG). The domestic automobile joint venture group includes Anadolu Group, BMC, Kıraça Holding, Turkcell, and Zorlu Holding (Demir, 2020).

TOGG's intellectual and technical rights belong to Türkiye; It was stated that the design was made in Italy, the engine was purchased from Bosch, the battery group was purchased from China, and the integration of the vehicle was carried out by Germany's EDAG Engineering company. Offering two different battery options that provide a range of 300 km or 500 km, TOGG will be able to reach 80% traction battery charge level in 30 minutes with fast charging. The car, whose electric vehicle battery layout is shown in Figure 6, provides technical advantages such as lithium-ion traction battery technology and active thermal management systems and has a battery warranty for 8 years (Gürbüz, 2021).

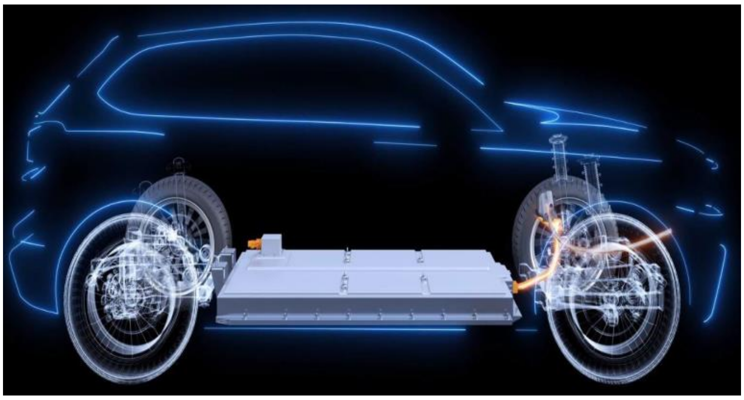

Figure 6. TOGG electric vehicle battery placement.

4. CONCLUSION

Türkiye should make efforts to minimize the use of fossil fuels in order to achieve the 2030 and 2053 targets specified in the Kyoto, Paris and Glasgow agreements within the framework of the United Nations Environmental Convention on Climate Change. To achieve this goal, efforts must be made to make the necessary investments and find financing sources for these investments, starting today. According to research conducted by the International Energy Agency (IEA), it is estimated that the number of electric cars on the market will be approximately 40 million in 2025. According to another study by the IEA, it is estimated that in 2040 there will be around 8% electric vehicles in the most pessimistic scenario and 26% in the most optimistic scenario. To increase these estimates even further, incentives and tax reductions given by local governments and national governments are important for electric vehicles to compete with other vehicles.

The future success of the electric car industry is also highly dependent on technological innovation. Especially in far eastern countries such as China, Korea, and Malaysia, policymakers draw attention to the technological innovations of electric cars and encourage policies for research and development on this subject. In this regard, Türkiye's design of the TOGG branded fully electric vehicle and its mass production by 2023 was an appropriate and correct decision to catch up with today's technology. However, today, internal combustion engine vehicles constitute the majority of total vehicles in Türkiye. Faster steps must be taken to increase the number of electric vehicles to reduce CO_2 emissions. Installing charging stations in the necessary places with route measurements, shortening charging times, increasing driving distance, reducing electricity prices, and selling electric vehicles cheaper will affect consumer preference and ensure the widespread use of electric vehicles. Additionally, it is necessary to provide necessary legal regulations, incentives and advantages such as tax exemption to facilitate access to electric vehicles.

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Low Carbon Technologies in Green Buildings

***Ahmet Nur*[1✉], *Nur Sabah Nur*[2]**

[1]*Adıyaman University, Department of Electrical-Electronics Engineering, Adıyaman/TÜRKİYE*

[2]*İstanbul University, Department of Geography, İstanbul/TÜRKİYE*

✉***Correspondence**:* anur@adiyaman.edu.tr

Abstract: Increasing population, industry, and developing technology, rising energy need, running out of fossil fuels, and limited existing energy resources have made it necessary to work on the efficient use of energy. In this context, energy efficient building design approaches have found an important place in interdisciplinary studies in recent years. Green building systems are nano-technology building automation control systems that facilitate home life and provide security. By integrating living spaces with developing technologies, it transforms it into a more comfortable, safer, and more enjoyable way of life. Green buildings enable building owners, building managers, and users to achieve their goals in cost, energy management, comfort, convenience, security, long-term flexibility, and visuality. Low carbon technologies, also known as green technology, are defined as the development and implementation of systems that are used to protect the natural environment, resources, and minimize the negative effects of human activities. The main objectives of low carbon technologies are; to control global warming, reduce greenhouse gas emissions, and develop innovative inventions that do not affect natural resources. In general, the necessity of low carbon technologies is related to reducing risks to the environment and protecting natural resources. At the same time, low carbon technologies enable the use of clean and renewable energy sources to prevent the complete depletion of other non-renewable resources. It is very important to use low-carbon technologies for the effective use of energy in buildings and not to pollute the environment. In this study, green buildings and low carbon technologies that can be used in these buildings are researched and suggestions are made.

Keywords: Technology, Green building, Low carbon.

1. INTRODUCTION

Many gases are produced as a result of the use of fossil resources. Most of these gases constitute greenhouse gases. Many gases such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrogen oxides (NO_x), chlorofluorocarbons (CFC) and hydrofluorocarbons (HCFC) are greenhouse gases. These gases provide the required temperature for the world. Normally, some of the rays coming from the sun to the earth are reflected by the atmosphere, while the other part creates a greenhouse effect with greenhouse gases. The greenhouse effect provides the temperatures required for life on Earth. The average temperature of the earth is +15 degrees Celsius. However, if these gases did not exist, the temperature would be -18 degrees Celsius (Guliyev, 2022). Although this phenomenon is a natural phenomenon, today the excessive use of fossil resources increases the amount of these gases in the atmosphere. The more intense greenhouse effect that occurs as a result of this causes global warming by hiding more sunlight and causing the world temperature to increase. Global warming also raises the problem of climate change (Güzel & Alp, 2020).

CO_2 gas (9%-26%), which contributes the most to the world's greenhouse effect after water vapor (36%-70%), is responsible for 3/4 of global warming. Other greenhouse gases make up the remaining part. Total greenhouse gas emissions are given in Figure 1. Greenhouse gas emission units are CO_2 eq. (CO_2 emission equivalent) and metric tons of CO_2. When greenhouse gas emissions are compared, it is seen that CO_2 has a much stronger greenhouse effect potential than other greenhouse gases (Roston et al., 2021).

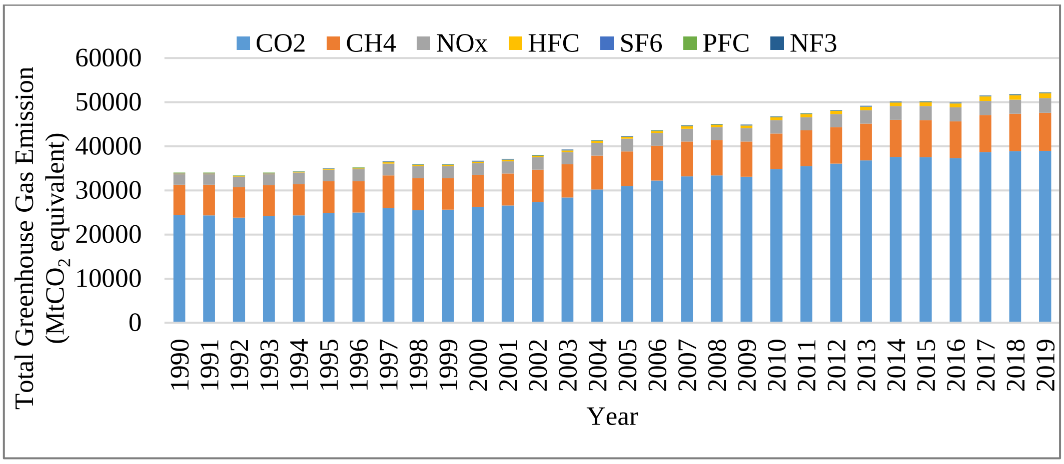

Figure 1. Change in total greenhouse gas emissions in the world.

Due to Covid-19, CO_2 emission values decreased in 2020 compared to previous years. As seen in Figure 2, carbon emissions resulting from energy use in 2020 decreased by 6.3%, falling to the lowest level since 2012. The year 2020 was recorded as the largest decrease in the amount of CO_2 emissions in primary energy consumption since the Second World War (BP Statistical, 2021).

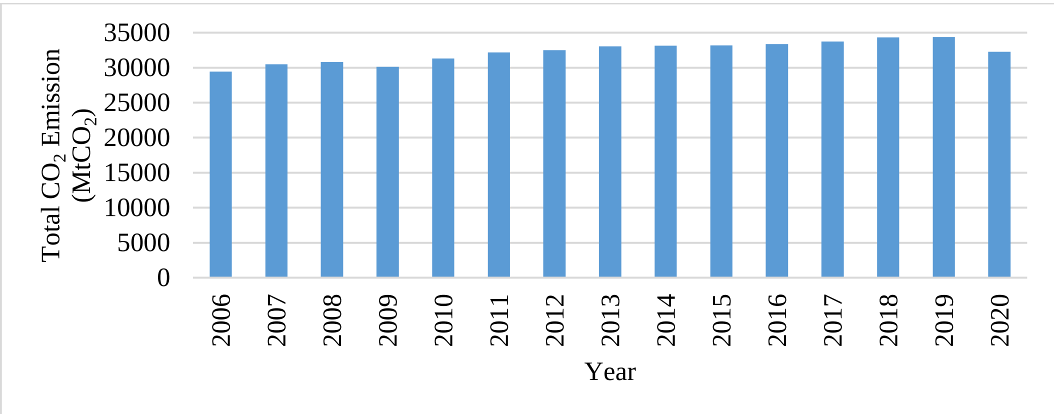

Figure 2. Change in total CO_2 emissions in the world.

2. GREEN BUILDINGS

The term green building was first used in the USA in the early 80s when information technologies were rapidly spreading. Green buildings are also called sustainable buildings, ecological buildings, and energy efficient buildings in the literature, where energy is used efficiently and at a minimum level. Green buildings start from the land selection of the building. Then, they are sustainable buildings designed with an understanding of environmental responsibility, suitable for climate data and local conditions, consuming as much as needed, oriented towards renewable energy sources, using natural, and waste-free materials, encouraging participation, sensitive to ecosystems (Kayın, 2019).

Green buildings are also structures that are designed, constructed, renovated and operated in a way that uses natural resources efficiently, and they are built to protect the health of the people living in them, increase the productivity of employees, use water, energy, and other resources more efficiently and to minimize the negative effects that may occur. There are several major benefits of green buildings. These include reducing carbon dioxide emissions, ensuring the use and development of renewable energy, utilizing natural light, providing energy savings, reducing heating and cooling costs with insulation systems, increasing the value of the building, and providing a healthier environment for users. Research on green buildings shows that if buildings are designed and operated in this way, there can be a 24% to 50%

reduction in energy use compared to buildings designed with traditional methods. Green buildings also show that CO_2 emissions can be reduced by 33% to 39% (Kılıç & Erikli, 2021).

Green building energy modeling is the creation of an abstract model of a building design in the required detail in a computer environment and testing it under the conditions that will occur during its use. The model to be created can be created from scratch by an energy modeling expert or can be derived from existing models. As seen in Figure 3, the main goals of green building are (Khosla & Singh, 2014):

- Building design that is flexible and can adapt to changing conditions and has a long lifespan,
- Efficient use of energy,
- Effective use of resources,
- Reducing waste,
- Protection of clean water resources,
- Avoiding harmful and dangerous substances,
- Minimizing health and safety risks,
- Ensuring healthy indoor air quality
- Preservation of biological diversity

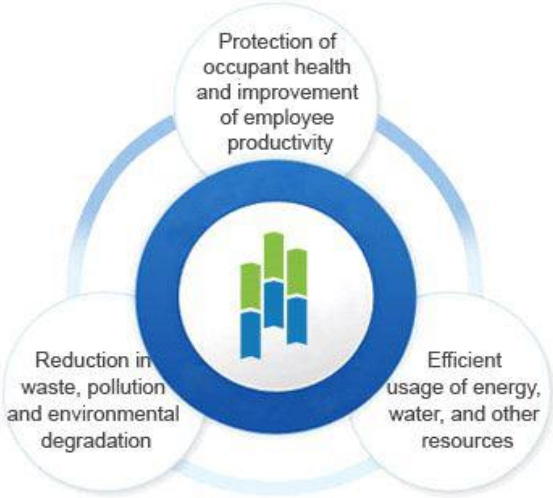

Figure 3. Green building design concept.

Applying building energy modeling brings many benefits. These are determining the optimum building layout by examining the land-sun relationship, evaluating approaches such as natural ventilation or night cooling by examining the prevailing winds, evaluating innovative air conditioning systems suitable for the building usage profile, determining the amount of energy production with the use of renewable resources, evaluating passive architectural measures and shading approaches on a seasonal basis, reducing the electrical energy required for lighting by optimizing the use of daylight. Energy modeling can be applied in new buildings as well as in operational decisions or renovations of existing buildings. As seen in Figure 4, energy modeling studies require a labor-intensive process that involves defining the building's current data regarding energy consumption (Energy, 2019).

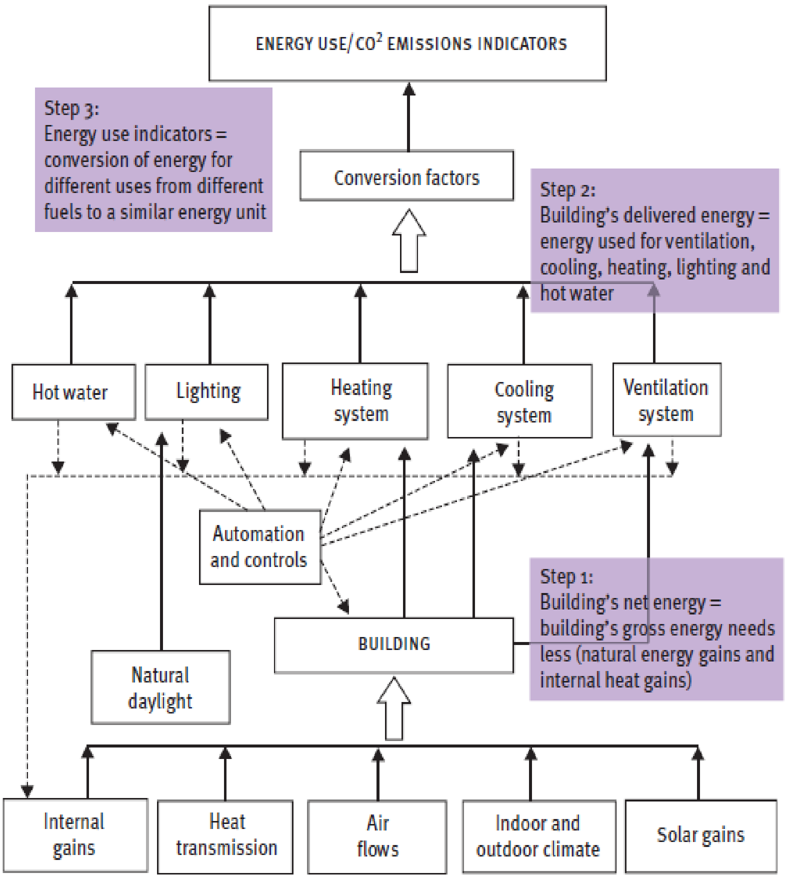

Figure 4. Energy modeling in green buildings.

3. LOW CARBON TECHNOLOGIES

Energy needs can be reduced by using renewable energy sources in buildings. On-site production from renewable energy sources and the use of the produced energy in the building can help reduce or completely eliminate the building's dependence on energy networks. The main active systems that produce energy in green buildings and affect energy efficiency, reducing the energy needs of buildings, are as follows; photovoltaic systems, wind systems, and hybrid systems (Zhou et al., 2012).

3.1. Photovoltaic Systems

Solar panels, which are in the distributed electricity generation system category, consist of modular photovoltaic systems that can produce electricity. These systems, which are generally installed on the roofs of buildings, meet the energy needs of the building with the electricity they produce. At the same time, since they function as a small-scale energy production plant working in parallel with the electricity grid, they can transmit this electricity to the nearest point of need. If excess energy remains in the system in the building where the system is installed, the energy produced can be sent to the grid to meet the energy needs of other buildings. While these systems operate with zero CO_2 emissions, they also prevent almost 40% of energy losses resulting from transmission. In addition, other advantages provided by the system are (Küçükgil, 2021);

- The system can be installed and operated without a license
- Installation can be achieved quickly
- It saves space by being installed on empty roofs.
- Since they are installed instead of the roof systems in the building, they do not require another roof element

- In this system, choosing distributed generation points instead of providing energy from central points contributes to the emergence of a more durable and less risky energy system
- These systems can provide the support energy services that energy networks need
- As seen in Figure 5 and Figure 6, these systems can be applied as desired, both on-grid and off-grid (Nur & Buğutekin, 2017).

Figure 5. On-grid residential photovoltaic systems.

Figure 6. Off–grid residential photovoltaic systems.

3.2. Wind Systems

Wind systems are the main structural elements of wind power plants and are machines that convert the kinetic energy of the moving air first into mechanical energy and then into electrical energy. Although wind energy has been widely used since the 90s, its use in buildings has become more prevalent in recent years. The need for clean and renewable energy has made the use of wind energy in buildings mandatory. Wind systems can be used wherever electricity is needed, such as (Yılmaz, 2006);

- Buildings
- Businesses
- Park, garden, and street lighting
- Signaling systems
- Irrigation systems
- Caravan, boat, and mobile stations

Wind systems, like photovoltaic systems, can be divided into two groups: independent from the grid and dependent on the grid. The types of wind turbines used in buildings are used independently of the building, as in Figure 7, or connected to the building, as in Figure 8 (Bektaş, 2013).

Figure 7. Halifax marina market, Canada.

Figure 8. The green building, England.

3.3. Hybrid Systems

Hybrid systems are systems that produce energy by combining at least two energy sources. Wind systems and photovoltaic systems are used as a hybrid system and these systems are very efficient. In this system, wind turbines and solar panels are used together. In this type of system, when the wind blows, electricity is produced from the wind and the energy stored by the solar panel during the day is accumulated in the battery system. When weather conditions are not sufficient (for example, when the wind is not blowing or the weather is cloudy), it is used by supplementing it with either stored energy or energy taken from the grid. Generally, the wind-solar hybrid system includes a wind turbine, solar module, regulation unit, generator, and battery system. Moreover, such systems can be easily mounted and used on the roof in homes and industrial facilities. Figure 9 shows the use of a photovoltaic-wind hybrid system (Bektaş, 2013).

Figure 9. Yıldız Technical University, Türkiye.

4. CONCLUSION

Green buildings are designed and operated to minimize the negative effects of the built environment on human health and the natural environment. It ensures the effective use of energy, and other resources, protecting the health of users and increasing the productivity of employees. It also means reducing waste, pollution and environmental degradation. Using low carbon technologies in homes is the first step to be taken individually in reducing carbon footprint. The cost of these technologies used to benefit from renewable energy sources is decreasing day by day. Low carbon technologies should be disseminated by producers, distributors and consumers, and renewable energy storage systems should be developed. Current energy policies in the electricity sector should be updated again and focused on low carbon technologies. All these studies will make great and important contributions to achieving national and international targets in both ensuring energy efficiency and reducing greenhouse gas emissions produced by buildings.

In Türkiye, within the framework of the harmonization process with the European Union, various legal regulations, standards, and regulations on the use of renewable energy sources have begun to be implemented regarding the effective and efficient use of energy in buildings. Studies have been carried out within the framework of the activities of the public, private sector and local governments to raise sufficient awareness about energy efficiency in buildings and to draw attention to reducing carbon emissions in buildings. Suggestions that will be useful are as:

- Developing energy and carbon policies at the national level and strengthening this framework's institutional and legal structure
- Increasing the energy performance of buildings and reducing carbon emissions
- Expanding the use of renewable energy sources in buildings
- Revision of relevant standards in buildings
- Developing energy performance and carbon emission calculation programs
- Strengthening relevant control and audit mechanisms
- Raising public awareness and training about energy consumption and carbon emissions

- Eliminating the lack of relevant and expert personnel on carbon emissions and increasing training at universities
- More active involvement of energy and carbon emission consultancy services in buildings

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Biochar/Slag Composite: A Novel Adsorbent for CO_2 Capture

İlayda Çalış, Gülcihan Güzel Kaya
Konya Technical University, Chemical Engineering, Konya/TÜRKİYE
***Correspondence**: ggkaya@ktun.edu.tr*

Abstract: Carbon dioxide (CO_2) is one of the main greenhouse gases which contribute to global warming. CO_2 concentration is increasing around the world day by day. It is estimated that CO_2 concentration will be approximately 570 ppm in 2100. Many carbon capture and storage techniques have been developed to reduce CO_2 emission. Adsorption with using low-cost solid adsorbents is a promising CO_2 capture technique. In this study, low-cost biochar/slag composites were evaluated as a CO_2 adsorbent. Firstly, neat slag was modified with different concentrations of HCl solution (0.25, 0.50, 1.00, 3.00 and 5.00 M). Maximum surface area and pore volume were achieved through the 1.00 M HCl modification. So, biochar/slag composites were prepared using 1 M HCl modified slag and various amount of biochar (1, 3 and 5 wt%). Structural and morphological properties of the biochar/slag composites were investigated by Fourier transform infrared spectroscopy (FTIR) and field emission scanning electron microscopy (FESEM) analyses, respectively. To examine surface charge of the biochar/slag composites, point of zero charge (pHpzc) measurements were conducted. CO_2 adsorption studies were carried out with volumetric sorption analyzer at ambient conditions. The biochar/slag composite including 3 wt% biochar showed maximum CO_2 adsorption capacity. With the addition of 3 wt% biochar, CO_2 adsorption capacity of the 1 M HCl modified slag increased from 0.10 mmol g^{-1} to 0.18 mmol g^{-1}. The possible CO_2 adsorption mechanisms of the biochar/slag composites are thought to be electrostatic attractions and hydrogen bonds as well as pore filling. The results revealed that the biochar/slag composites can be used as novel and low-cost CO_2 adsorbents.

Keywords: Biochar, Slag, Composite, CO_2 adsorption.

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Forest Laws and Wildfire: A Comparative Legal Study of Iran, France, Türkiye and South Africa

Hamidreza Afrand Sorkhani[1]✉, Mohammad Avatefi Hemmat[1], Taghi Shamekhi[1], Elaheh Mohseni[2], Osman Devrim Elvan[3]

[1]*University of Tehran, Faculty of Natural Resources, Department of Forestry and Forest Economics, Karaj/IRAN*

[2]*Azad University, Department of Private Law, Mashhad/IRAN*

[3]*İstanbul University-Cerrahpaşa, Faculty of Forest, Department of Environment and Forestry Law, İstanbul/TÜRKİYE*

✉***Correspondence****:* afrand@ut.ac.ir

Abstract: Global warming and climate changes have caused an increase in the frequency and intensity of forest fires in recent years, which in turn exacerbates the climate change speed with the emissions of carbon from burned plant biomass. This paper deals with the comparative study of forest fire in the forest laws of Iran, France, Türkiye and South Africa countries to identify the national solutions in dealing with wildfires and to suggest the best solutions. Comparative law is among the best ways to study the legal solutions of specific countries to learning from each other's and improve the laws. Comparative law has five steps: the first step is the determination of the scope and delimitations of the study, which in this research includes the selection of the mentioned four countries and the topic of forest fires; The second step is the description and analysis of legal materials; The third step is the Comparison of laws and show the similarities and differences; The fourth step is the explanation of the reasons for similarities and differences and the fifth step is the evaluation of laws and provide best solutions of the studied countries in the field of wildfire control. The categories extracted from the content of legal articles and the classification of categories with a common meaning together showed that the legal measures of combat wildfire can be classified into four main pillars as well as the following sub pillars: 1- Measures before fire include a) limitations, regulations and preventive measures, b) cleansing, c) screening, firebreak and prescribed fire, d) fire protection associations, e) determination of high-risk areas and fire risk rating. 2- Measures during fire outbreaks include a) Custodian of fighting fire and providing equipment, b) right of way, servitude, possession, intervention, c) firefighting tactics and use of controlled fire. 3- Measures after the fire include a) Improvement and sanitation measures, b) Prohibitions, regulations, evaluation and review, c) Revival and restoration, d) Incentives, compensation, and 4- Crimes and punishments. Evaluation of the legal solutions of the studied countries showed that some countries have performed well in some pillars and sub-pillars and poorly in some others. South Africa provides considerable provisions by establishing a law specific to fire. However, French legislators have done well in this field by setting up appropriate legal requirements and prohibitions during fire season. While the forest firefighting laws of Türkiye and Iran are scattered throughout the text of the forest law and are not sufficient. Finally, by using the strengths of the laws of the studied countries, the weak points of the national forest laws are identified and recommendations suggest to modify. Also, this research introduces a legal framework to classify national forest laws in the field of forest fire management.

Keywords: Comparative laws, Forest laws, Preventive measures, Wildfire.

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Enhancing Blue/Green Infrastructure for Resilient Urban Environments: Smart Solutions and Nature-Based Strategies

Zahid Hassan[1]✉, Babar Shahbaz[1], Felipe Gallardo Lopez[2]

[1]University of Agriculture Faisalabad, Faculty of Social Sciences, Punjab/PAKISTAN

[2]Postgraduate College, Veracruz Campus, Veracruz/MEXICO

✉***Correspondence**: zahidhassan2142@gmail.com*

Abstract: The rapid increase in urban population density has put tremendous pressure on urban ecosystems and infrastructure, resulting in an array of environmental issues. Blue/green infrastructure has emerged as a viable solution for addressing these issues by creating resilient urban settings. This abstract revisit the concept of blue/green infrastructure and emphasizes the importance of nature-based, smart solutions and methods. The blue/green structure refers to a network of designed and natural landscapes such as green spaces, parks, wetlands, sustainable drainage systems, and rivers that all work together to improve air quality, manage stormwater, offer recreational places, and increase biodiversity in metropolitan settings. Smart solutions like advanced sensor technologies, data analytics, and Internet of Things (IoT) integration can improve the efficiency and efficacy of blue and green infrastructures. They provide real-time monitoring, informed decision-making, and adaptive management for long-term urban development. Nature-based strategies that include the restoration and maintenance of natural bionetworks in urban environments. These measures not only provide numerous conservation advantages, but they also help in the adaptation and mitigation of climate change. Our cities can lower flood risk, lessen urban heat island effect, sequester carbon, and increase overall urban resilience by utilizing natural power. The global data show the importance of improving the blue/green structure. According to a United Nations estimate, around 55% of the world's population lives in cities, with that proportion expected to rise to 68% by 2050. Furthermore, metropolitan areas account for more than 70% of global greenhouse gas emissions, emphasizing the importance of sustainable urban growth. The World Health Organization estimates that urban air pollution causes 4.2 million premature deaths per year. This research emphasizes the significance of incorporating smart solutions and nature-based techniques into urban planning and design in order to improve blue and green infrastructure. Cities may establish resilient and sustainable environments that will increase citizens' well-being, encourage natural biodiversity, and reduce the impacts of the changing climate.

Keywords: Blue/green infrastructure, Nature-based strategies, Smart solutions, Urban resilience, Climate change mitigation.

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Morphology and Exposure Studies in the Autonomous Republic of Abkhazia (West Georgia) on the Background of Modern Climate Change

George Kordzakhia[1✉], Larisa Shengelia[1], Gennady Tvauri[2], Guguli Dumbadze[3]

[1]Technical University of Georgia, Institute of Hydrometeorology, Tbilisi/GEORGIA

[2]Tbilisi Iv. Javakhishvili State University, Andronikashvili Institute of Physics, Tbilisi/GEORGIA

[3]Sh. Rustaveli Batumi State University, Batum/GEORGIA

✉***Correspondence***: giakordzakhia@gmail.com

Abstract: The degradation of glaciers is one of the most obvious signals of climate change in the current period of Earth's history. Modern glaciation is unevenly distributed between different regions of the Earth and some river basins. Glaciers in Georgia are spread over the Great Caucasus Range, concentrated in the basins of the Enguri, Rion, Kodori, Tergi and other rivers, where there are mountain peaks of 3500 m and higher. The study of the melting of glaciers due to the ongoing climate change is extremely important to clarify natural events of a glacial nature, to ensure the rise of the sea level and the safety of the population living in the coastal zone, to determine the change in glacial water runoff and to assess the risks related to the melting of glaciers in general, to develop adaptation strategies and mitigation measures to the melting of glaciers. In the article, the glaciers of the Autonomous Republic of Abkhazia (hereafter "Abkhazia") and their characteristics are studied. High-resolution satellite remote sensing (SRS) is the only way to study the current state of glaciers in the Autonomous Republic of Abkhazia, because on the one hand, there is no local glaciology school, and on the other hand, the current political situation does not allow conducting expeditions and studying glaciers in field conditions. The objective of the article is to study the morphology and exposure of these glaciers and snowfields based on the data from the catalogue of the former USSR (hereafter "catalogue") which is called initial data and is obtained from more than one century of observations and is issued between 1960 -1975 and satellite data, at several time points, namely 2010 and 2015 that are derived from high-resolution (30 m) LANDSAT satellite data, and the latest 2020 data are processed from satellite MODIS (1.5 m resolution). Complexly using the best international practices, processed SRS data and several SRS databases, historical data and expert knowledge define the reliability of received data. It should be noted that the authors had to overcome several difficulties and ambiguities in the data to discuss the problem relevantly.

Keywords: Glaciers of Abkhazia, Morphology, Exposure, Climate change.

1. INTRODUCTION

The degradation of glaciers is one of the most obvious signals of climate change in the current period of Earth's history (Bates et al., 2008; Tignor et al., 2018; Gaudio & Gobbi, 2022). The study of the melting of glaciers due to the ongoing climate change is extremely important to clarify natural events of a glacial nature, to ensure the rise of the sea level and the safety of the population living in the coastal zone, to determine the change in glacial water runoff and to assess the risks related to the melting of glaciers in general (Kordzakhia et al., 2015), to develop adaptation strategies and mitigation measures to the melting of glaciers. Mountain glaciers are an important source of fresh water, which is used for population, agriculture, energy and industrial needs.

High-resolution satellite remote sensing (SRS) is the only way to study the current state of glaciers in the Autonomous Republic of Abkhazia, because on the one hand, there is no local glaciology school, and on the other hand, the current political situation does not allow conducting expeditions and studying glaciers in field conditions.

2. METHODOLOGY, DATA, RESULTS

The study of the degradation of glaciers is very important in the background of modern climate change (Kordzakhia et al., 2019). One of the important problems is the research of Glaciers is the study of changes in morphology and exposure (Matnazarov et al., 2022). In the present work morphology and exposure of Abkhazian glaciers based on the data of the catalogue of the former USSR (hereinafter “Catalogue”) [Maruashvili et al., 1975] and satellite data from 2010, 2015 and 2020 are made. The glaciers' characteristics determination is realized based on international best practices using satellite remote sensing (SRS), historical data (catalogue including topographic maps), expert knowledge and satellite databases of 2010, 2015, and 2020 (Gobejishvili & Kotliakov, 2006; Kordzakhia et al., 2020).

Data on all the characteristics of glaciers in dynamics, which are given in the catalogue are determined by using SRS data, namely Landsat satellite images (resolution 15–30 m) and GIS (geo-information systems) technologies. These data are: morphological type, general exposure, maximum length, area, minimum height, maximum height, firn line height, and ablation area of the glaciers. The changes in these characteristics for the mentioned dates are due to the current climate change.

The paper presents the results on the morphology and exposure of Abkhazian glaciers in the last decade using catalogue and SRS data. In the early studies, where we compared the data of the catalogue with the data of only one term (2015) of the SRS, no attention was paid to the study of this issue. As it turned out, comparing the characteristics of all four periods of observation of glaciers and discussing their dynamics is important, because due to current climate change, glaciers are degrading, small glaciers are separating, which leads to a change in their morphology. It is important to determine the exposure of the changed glaciers, which determines the rate of their melting.

The morphological types of mountain glaciers are: kar, valley and hanging types (Kordzakhia et al., 2015).

As for the exposure of glaciers, we have the following designations as in the catalogue: West - W, East - E, South - S; Southwest - SW; Southeast - SE, North - N; North-west - NW; Northeast - NE.

Three glacial basins are presented in Abkhazia and in total, they amount to 136 glaciers. The distribution of morphological types of glaciers of Abkhazia are:

- In r. Bzibi glacial basin (13 glaciers in total) seven glaciers were located on the southern slope of the main ridge and Bzibi ridge, and 6 glaciers were on the northern slope;
- In r. Kelasuri glacial basin (3 glaciers in total) three glaciers are located on the northern slope of the Bzibi ridge;
- In r. Kodori glacial basin (120 glaciers in total) there was one glacier on the northern slope of the Chkhalta ridge of the r. Amtkeli glacial basin and one more on the northern slope of Chkhalta ridge, 43 glaciers are located r. Chkhalta glacial basin and on the southern slopes of the main ridge; there are 7 glaciers in r. Khetskvar glacial basin, two glaciers in Gentsvishi glacial basin, one glacier in r.Klisch glacial basin, 23 glaciers in r. Gvandra Basin.

Morphology of Abkhazian Glaciers: The distribution of morphological types of Abkhazian glacial basins for catalogue data and according to the SRS info for four data is presented in Table 1.

Table 1. Distribution of morphological types of Abkhazian Glaciers according to the Catalogue (a) and the SRS data of 2010 (b), 2015 (c), 2020 (d).

	Glacial basin	a. According to catalogue							
		The morphological types							
		Kar		Kar - valley		Valley		Hanging	
		quantity	area	quantity	area	quantity	area	quantity	area
1	Bzibi	11	5,5	0	0	1	1,3	1	0,3
2	Kelasuri	3	1,5	0	0	0	0	0	0
3	kodori	97	45,0	3	4,5	14	16,8	6	2,8
	Total	111	52	3	4,5	15	18,1	7	3,1

Table 1. (continued)

Glacial basin		b. According to SRS 2010							
		The morphological types							
		Kar		Kar - valley		Valley		Hanging	
		quantity	area	quantity	area	quantity	area	quantity	area
1	Bzibi	12	3,6	0	0	1	0,9	2	0,4
2	Kelasuri	2	0,9	0	0	0	0	0	0
3	kodori	99	28,0	4	5,6	15	11,4	29	4,9
	Total	113	32,5	4	5,6	16	12,3	31	5,3

Glacial basin		c. According to SRS 2015							
		The morphological types							
		Kar		Kar - valley		Valley		Hanging	
		quantity	area	quantity	area	quantity	area	quantity	area
1	Bzibi	8	2,1	0	0	1	0,8	1	0,2
2	Kelasuri	1	0,7	0	0	0	0	0	0
3	kodori	85	22,7	4	5,4	15	9,8	20	4,1
	Total	94	25,5	4	5,4	16	10,6	21	4,3

Glacial basin		d. According to SRS 2020							
		The morphological types							
		Kar		Kar - valley		Valley		Hanging	
		quantity	area	quantity	area	quantity	area	quantity	area
1	Bzibi	8	1,6	0	0	1	0,8	1	0,2
2	Kelasuri	1	0,6	0	0	0	0	0	0
3	kodori	74	18,0	4	4,9	15	7,8	17	3,4
	Total	83	20,2	4	4,9	16	8,6	18	3,6

As can be seen from the table, the glaciers of Abkhazia have karuli, gorge, karuli-valley and hanging morphologies. According to the catalogue, there is the largest number of kar glaciers, a total of 111. According to the data from 2010, 2015 and 2020, glaciers are degrading and dividing, small glaciers are separating. A kar glacier can be divided into two or three kar-type glaciers, one or two hanging type glaciers, and one or more snowfields. An example of this is No. 117 kar type medium glacier, which by 2010 was divided into 3 kar type glaciers, 1 hanging type small glacier and six snowfields. By 2015, only one kar-type small glacier and six snowfields remained from this glacier, and by 2020 - one kar- type small glacier and five snowfields.

A valley-type glacier generally retains its morphology, although it can be divided into valley and hanging type glaciers, as well as one or more snowfields. The kar-valley type glacier maintains its morphology in all three periods, although the occupied area decreases consistently. A hanging type glacier maintains its morphology, only its area decreases over time and sometimes it turns into a snowfield or disappears.

It should be noted that all snowfields are of kar or hanging type morphology. It is interesting to present Table 2, where it is visible that according to the satellite data of 2010, 60 snowfields were formed and none of the glaciers disappeared; by 2015, 77 snowfields were formed and 36 glaciers disappeared and by 2020, 103 snowfields were formed and 47 glaciers disappeared. Thus, since 2010, the number of snowfields and disappearing glaciers has been increasing intensively.

Table 2. Distribution of Snowfields and Fully Melted Glaciers of the Autonomous Republic of Abkhazia according to Glacial Basins according to the SRS data of 2010 (I), 2015 (II), 2020 (III).

Glacial basin		Snowfields			Fully melted glaciers		
		I	II	III	I	II	III
1	Bzibi	3	15	16	0	0	0
2	Kelasuri	1	2	2	0	0	0
3	Kodori	56	60	85	0	36	47
	Total	60	77	103	0	36	47

The valley type glaciers number is 15 according to the catalogue and their total area is 18.1 km^2. One of them, namely glacier No. 122, which according to the catalogue is an average glacier with an area of 1.4 km^2, is of the valley type, and according to the data of SRS in 2010 it was divided into two small glaciers of the valley type with areas of 0.4 and 0.3 km^2. In 2015, the area of each of them decreases and becomes 0.3 and 0.2 km^2, respectively. According to the SRS of 2020, both of them were divided into a small glacier and a snowfield of less than 0.1 km^2 area. Thus, the number of valley-type glaciers increased by 1 in 2010 and remained the same in 2015 and 2020. The total area of valley-type glaciers decrease over the years: 2010 - 12.3 km^2, 2015 - 10.6 km^2, 2020 - 8.6 km^2.

The number of hanging-type glaciers in Abkhazia is the smallest according to the catalogue. There is a total of 1 glacier in the Bzibi glacial basin, no hanging glacier in the Kelasuri glacial basin and 6 in the Kodori glacial basin valley. By 2010, a hanging-type glacier separated from Kar-type glacier No. 5 in the Bzibi glacial basin, thus the number of hanging glaciers became 2, however, in the following years, this glacier turned into a snowfield. By 2010, the number of hanging glaciers in the Kodori glacial basin was 29. In the following years, the number decreased in 2015 – to 20 and in 2020 – to 17.

Under the influence of current climate change, the increase in the number of kar and hanging glaciers by 2010 is due to the division of glaciers and the separation of small glaciers. This process continues further, but since 2010 their number has been consistently decreasing.

It should be noted that the number of the valley and kar-valley type glaciers remain unchanged, which is due to their morphological features, although the areas occupied by them are also consistently decreasing compared to 2010.

Since 2010, the area occupied by all morphological types of glaciers in Abkhazia has been decreasing, which is undoubtedly related to the current climate change.

General exposure of Abkhazian glaciers: The initial data on the general exposure of the Abkhazian glaciers was taken from the catalogue, and the general exposure of the glaciers in 2010, 2015 and 2020 was determined using the Google Earth program, where the direction and exposure of the valleys of the slopes can be seen. The contours of the glaciers of the mentioned years were included in the program, according to which the exposure of the slopes was determined. Also, the mentioned data was checked in Arc Map (Arc Gis) using specially designed Arc Toolbox tools. The method provides for the so-called Digital Elevation Model (DEM) of the terrain of Georgia. Processing with DEM is carried out in such a way as to obtain a map of the exposure of the slopes of Georgia. During processing, the DEM of the terrain of Georgia with a resolution of 20x20 was used (Figure 1).

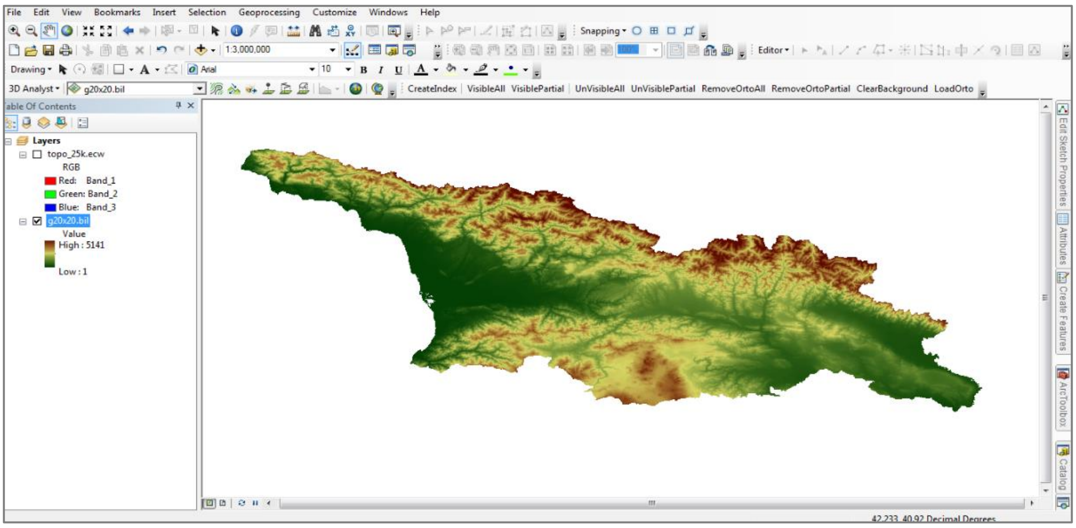

Figure 1. Digital elevation model of the terrain of Georgia with a resolution of 20x20.

Figure 2 shows the exposure map of the slopes of Georgia.

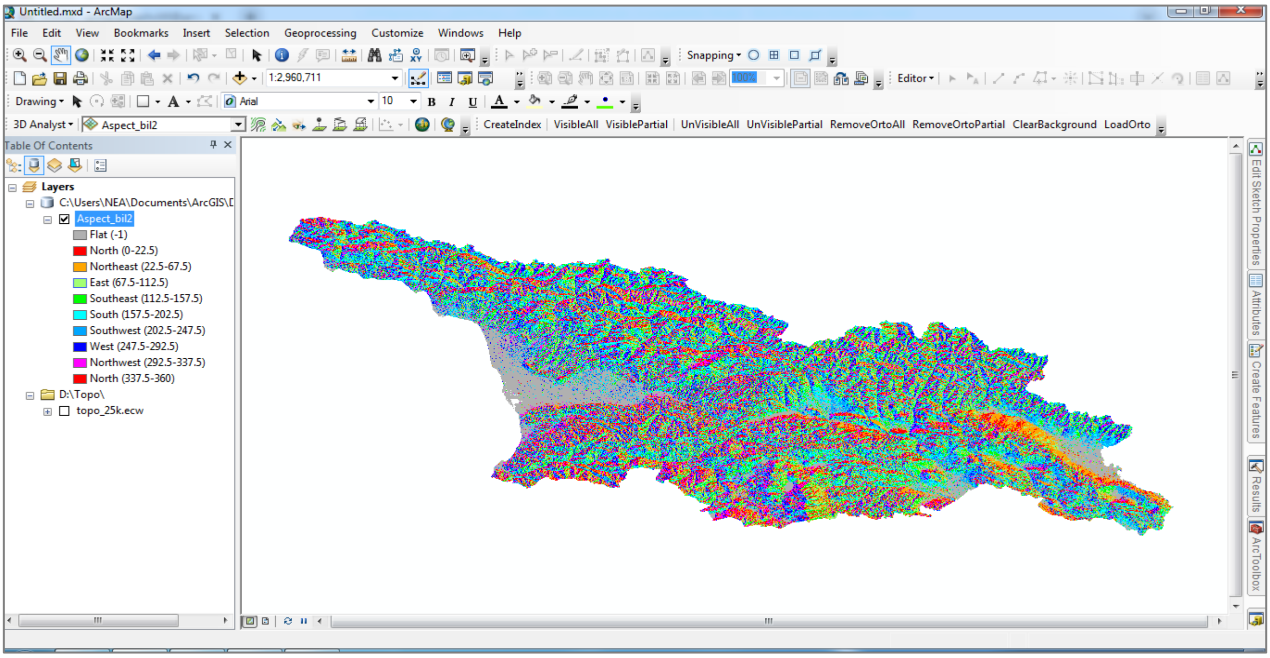

Figure 2. The exposure map of the slopes of Georgia. The image legend indicates conditional signs of the slope exposure by colour: N exposure is shown in red, NE - in orange, E - in light green, SE - in green, S- in blue, SW - in light blue, W - in yellow Blue, SW - with violet.

The contours of the research glaciers (according to years) were included in the image and their exposure was determined. For example, we have the image of the contours of glaciers №118, №119 and №120 on the slope exposure map of 2015 (Figure 3).

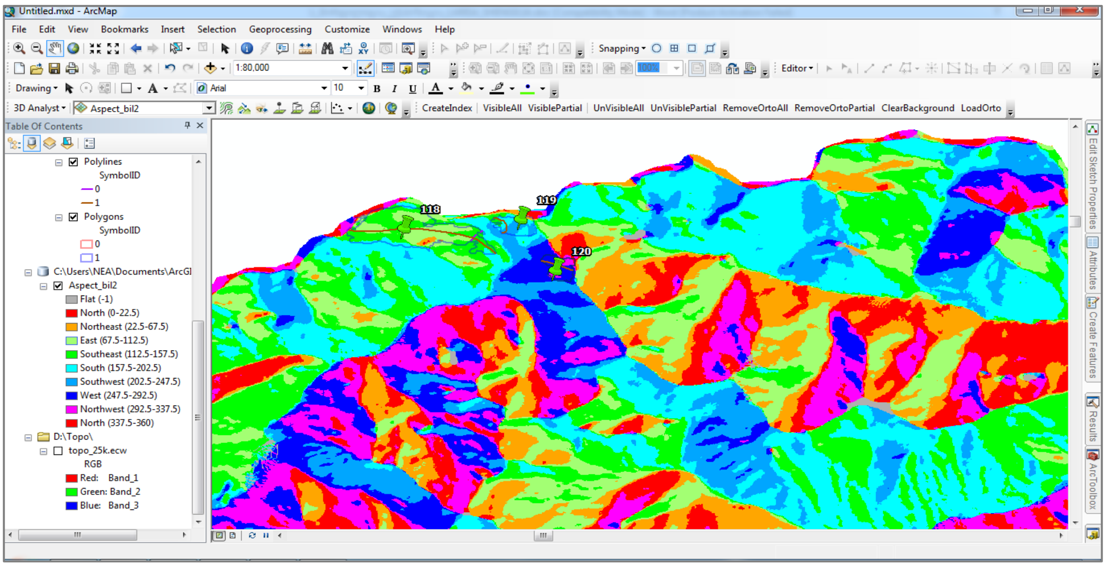

Figure 3. Contours of glaciers №118, №119 and №120 of 2015 on the exposure map of the slopes of Georgia.

In Figure 3 The contours of the research glaciers (according to years) were included in the image and their exposure was determined. For example, we have the image of the contours of glaciers №118, №119 and №120 on the slope exposure map of 2015 (Figure 3).

The contour of glacier №118 is in green, №119 – blue-sky, and №120 - blue, therefore the exposure of glacier №118 is SE, №119 - S, and №120 - W.

In the Figure 4 the contours of glaciers №118, №119 and №120 according to the Landsat 7 ETM+ sensor image of September 6, 2015 are shown.

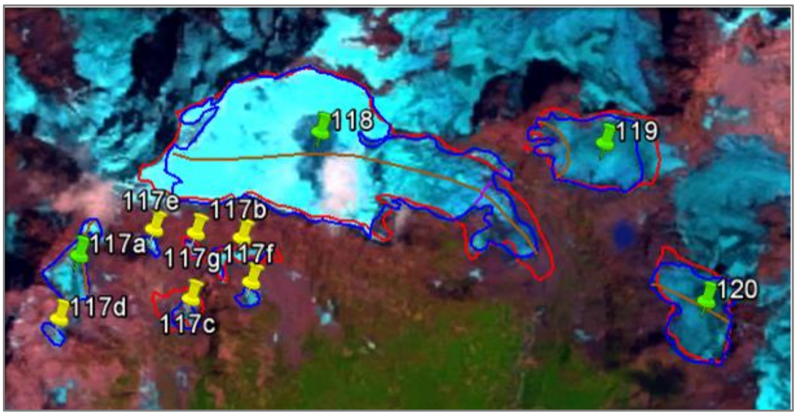

Figure 4. The contours of glaciers №118, №119 and №120 according to the Landsat 7 ETM+ sensor image of September 6, 2015.

In Figure 3, the contour of glacier№118 is green, №119 – sky-blue, and №120 - blue, therefore the exposure of glacier №118 is SE, №119 - S, and №120 - W.

The mentioned method has been tested and accepted in the world. Its use practically eliminates errors during the study of glacier exposure.

The study of the exposure of glaciers is of great importance in the issue of melting glaciers. For the research, we compiled a table of the distribution of the general exposure of glaciers according to the glacial basins of Abkhazia, for four dates (Table 3). Analysis of this table shows that the predominant direction of the general exposure of the Abkhazian glaciers both in the catalogue and in all three dates of SRS data is the NW and W directions. Naturally, these directions coincide with the direction of the invasion of air masses from Abkhazia to Georgia, which leads to the development of synoptic processes in the mountainous regions of Abkhazia, which are associated with the arrival of heavy precipitations.

Table 3. Distribution of general exposure of glaciers of Abkhazia according to catalogue (a) and SRS data from 2010 (b), 2015 (c), 2020 (d).

		a. Catalogue Data															
Glacial Basin		**N**		**S**		**W**		**E**		**W**		**NE**		**SW**		**SE**	
		quantity	**area**	**quantity**	**area**	**quantity**	**area**	**quantity**	**area**	**quantity**	**area**	**quantity**	**area**	**quantity**	**area**	**quantity**	**area**
1	**Bzibi**	6	2,7	0	0	3	2,6	0	0	0	0	0	0	4	1,8	0	0
2	**Kelasuri**	0	0	0	0	0	0	0	0	0	0	3	1,5	0	0	0	0
3	**Kodori**	11	4,5	20	13,8	23	9,9	14	8,6	25	14,2	9	8,0	7	3,1	11	8,8
	Total	17	7,2	20	13,8	26	12,5	14	8,6	25	14,2	11	9,5	11	4,9	11	8,8

Table 3. (continued)

Glacial Basin		b. SRS Data from 2010															
		N		S		W		E		NW		NE		SW		SE	
		quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area
1	**Bzibi**	6	1,6	0	0	4	1,7	0	0	1	0,1	0	0	4	1,5	0	0
2	**Kelasuri**	0	0	0	0	0	0	0	0	0	0	2	0,9	0	0	0	0
3	**Kodori**	12	2,7	17	8,8	25	6,2	13	6,3	28	10,1	17	5,4	12	2,9	23	8,0
	Total	18	4,3	17	8,8	29	7,9	13	6,3	29	10,2	19	6,3	16	4,4	23	8,0

Glacial Basin		c. SRS Data from 2015															
		N		S		W		E		NW		NE		SW		SE	
		quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area
1	**Bzibi**	2	0,9	0	0	1	0,2	0	0	0	0	1	0,1	4	1.1	0	0
2	**Kelasuri**	0	0	0	0	0	0	0	0	0	0	1	0,7	0	0	0	0
3	**Kodori**	12	1,9	15	7,8	19	5,2	12	5,4	25	8,6	16	4,5	10	2,5	15	6,1
	Total	14	2,8	15	7,8	20	5,4	12	5,4	25	8,6	18	5,3	14	3.6	15	6,1

Glacial Basin		d. SRS Data from 2015															
		N		S		W		E		NW		NE		SW		SE	
		quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area	quantity	area
1	**Bzibi**	1	0,8	0	0	4	1,0	0	0	0	0	1	0,1	4	0,6	0	0
2	**Kelasuri**	0	0	0	0	0	0	0	0	0	0	1	0,6	0	0	0	0
3	**Kodori**	10	1,1	13	6,6	16	4,0	11	4,5	27	7,4	12	3,5	10	2,1	11	4,9
	Total	11	1,9	13	6,6	20	5.0	11	4,5	27	7,4	14	4,2	14	2,7	11	4,9

It is also important to note that among the snowfields formed as a result of the degradation of glaciers due to climate change, the number of northern exposure snowfields increased the most by 2020, from 8 in 2010 to 23 in 2020, i.e., an increase of 65%. The snowfields of western exposure increased by 61%, and those of south-eastern exposure - by 54% (see Table 4).

Table 4. Distribution of snowfields of Abkhazia according to general exposure and SRS data from 2010 (1), 2015 (2), 2020 (3).

Glacial Basin		N			S			W			E			NW			NE			SW			SE		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	**Bzibi**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	-	-	-	-	-	-
2	**Kelasuri**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	-	-	-	-	-	-
3	**Kodori**	8	15	23	3	5	4	7	11	18	5	5	8	10	10	10	8	8	10	2	3	5	13	15	20
	Total	8	15	23	3	5	4	7	11	18	5	5	8	10	10	10	12	13	15	2	3	5	13	15	20

3. CONCLUSION

Under the influence of current climate change, the increase in the number of closed and hanging glaciers by 2010 is due to the division of glaciers and the separation of small glaciers. This process continues further, but since 2010, their number has been steadily decreasing.

The number of the Valley and Karuli-valley type glaciers remains unchanged, which is due to their morphological features, although the areas occupied by them are also consistently decreasing compared to 2010. Since 2010, the area occupied by all morphological types of glaciers is decreasing, which is directly related to the current climate change.

The predominant direction of the general exposure of Abkhazian glaciers, both in the catalogue and in all three periods, is the northwest and west direction. Naturally, these directions coincide with the direction of the invasion of air masses from Abkhazia to Georgia, which leads to the development of synoptic processes in the mountainous regions of Abkhazia, which are associated with the arrival of large precipitations.

According to the data of all four periods in Abkhazia, there are more glaciers in the northern exposure (N, NW, NE) than in the southern exposure (S, SW, SE) and the territories occupied by them are also larger. This is an important conclusion because, in all other glacial basins of West Georgia, the picture is the opposite. As a result of the ongoing climate change impact on these glaciers, the areas of Abkhazian glaciers have been consistently decreasing since 2010 compared to catalogue data for glaciers of all exposures.

Of the snowfields formed as a result of the degradation of glaciers due to climate change, the number of snowfields with northern exposure increased the most by 2020.

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ORAL PRESENTATION https://doi.org/10.61326/icelis.2023.22

Carbon and Nitrogen Storage Capacities of Soils of Different Land Use in Karstic Ecosystems

***Ayşe Sena Küçük*[1], *Turgay Dindaroğlu*[2], *Emre Babur*[1]✉**
[1]*Kahramanmaraş Sütçü İmam University, Faculty of Forestry, Kahramanmaraş/TÜRKİYE*
[2]*Çukurova University, Faculty of Fisheries, Adana/TÜRKİYE*
✉***Correspondence**:* emrebabur@ksu.edu.tr

Abstract: There are significant differences in carbon and nitrogen storage of soils developed under to different land uses in areas where climate, bedrock and other external factors are similar. This study was carried out to determine soil carbon and nitrogen stocks of forest (O), Agriculture (T) and bare (B) areas, including Ahir Mountain Green belt afforestation area in Kahramanmaraş province. Disturbed and undisturbed soil samples (72 in total) were collected from the topsoil (0-20 cm) of 36 systematically determined points on Mount Ahir. Soil organic carbon (SOC), total nitrogen (N) and bulk weight (BD) analyzes were made in soil samples. The amount of carbon and nitrogen stored in the area was estimated by using the data obtained as a result of the analyzes and the inequalities. According to the data, the amount of carbon stored in forest, agriculture and clearing areas is 75.49 t C Ha^{-1}, 73.56 t C Ha^{-1} and 47.31 t C Ha^{-1}; the amount of stored nitrogen was found to be 6.05 t N Ha^{-1}, 7.67 t N Ha^{-1} and 4.40 t N Ha^{-1}. Forest soils have approximately 46% more carbon than bare areas soils and 5% more than agricultural soils. In terms of total nitrogen amount, it was found 20% higher in the soils of agricultural areas compared to forest and 50% more than in bare space soils. It has been determined that there are significant differences in the chemical parameters of the soils belonging to the lands with different land use capabilities, especially in the C and N concentrations. Examining this change reveals the effect of land use on carbon and nitrogen stocks of soils. Changes in the organic C and N status of our soils, which are of great importance for a sustainable agriculture, should be well observed.

Keywords: Land use, Nitrogen, Carbon stocks, Soil properties.

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Activated Carbon Fibers/Zinc Oxide Nanorods Fabrics for UV Protection

Borhan Albiss[1]✉, Muna Abu-Dalo[2]

[1]*Jordan University of Science and Technology, Nanotechnology Institute, Irbid/JORDAN*

[2]*Jordan University of Science and Technology, Department of Chemistry, Irbid/JORDAN*

✉***Correspondence****:* baalbiss@just.edu.jo

Abstract: Organic–inorganic nanocomposite materials represent a creative platform to design new materials with improved or novel features that allow the development of innovative industrial applications. In this project, based on the fact that ZnO nanostructures are among the best and safest choices for ultraviolet (UV) protection materials for potential applications for UV preservation, Zinc oxide nanorods (ZnO-NRs) were grown on the surface of the activated carbon fibers (ACF) fabrics using a simple and cost-effective hydrothermal method to produce (ACF/ZnO-NR) nanocomposites. The experimental conditions (such as ZnO-NR density, lengths, and diameters) were optimized to obtain nanocomposites with best performance. The optical, microstructural properties of the nanocomposites were investigated using, SEM, XRD, UV-Vis, Contact angle test, and FTIR. The behavior of ZnO-NR, ACF, and ACF/ZnO-NR samples under UV-radiation exposure has been studied after different exposure times. The results obtained showed that the prepared ACF/ZnO-NR nanocomposites were somewhat transparent under the visible wavelength region and highly protective against UV radiation. Moreover, results revealed that the successful homogeneous immobilization of ZnO-NR on ACFs surface effectively enhances the UV-shielding performance. Particularly, the pristine ACF fabrics achieved a quite modest UV-blocking efficiency in the UVA (96%) and UVB (95%) regions. However, ACF/ZnO-NR fabrics showed a relatively high UV-blocking efficiency in the UVA (98%) and UVB (97%) regions. Additionally, fabrics with1%wt ZnO-NR content demonstrate an enhanced hydrophobicity with a contact angle over 135° compared to pristine ACF. Moreover, ACF/ZnO-NR fabrics also displayed an outstanding thermal and UV stability and exhibit an excellent UV-protection factor of 50+. The experimental results suggest that the synthesized samples can be used as a UV-blocking material and find potential applications as a UV absorber in optical devices, cosmetics, smart packaging, textiles, and protective coatings.

Keywords: Hydrothermal process, ZnO nanorods, Activated carbon fabrics, Nanocomposite, UV protection.

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Determination of 180-Year Variation of Li Concentration in the Atmosphere using *Corylus colurna* L. Annual Rings

Kübra Key[1], Şemsettin Kulaç[1], İsmail Koç[2], Hakan Şevik[3]✉

[1]*Düzce University, Forestry Faculty, Düzce/TÜRKİYE*

[2]*Düzce University, Forestry Vocational School, Düzce/TÜRKİYE*

[3]*Kastamonu University, Faculty of Engineering and Architecture, Kastamonu/TÜRKİYE*

✉***Correspondence**: hsevik@kastamonu.edu.tr*

Abstract: Environmental pollution has increased significantly in the current century due to various anthropogenic effects, especially industrial activities, mining, urbanization, and traffic. Significantly increasing air pollution has become a global problem that causes millions of people to die yearly. Heavy metals, the most dangerous and harmful components of air pollution, do not easily deteriorate and disappear in nature. They can be carried far from their source, tend to bioaccumulate in living organisms, and some can be toxic, carcinogenic, and fatal even at low concentrations for humans and animals. Therefore, monitoring the change of heavy metal concentrations in the air is critical. One of the most effective methods in determining the heavy metal concentration changes in the atmosphere from past to present is using annual rings of trees as biomonitors. In this study, the variation of Li concentrations, which is one of the most harmful heavy metals in terms of human and environmental health, in the last 180 years, was tried to be determined by using *Corylus colurna* L. annual tree rings, which was cut at the end of 2020 in Kastamonu province, Türkiye. Within the scope, the heavy metal concentrations in the bark and inner bark were also compared with the heavy metal concentrations in the woods, and the directional variation of the heavy metal concentrations was also evaluated. As a result, there was a significant difference between wood and bark ($p<0.05$) except for the north direction of Li element, and the concentrations obtained in the woods were much higher than those in the bark. In the annual rings, the variation of the Li concentration in all directions, except for the west direction, is significant ($p<0.05$). However, Li concentration generally varies in a narrow range, and this can be interpreted as the Li element being transferred between woods in *C. colurna*.

Keywords: Oak seedling, Biomass, Carbon sequestration, Basic density, Root collar diameter.

1. INTRODUCTION

Environmental and especially air pollution has become one of the most critical issues worldwide in the last century, increasing rapidly due to anthropogenic factors, especially industrial activities (Ateya et al., 2023a, 2023b; Cobanoglu. et al., 2023a; Isinkaralar et al., 2023). It is stated that approximately 2.5 million living spaces across Europe are polluted, and 90 percent of the world's population now breathes polluted air (Cesur et al., 2022). It is emphasized that air pollution causes more than 4 million premature births and approximately 7 million deaths worldwide every year (Ghoma et al., 2022). Air pollution is one of the most critical global problems associated with urbanization, and global climate change is considered an irreversible problem worldwide (Varol et al., 2022; Canturk et al., 2023a; Cetin et al., 2023).

Amongst the ingredients of air contamination, heavy metals are significant for human and environmental health. Heavy metals do not degrade quickly in nature. Many are toxic and lethal to living organisms, even at low concentrations. Even those necessary as nutrients for living organisms are harmful at high concentrations, and their inhalation into the living body is a significant threat to living health. Therefore, monitoring the alterations in heavy metal levels in the air is crucial. However, studies on observing the difference in heavy metal contamination in the air mostly focus on heavy metals such as Co, Cr, Pb, Ni, Cu, and Mn, while many other elements are neglected. One of the neglected elements in these studies is Lithium (Li).

Li is widely preferred in the innovative industry of recent times. It is used in organic synthesis, glass, plastic and aluminum production, radio engineering, computers, cameras, telephone batteries, electronics, and laser devices. With the increase in these uses, the amount of Li in the biosphere is also increasing (Kashin, 2019). Li has no known biological usage and does not appear to be a crucial element for life. The Australian Inventory of Chemical Substances has categorized metallic lithium as a health, ecotoxicological, and/or physiochemical hazard according to the National Occupational Health and Safety Commission (NOHSC) approved criteria for categorizing hazardous substances. Li, lithium aluminum hydride, and lithium methanolate are dangerous substances on the Danish list (Aral & Vecchio-Sadus, 2008).

Therefore, monitoring the difference of Li concentration in the airborne is crucial. Tree annual rings are the most frequently used biomonitors for observing the variations in heavy metal concentrations in the air. This study aimed to determine the variation in Li concentration over time by analyzing the annual tree rings of a 180 years old Turkish hazelnut (*Corylus colurna* L.) tree.

2. MATERIALS AND METHODS

The present research was conducted on the specimens obtained from the stem of Turkish hazelnut (*Corylus colurna* L) grown in a site (41°38ˈ14″N-33°29ˈ58″E) near Ağlı region (Müsellimler Village) of Kastamonu city. The stem was taken after the growing period at the end of 2020. The direction of the stem was marked before cutting. The tree is surrounded by pasture, agriculture, and a forest stand. Except for small-abandoned settlements, no industrial plants and heavy metal contamination sources exist at 5 km of air space.

Ten cm thick wood sample cut roughly 50cm above the soil level. It was taken to the laboratory, and it was polished by a planner to see tree rings nicely. The plant was found to be 180 years old by calculating the annual tree rings. Considering the annual ring widths, they were grouped into 10-year age clusters. It was documented which stage occurs in which years. Then, samples were taken from each age group's wood, inner bark, and outer bark using a steel drill. These specimens were placed into the petri dishes, and metal instruments were not used during the analysis.

All these procedures were described as follows (Koç, 2021a; Key & Kulac, 2022; Yayla et al., 2022; Kuzmina et al., 2023). Wood samples were crushed into chips, and after marking, they were moved into glass petri dishes. In order to get air-dried specimens, they were held in petri dishes with open lids for 14 days. Then, the specimens were dried (45 °C) in an oven for a week. After that, 0.5g dried samples were taken; they were added with 2 ml 30% H_2O_2 and 6 ml 65% HNO_3 and moved into a microwave developed for this element analyses. The microwave program was set to rise to 200 °C for 15 minutes and then remain at this temperature for 15 minutes. After burning the samples, the solution specimens were placed to flasks and filled to 50 mL using ultrapure water. The ICP-OES device was used for this heavy metal analysis. The analyses were triplicated.

Analysis of Variance (ANOVA) and Duncan tests were used to evaluate the data using SPSS 21.0 software. Homogeneous groups are presented in the tables by applying Duncan tests for the factors with significant differences ($p<0.05$) in the ANOVA test.

3. RESULTS AND DISCUSSION

3.1. Results

The mean values, Duncan test results and P-values obtained from the ANOVA regarding Li concentration difference in terms of direction and organ are given in Table 1. As a result of the ANOVA, Li concentrations differed based on organs in all directions except north, and in all organs based on directions, statistically significant at least at 95% confidence level. When the values are evaluated, the highest value was obtained in the wood in the west direction with 2079.9 ppb. The lowest value was obtained in the outer bark in the south with 519.8 ppb.

Table 1. Variation in Li (ppb) concentration levels by direction and organ.

Organ	East	West	South	North	P - value
Outer Bark	570.2^{Aa}	1700.1^{Bb}	519.8^{Aa}	1667.0^{B}	***
Inner Bark	640.5^{Aa}	1306.0^{Ba}	880.4^{Aa}	1646.0^{B}	**
Wood	1422.7^{Ab}	2079.9^{Cc}	1769.5^{Bb}	1467.3^{A}	***
P – value	*	***	***	ns	

Note: Lower-case letter indicates to the vertical way within each row, whereas upper-case letter suggests to the horizontal way within each column. ns: not significant. * = P≤0.05; ** = P≤0.01; *** = P≤0.001. This explanation is also valid for Table 2.

The Li concentration variations in wood by periods and directions is given in Table 2. As a result of the ANOVA, it was determined that Li concentrations differed statistically at a 99.9% confidence level in all periods in all directions except the west. When the change of the values on a period basis is analyzed, it is seen that the values obtained in the western direction are generally higher than the other directions. In contrast, the values obtained in the eastern direction are quite variable.

Table 2. Variations in Li (ppb) concentration level in *Corylus colurna* wood by period and direction.

Periods	East	West	South	North	P- value
1841-1850	1100.2^{Bcd}	1993.7^{C}	1786.6^{Ccde}	520.4^{Aa}	***
1851-1860	989.9^{Aabc}	2142.0^{C}	1831.0^{Cdef}	1337.4^{Bdef}	***
1861-1870	2093.2^{Be}	2124.9^{B}	1483.0^{Aabc}	1273.1^{Acdef}	**
1871-1880	2284.0^{Bef}	2049.0^{B}	1563.2^{Aabcd}	1319.2^{Adef}	***
1881-1890	2236.1^{Cef}	1911.9^{B}	1565.6^{Aabcd}	1362.2^{Aef}	***
1891-1900	2390.4^{Cfg}	1870.0^{B}	1611.2^{Aabcde}	1444.2^{Af}	***
1901-1910	2546.8^{Cgh}	1932.0^{B}	1607.4^{ABabcde}	1343.9^{Adef}	***
1911-1920	2634.2^{Ch}	2121.3^{B}	1915.6^{Befg}	1155.6^{Abcde}	***
1921-1930	935.0^{Aabc}	2127.0^{C}	1750.1^{Bbcde}	1072.5^{Abc}	***
1931-1940	904.3^{Aabc}	2181.1^{D}	1850.0^{Cdef}	1131.5^{Bbcd}	***
1941-1950	1043.3^{Abcd}	2083.3^{B}	1850.0^{Bdef}	1063.0^{Abc}	***
1951-1960	862.2^{Aabc}	2142.7^{B}	2162.0^{Bfgh}	1066.7^{Abc}	***
1961-1970	745.1^{Aa}	2213.4^{B}	2190.7^{Bgh}	987.5^{Ab}	***
1971-1980	1255.5^{Ad}	2149.7^{B}	2376.5^{Bh}	2129.4^{Bgh}	***
1981-1990	933.1^{Aabc}	2196.3^{BC}	1943.0^{Befg}	2325.7^{Chi}	***
1991-2000	957.4^{Aabc}	2049.8^{C}	1556.7^{Babcd}	2002.9^{Cg}	***
2001-2010	910.5^{Aabc}	2160.6^{C}	1387.0^{Ba}	2359.8^{Ci}	***
2011-2020	787.8^{Aab}	1989.8^{C}	1421.0^{Bab}	2517.2^{Di}	***
P - value	***	ns	***	***	

3.2. Discussion

In this study, the directional variation of the concentration of Li in the outer bark, inner bark, and 180-year-old annual rings in *Corylus colurna* was evaluated. As a result, Li accumulated in all directions of all organs within determinable limits. This result indicates that the species subject to the study has a high Li accumulation potential. The most critical feature sought in species that can be used in determining heavy metal contamination is the ability of the species to accumulate the elements subject to the study. In many studies, it has been determined that some species have different levels of potential to absorb some elements (Karacocuk et al., 2022; Guney et al., 2023).

Another feature that determines the usability of annual rings as biomonitors is the limited movement of the element in the wood. According to the results, the transfer of Li in the wood is restricted. Indeed, when the values are evaluated, for example, Li concentration in the north direction was 987.5 ppb in 1961-1970. However, in the same direction, the Li concentration was 2129.4 ppb in the next period. Similarly, the Li concentration in the neighboring west direction was 2213.4 ppb in the same period. These results show that the transfer of Li in wood is limited. In studies conducted on this topic, it has been determined that the transfer of elements in wood differs according to the species. For instance, Pb and Zn element concentrations changed slightly, while the Cu element concentration did not alter in the annual tree rings of *Cedrus deodara* (Zhang, 2019). It was reported that Co, Mn, and Ni transfer in *Corylus colurna* woods is quite restricted (Key et al., 2022). It was also pointed out that Ni, Cd, and Fe transfer was restricted in *Cupressus arizonica* woods, but Li, Cr, and Bi transfer was more remarkable in its wood (Cesur et al., 2021, 2022). Therefore, proper plant species should be determined individually for each heavy metal contamination determination.

In plants, the transfer of elements within the wood section is primarily related to the structure of the cell and cell wall (apoplastic pathway). In plants, the apoplast between the cell wall and the plasma membrane is an apoplastic obstacle and a flexible structure that senses and signals metal/metalloid stress. Cell wall proteins (CWPs) that are activated under numerous abiotic strains have been considerably identified and categorized among diverse types of plants (Wani et al., 2018).

Plants frequently face various stress factors throughout their life cycle. Plants' most common stresses are related to climatic parameters such as drought (Koç, 2021b; Koç & Nzokou, 2022, 2023) and frost (Sevik & Karaca, 2016). Because plant development is shaped by the interaction of genetic structure (Kurz et al., 2023; Koç et al., 2023) and environmental conditions (Tandoğan et al., 2023; Sulhan et al., 2023; Yigit et al., 2023; Zeren Cetin et al., 2023). Therefore, changes in genetic structure and environmental conditions affect the heavy metal uptake of plants. For example, Lorenc-Plucińska et al. (2013) determined that Pb concentration in *Alnus incana* leaves of different origins grown in the same environment varied between 279-430 ppb and Zn concentration between 21000-30000 ppb, while Pb concentration in *Alnus glutinosa* leaves varied between 630-920 ppb and Zn concentration between 19200-27000. This outcome shows that heavy metal accumulation potential varies significantly depending on the origin, even in the same environment and in plants belonging to the same species.

The potential of plants to accumulate heavy metals also varies depending on environmental conditions. Therefore, factors that cause significant and permanent changes in climatic parameters, such as global climate change, trigger the stress mechanisms of plants (Koç, 2021c, 2022; Varol et al., 2021; Tekin et al., 2022; Dogan et al., 2023). In addition to these, stress factors such as UV-B stress (Ozel et al., 2021a; Çobanoğlu et al., 2023), anthropogenic radiation (Ozel et al., 2021b; Cobanoglu et al., 2023b), and heavy metal pollution (Cesur et al., 2022; Isinkaralar et al., 2022; Key et al., 2023; Erdem et al., 2023; Ghoma et al., 2023), which increase due to climate change, also affect plant metabolism and thus the potential of plants to accumulate heavy metals.

4. CONCLUSION AND RECOMMENDATIONS

One of today's most critical global problems is air pollution. Heavy metals are among the most studied subjects among the components of air pollution due to their potential hazards. The significance of heavy metals for people's health is known, and numerous studies have been conducted on this topic. However, the studies primarily focus on Co, Pb, Cd, Ni, and Cr. Still, it is essential to increase studies on elements such as Li, B, Tl, Ag, Sr, Sr, Ga, and As, which can be tremendously detrimental to environmental and human health but have not been given much prominence and have not been studied much until today, and to determine the risky areas.

In conclusion, in the current study, there was a significant difference between wood and bark in terms of Li concentration except for the north direction, and the concentrations obtained in the woods were much higher than those in the bark. In the annual rings, the variation of the Li concentration in all directions, except for the west direction, is noteworthy. However, Li concentration commonly varies in a limited range, and this can be interpreted as the Li element being transferred between woods in *Corylus colurna*.

Although many tree species have been the topic of studies to date, there needs to be more information about the accumulation potential of heavy metals in many tree species. However, as in the current study, it has been concluded that there are significant alterations between tree species' heavy metal accumulation potentials in various studies. Therefore, research on the topic should be expanded and continued.

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Variation of Gallium Concentrations in Some Forest Trees Depending on Species, Organ and Soil Depth

Ramazan Erdem[1], Burak Arıcak[2], Mehmet Çetin[3], Hakan Şevik[4]✉

[1]Kastamonu University, Araç Rafet Vergili Vocational School, Department of Forestry, Kastamonu/TÜRKİYE
[2]Bursa Technical University, Faculty of Forestry, Department of Forestry, Bursa/TÜRKİYE
[3]Ondokuz Mayıs University, Faculty of Architecture, Department of City and Regional Planning, Samsun/TÜRKİYE
[4]Kastamonu University, Faculty of Engineering and Architecture, Kastamonu/TÜRKİYE
✉***Correspondence**:* hsevik@kastamonu.edu.tr

Abstract: Heavy metal pollution is one of the most critical environmental problems threatening the environment and human health. Therefore, studies on monitoring and reducing heavy metal pollution are among the prioritized study topics. Plants are one of the most effective tools to monitor and reduce heavy metal pollution. However, the potential of heavy metal accumulation in various organs of plants is quite different. Therefore, it is necessary to determine the most suitable species and organs for this purpose and to have information on the transfer of heavy metals in the plant and the way of entry into the plant. In this study, the concentrations of Gallium, one of the most critical and dangerous heavy metals for human health, were evaluated at different soil depths in the soils where *Pinus nigra* Arnold., *Pinus sylvestris* L., *Fagus orientalis* Libsky. and *Abies nordmanniana* subsp. *bornmülleriana* Mattf. species grow in leaves, bark, wood, cones, and root organs. As a result of the study, there was no statistically significant difference between soil depths in terms of mean values of Gallium concentrations. In contrast, the highest importance on a species basis was obtained in *Fagus orientalis* Libsky. The lowest values were obtained in *Abies nordmanniana* subsp. *bornmülleriana* Mattf. Regarding organs, the lowest values were obtained in wood and the highest in roots.

Keywords: Gallium, Heavy metal, Plant, Biomonitor.

1. INTRODUCTION

In the last century, the increasing world population, the concentration of people in urban areas, and industrial developments have brought along many interrelated problems. The most critical issues worldwide are global climate change (Varol et al., 2021; Canturk & Kulaç, 2021; Koç & Nzokou, 2022a, 2022b, 2023), urbanization (Dogan et al., 2023; Zeren Cetin et al., 2023), and environmental pollution (Elsunousi et al., 2021; Cesur et al., 2022; Guney et al., 2023). Environmental pollution, especially air pollution, is the most essential social health problem worldwide. The WHO reported that more than 8 million people died yearly, exceeding air pollution limits (Isinkaralar et al., 2023a, 2023b; Sulhan et al., 2023).

Heavy metals are recognized as the most dangerous and harmful component of air pollution. Heavy metals are known as pollutants that do not quickly degrade and disappear in nature, bioaccumulate in living organisms, and some of them, such as Pb, Hg, and Ni, can be toxic, poisonous, carcin, and fatal even at low concentrations (Turkyilmaz et al., 2020; Key & Kulaç, 2022). Even heavy metals, essential for living organisms as nutrients, are harmful at high concentrations (Aricak et al., 2019; Ateya et al., 2023a, 2023b; Cobanoglu et al., 2023a). It is emphasized that heavy metals are much more dangerous when inhaled into the body (Ghoma et al., 2022).

Heavy metals pose a significant danger to humans, other living organisms, and the ecosystem (Koç, 2021). Therefore, monitoring and reducing heavy metal pollution is one of the priority study topics (Savas et al., 2022). It is stated that plants are the most effective elements that can be used to monitor the change of heavy metal pollution and reduce pollution. Plants grown in places with high levels of heavy metal pollution accumulate heavy metals in soil, water, and air. Thus, they contribute to reducing heavy metal pollution in these environments (Sharma et al., 2023; Li et al., 2023).

However, the accumulation potential of heavy metals in various organs of plants is quite different. For plants to be used effectively in reducing heavy metal pollution, the level of knowledge on issues such as in which organs plants grown under similar environmental conditions can accumulate heavy metals more, in which ways heavy metals enter the plant body more intensively, and how heavy metal concentrations change depending on soil depth in soils where different plants are grown is quite limited (Erdem et al., 2023a, 2023b). In this study, it was aimed to contribute to the elimination of these knowledge gaps. Within the scope of the study, it tried to determine the changes in Ga, one of the heavy metals used extensively in various fields. Still, it can be extremely harmful to human and environmental health in different organs of different plants and soil.

2. MATERIALS AND METHODS

Within the scope of the study, the change of Ga element, which is used intensively in various fields today and therefore its concentrations in air, water, and soil are constantly increasing but neglected in studies on heavy metals, was determined in soils and plant organs where different forest trees grow. For this purpose, leaf, bark, wood, cone, and root samples were taken from *Pinus nigra* Arnold., (Pni), *Pinus silvestris* L. (Psi), *Fagus orientalis* Libsky., (Fo) and *Abies nordmanniana* subsp. bornmülleriana Mattf. (Abo) species are growing in a limited area with similar soil and climate conditions in a flat area within the borders of Kastamonu Araç District. *Fagus orientalis* Libsky. It was not included in the study as its cones were not available. In addition, soil samples were taken from 0-5 cm depth (topsoil), 20-30 cm depth (middle soil), and 50-60 cm depth (subsoil) under each sampled tree by removing the dead cover on the soil. The soils brought to the laboratory were kept in a dry and ventilated environment for two weeks to make them room dry. The sieved soils were then dried in an oven at 45 °C for two weeks. The same preparations were applied to the plant samples except for sieving.

The dried samples were analyzed for Ga elements using ICP-OES, and their concentrations were determined at ppb level. This method has been frequently used in recent years for elemental analysis both in soils (Cetin et al., 2022a, 2022b; Elajail et al., 2022; Istanbullu et al., 2023) and in various organs of plants (Cesur et al., 2022; Ghoma et al., 2023). The data obtained were evaluated with the help of the SPSS 22.0 package program, and analysis of variance and Duncan test were applied to the data. The data obtained were simplified, tabulated, and interpreted.

3. FINDINGS

The variation of Ga concentration in soils depending on soil type and soil depth is given in Table 1.

Table 1. Variation of Ga concentration in soils.

Species	Depth			F	Aver
	Top.	Middle	Bottom		
Abo	23665,75 Aa	28085,88 Aa	34762,50 Ba	7,46**	28838,04 a
Pni	38930	34438,75 b	32553,63 a	1,32 ns	35307,65 b
Psi	33613,00 ab	32670,50 b	32854,19 a	0,14 ns	33045,89 ab
Fo	31681,25 Aab	45956,63 Bc	46868,52 Bb	3,61*	41502,13 c
F	2,97*	27,84***	4,63**		8,31***
Aver	31972,64	35287,94	36759,71	2,01 ns	

When the table values are analyzed, it is seen that the variation of Ga concentration depending on soil depth is statistically significant in Abo and Fo. In both species, the lowest values were obtained in the upper soils and the lowest in the more deficient soils. According to the mean values, the variation of Ga concentration based on soil depth is not statistically significant.

The species-dependent variation of Ga concentration was statistically significant at all soil depths. According to the results of Duncan's test at all soil depths, Abo grown soils were in the first group, and Fo grown soils were in the last group. The mean values indicate that Ga concentration is Abo<Psi<Pni<Fo. The variation of Ga concentration in plants by organ and species is given in Table 2.

Table 2. Variation of Ga concentration in plants.

Species	Organ					F	Aver
	Leaf	Bark	Cones	Wood	Root		
Abo	5822,09 Aba	8080,86 ABC	10051,43 Cb	4962,71 A	9415,02 B	2,76*	7624,83 a
Pni	4727,15 Aa	9134,35 B	8826,40 Bb	4918,03 A	11719,73 B	7,80***	8075,64 a
Psi	8941,51 Cb	7966,73 B	3882,42 Aa	6073,53 A	11382,60 D	14,15***	7746,16 a
Fo	10093,77 Bb	11194,36 B	-	7325,66 A	12797,73 C	7,91**	10024,25 b
F	12,94***	1,72 ns	7,46**	0,94 ns	1,93 ns		3,00*
Aver	7539,23 AB	8996,78 B	7278,66 AB	5884,82 A	11195,23 C	11,78***	

As a result of the analysis of variance, it was determined that the species-dependent variation of Ga concentration in organs was statistically significant only in leaves and cones. According to the mean values, the highest value was obtained in Fo, and the other species were in the same group due to the Duncan test.

The variation of Ga concentration by organ was statistically significant in all species. When the table is examined, it can be said that the lowest values were obtained in wood, and the highest values were obtained in roots in all species. According to the mean values, the lowest values were obtained in wood and the highest in roots and bark.

4. DISCUSSION

As a result of the study, the lowest Ga concentrations in both soils and plant organs were obtained in Abo, and the highest Ga concentrations in Fo. Ga concentration in the subsoils is higher in the soils where these two species grow. The results of the study show that Ga is utilized by plants at different levels. In many studies to date, it has been determined that heavy metal and element concentrations are at different levels both in the organs of different plants (Sevik et al., 2020; Isinkaralar et al., 2022) and in soils where different plants grow (Erdem et al., 2023a, 2023b).

Heavy metals can threaten humans, other living organisms, and the entire ecosystem. Therefore, many studies have been conducted on heavy metals (Key et al., 2022; Kuzmina et al., 2023). However, the studies on the subject have primarily focused on elements such as Pb, Zn, Cd, Mn, Ni, Cr, and Co (Ghoma et al., 2022; Yayla et al., 2022), and Ga has been neglected. However, acute exposure to gallium III chloride can cause throat irritation, breathing difficulties, chest pain, and fumes, which can cause serious problems such as pulmonary edema and partial paralysis. Similarly, exposure to high levels of silver vapor can cause dizziness, breathing difficulties, headaches, or irritability (TÜİK, 2023). Therefore, it is essential to determine the changes in the concentrations of these elements in the environment.

The most critical problem in the studies on this subject is the need for more to equalize environmental conditions. Plant development is shaped by the interaction of genetic structure (Kurz et al., 2023; Yigit et al., 2023; Çobanoğlu et al., 2023) and environmental conditions (Şen et al., 2018; Özel et al., 2022; Tandoğan et al., 2023; Sevik et al., 2019), and many environmental factors are involved in this process (Tekin et al., 2022; Varol et al., 2022). The potential of plants to accumulate heavy metals is related to plant habitat and development. All environmental factors affecting plant growth also jeopardize the possibility of heavy metal accumulation in plants (Cesur et al., 2022; Savas et al., 2022). Therefore, it is recommended that studies on the subject should be carried out in controlled environments or, if this is not possible, in areas where environmental conditions are as similar as possible. This study is essential as an example for future studies on the subject.

Since heavy metals are known to be harmful to the environment and human health, reducing the concentrations of these elements in the environment is important. For this purpose, the use of plants has become widespread in recent years. Plants keep heavy metals in their bodies, remove them from the environment, and clean the environment. Phytoremediation studies with the help of plants have been widely used to reduce heavy metal pollution in soil, water, and air (Bhat et al., 2022; Sharma et al., 2023; Li et al., 2023). However, studies reveal that each plant has different levels of potential to accumulate different heavy metals in their organs (Karacocuk et al., 2022). This study determined that Fo had the highest Ga accumulation potential among the plants subject to the study.

As a result of the study, the highest Ga concentration was obtained in the roots. Heavy metals can enter the plant body from the soil through the roots and air through the leaves and stem parts (Cobanoglu et al., 2023b; Key et al., 2023). Plant roots are the organs that have the most contact and interaction with the soil. Therefore, the highest Ga uptake in the plants subject to the study was from the soil.

5. RECOMMENDATIONS

Heavy metals can be highly threatening to environmental health. Therefore, studies on heavy metals are among the prioritized topics of study. Although there are many studies on heavy metals, the studies are mostly focused on comprimarily known elements such as Pb, Cr, Ni, and Co. However, many elements, such as Ga, V, discussed in this study, threaten human environmental health. Therefore, other heavy metals should be included in the studies on the subject. It may be suggested to prioritize elements such as Sr, As, and Tl, which are dangerous for human health.

The entry of heavy metals into the plant body results from a highly complex mechanism, and it is significant to know more on this subject. The studies should be carried out in controlled environments to overcome the lack of information on this subject. If this is not possible, conducting studies, at least in areas with similar environmental conditions, is recommended. This study may serve as an example for the proposed studies.

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Approaches to Environmental Ethics

Nihan Yılmaz

Hacettepe University, Department of Family and Consumer Sciences, Ankara/TÜRKİYE

***Correspondence**:* nihangursoy@hacettepe.edu.tr

Abstract: Environmental ethics is the study of ethical questions raised by human relationships with the nonhuman environment. Ethical questions are those about what we ought to do, and ethical claims are prescriptive, rather than descriptive or predictive. Knowledge about ecological systems, the state of the world, human psychology, and social institutions is crucial to good ethical reasoning. For example, part of determining whether we ought to reduce our ecological footprint is having good data about ecological limits, lifestyle impacts, and what may occur if lifestyles do not change. However, to get from descriptive and predictive claims to normative or prescriptive claims other things are required—values and principles. Industrialization, urbanization and population growth in the 19th century created a significant pressure on the environment and natural resources, and since the second half of the 20th century, the impact of environmental problems began to be clearly felt. Industrialization, population growth and urbanization have been tried to be placed on the basis of these problems. Although it is possible to explain the concrete causes of environmental problems with three variables, it should be noted that people's perspective, attitudes and values towards the environment constitute the driving force of their actions towards the environment. Questioning the values, attitudes and behaviors that determine human and environmental interaction and trying to determine what is good and right behavior for the environment has led to the emergence and differentiation of environmental ethics approaches.

Keywords: Environment, Ethic, Environmental ethics.

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New Approaches to Determining Carbon Capture Potential

Sümeyye Güler[1], Bülent Turgut[2]✉, Sezgin Ayan[3]

[1]*Kastamonu University, Institute of Science, Sustainable Forestry Doctorate Programme, Kastamonu/TÜRKİYE*
[2]*Karadeniz Technical University, Faculty of Forestry, Department of Forest Soil and Ecology, Trabzon/TÜRKİYE*
[3]*Kastamonu University, Faculty of Forestry, Department of Silviculture, Kastamonu/TÜRKİYE*
✉***Correspondence***: bulentturgut@ktu.edu.tr

Abstract: Climate change and global warming are among the most important environmental issues and require sufficient and urgent global action to protect the Earth for future generations. One of the main approaches used to reduce CO_2 emissions and mitigate the worst impacts of climate change is carbon capture technology. Carbon capture technologies have the potential to capture carbon from the atmosphere and convert it into fuels that can be used in environmentally friendly energy production. Innovative technologies can increase the potential for carbon capture, which can play an important role in combating climate change. A better understanding of the mechanisms that extract, store and release carbon from the atmosphere will allow us to make more accurate predictions for assessing carbon capture potentials. There have been many efforts by scientists, industry sectors and policy makers in the search for new technologies to reduce greenhouse gas emissions and achieve net zero emissions targets. Research and development work to create new technology involves complex processes and requires a digital system to optimize big data forecasting as well as reduce production time. A mathematical and statistical approach such as machine learning plays an important role in solving research problems, providing fast results and cost-effective tools for predicting big data. Effective policies and international cooperation for carbon capture can increase the potential for carbon capture. New policies and cooperation models can incentivize investment in carbon capture projects, which can increase potential. These new approaches can be used to better understand the potential for carbon capture and develop effective solutions to tackle climate change. However, work in this area is still ongoing and more research and development is needed in the future.

Keywords: Carbon capture, Climate change, Machine learning.

1. INTRODUCTION

In ecosystems on earth, living and non-living elements are interconnected by three basic functions such as energy transfer, chemical cycles, and population controls and these three functions constitute the basis for the quantitative functioning of ecosystems (Odum, 1989). Each element in the ecosystem, which has certain functions, is in balance within itself and with other elements. Disruption of this balance leads to disruptions in the functioning of the whole system and may threaten the existence of the system. Carbon (C), which is widely found in nature, is one of the common and basic elements of all living organisms. Carbon, which has high bonding properties compared to many elements, is found both singly and in compounds in nature. Due to its properties, carbon, which is found in living and non-living structures from photosynthesis process to glucose structure, has become an increasingly important environmental component since it has caused global warming in the last century.

The carbon cycle is nature's method of recycling carbon atoms. Plants, the nexus of the carbon biogeochemical cycle in terrestrial ecosystems, play a vital role in the global carbon cycle. Green plants can absorb atmospheric CO_2 through photosynthesis and forests therefore act as a large and permanent carbon sink (Pan et al., 2011). Plants are also the primary pathway for transferring CO_2 to soil through their roots and fallen leaves (Felzer et al., 2005; Sitch et al., 2007; Ainsworth et al., 2012). Meanwhile, carbon flows back into the atmosphere from vegetation through the release of volatile organics from leaves (Guenther et al., 2012) and the release of CO_2 from the decomposition of soil organic matter and plant debris (Krishna & Mohan, 2017; Chen & Chen, 2018). As climate and environmental conditions greatly influence the physiology of plants, there is a growing concern that global warming and changing atmospheric compositions are disrupting the carbon cycle, crop yields and biodiversity (Feng et al., 2019, 2022; Agathokleous et al., 2020; Chaudhry & Sidhu, 2022).

Efforts to achieve post-industrial economic development goals, the use of ecosystem products as free natural capital, and improper land use policies lead to high CO_2 emissions from the terrestrial ecosystem to the atmospheric system.

Carbon dioxide that cannot leave the atmosphere can be trapped in the forest biomass, from the root and stem structures of woody and herbaceous annual and perennial plants on the earth to the leaf and bark contents. For this reason, green wealth is one of the most important sink areas that provide a high rate of absorption of free travelling carbon gas in the world. The sequestered carbon dioxide gases are stored in different ways in the genetic structures of all herbaceous and woody individuals in the forest ecology (Ataf, 2017).

The gradual increase in the rate of CO_2 in the earth's atmosphere causes global (worldwide) climate change and temperature increase together with other gases that cause greenhouse effect. Research on the causes of global climate change has shown that the effect of CO2 on this phenomenon is 55-80% (Asan, 1995). As it is known, all plants produce organic matter by taking CO_2 from the air through photosynthesis and then convert it into other organic matter through a series of chemical reactions. Since CO_2 uptake increases with the number of leaves in plants and forests have the highest number of leaves compared to other plant communities, CO_2 consumption occurs mostly in forests. Due to this fact, the protection of forest areas on earth and their expansion through afforestation is recommended by many researchers as the most effective method to delay global climate change.

Forests, which are the largest sink areas on the globe, are important sources where carbon gases affecting climate changes are sequestered. Thanks to their structural abilities, forest assets with their above- and below-ground components, annual and perennial herbaceous and woody structures provide the absorption of carbon gas travelling freely in the earth. For this reason, it is understood that more carbon gas is sequestered in areas where photosynthesizing organisms are dense (Kahyaoğlu et al., 2019). The forest ecosystem, which contains 76-78% of the carbon gas sequestered in land areas on the globe, is one of the major sink areas that have an important place in the fight against global warming.

Greenhouse gas emissions are causing serious global climate change and CO_2 emissions urgently need to be stopped. Carbon capture and storage is emerging as the last guaranteed technology to reduce carbon emissions and has the potential to be an important option to reduce the greenhouse effect in the future. Machine learning (ML), one of the fastest developing areas of smart technology today, is considered as an important way to realise demand forecasting based on computer science and data statistics.

Nowadays, machine learning is applied to the development of prediction systems using experience, especially in highly complex systems that are difficult to model with deterministic methods (Kubat, 2017). Machine learning provides techniques that can automatically generate computational models directly as a closed-form input-output relationship, based on this available data, and maximize a performance criterion depending on the problem (Bhatnagar, 2020).

Recently, the developed machine learning methods are a promising development direction due to their ability to effectively combine remote sensing products with ground observation data. The data-driven machine learning method can preserve the effective information of remote sensing products and sample observation data, extract the complex non-linear relationship between input and output variables, and achieve the goal of combining different data scales; thus, it has a high degree of flexibility and data adaptability (Ali et al., 2015). Data-driven approaches based on machine learning can extract new knowledge from data, which can provide a new understanding of new mechanisms. Research has also proven that machine learning methods are more successful in predicting ecosystem carbon sinks compared to traditional statistical methods (Wood, 2023). A carbon sink estimation method that uses machine learning as a bridge to combine remote sensing products and ground observation data is an effective solution to reduce estimation uncertainty.

The effects of global climate change are increasing and the increase in greenhouse gas concentrations in the atmosphere is accelerating this process. Therefore, the protection and restoration of ecosystems with high carbon sequestration capacity is of great importance. Forests play a critical role in the Earth's carbon cycle and biodiversity, and therefore determining their carbon sequestration potential is an important research topic. In this study, we will discuss new approaches used in addition to traditional methods to determine the carbon sequestration potential of forests.

2. TRADITIONAL CARBON ESTIMATION METHODS

Traditional carbon sequestration estimation methods are used to predict how carbon will be sequestered in relation to natural resources. These methods use different mathematical models and data analysis techniques to determine the carbon storage capacity of forests, farmland, water systems and other ecosystems. These methods provide an important tool in the design and management of carbon sequestration projects.

The methods commonly used to calculate carbon stocks in forests are common tree inventories and estimation formulae. These methods estimate carbon values using parameters such as tree diameter, height, and density.

Traditional carbon sequestration estimation methods are used in the development of ecosystem-based strategies to reduce carbon emissions. These methods suggest various interventions including crop rotations of forests and sustainable agricultural practices of soils. They also promote the conservation and restoration of ecosystems with high carbon storage potential. However, these methods have some limitations and often face difficulties in providing sufficient accuracy. Mathematical models need to be based on sufficient data for specific ecosystems. This lack of data can reduce the accuracy of predictions and create uncertainty about the effectiveness of projects. Furthermore, climate changes can also be difficult to predict, which can affect the reliability of predictions.

3. NEW APPROACHES AND TECHNOLOGIES

In recent years, developing technologies and advanced analysis methods have led to the emergence of new approaches to determine the carbon sequestration potential of forests.

3.1. Remote Sensing Methods

Remote sensing methods are frequently used to determine the carbon sequestration potential of forests. Remote sensing is a technique for determining the properties of objects using data collected through remote sensors and instruments. Remote sensing techniques can be used to estimate the carbon stock in forest cover through aerial and satellite imaging systems. High resolution satellite data allow the development of models that determine the relationships between plant biomass and carbon stock. Furthermore, the use of artificial intelligence algorithms and computer vision analyses increases the potential to automatically identify trees and estimate carbon stocks.

The most widely used technique in remote sensing methods is, roughly speaking, the analysis of remote images of the earth. In this analysis, some important data are used to determine the carbon sequestration potential of forests. For example, parameters such as vegetation density, leaf area index and chlorophyll content are used to provide information on the carbon sequestration capacity of forests.

In previous studies, valuable information on the biological characteristics and carbon stocks of forests has been obtained using remote sensing methods such as satellite images and aerial photographs. The colour in satellite images is used to obtain spectral data to determine parameters such as photosynthetically active radiation of vegetation and vegetation density. In addition, mapping of parameters such as climate data, soil properties and vegetation structure used to estimate the carbon sequestration capacity of forests is also carried out by remote sensing methods.

Remote sensing methods are very valuable tools to determine the carbon sequestration potential of forests. These methods provide more information about the ecosystem services of forests and their role in combating climate change and contribute to the sustainable management of forests. Therefore, the use of remote sensing methods to determine the carbon sequestration potential of forests is an important research area.

3.2. Artificial Intelligence

Determining the carbon sequestration potential of natural forests is of great importance in combating climate change and is a research area of activity among forestry experts. In this field, artificial intelligence methods have emerged as advanced analytical tools used to determine the carbon sequestration potential of natural forest ecosystems. Artificial intelligence methods are used to perform several complex operations such as analyzing large data sets, identifying carbon sequestration characteristics, and estimating the emissions of forest ecosystems.

Machine learning, an artificial intelligence method, plays an important role in determining the carbon sequestration potential of natural forests. Machine learning methods analyse large data sets to identify factors associated with carbon sequestration and use these factors to estimate the carbon sequestration potential of forest ecosystems. These methods use learning algorithms to identify plant species and other ecosystem components in the forest and estimate their carbon sequestration capacity.

3.3. Machine Learning (ML) Methods

3.3.1. Decision tree (DT)

Decision Tree algorithm is one of the data mining techniques, also known as decision trees. Decision Tree refers to a tree structure that makes meaningful decisions using a given data set. This algorithm works by dividing the dataset into small subsets and applying classification methods on each subset.

Decision tree structure:

Decision Tree has a structure consisting of many inner nodes and leaf nodes. Each internal node represents a decision point, while each leaf node represents a classification. Decision points are determined based on the characteristics of the dataset and partitioning operations are performed at each level. In this way, the decision tree divides the dataset into smaller subsets and performs more detailed classifications on each subset (Figure 1).

How the algorithm works:

To create a Decision Tree, training data is needed first. Training data refers to the features or attributes associated with a particular target variable (class). The algorithm is used to classify an unknown data sample, taking these features into account. The decision tree building process includes the steps of partitioning the dataset according to the best indivisibility criteria, selecting the most effective decision node and building the structure of the tree, respectively. These steps are important for the correct classification of the dataset.

Decision Tree is a machine learning algorithm and can be used in many different fields. Carbon estimation is one of these areas.

Carbon forecasting aims to estimate the carbon emissions of an organization or a country. Decision Tree is a tree structure consisting of interconnected "decision" nodes used to estimate this carbon emission.

The use of Decision Tree in carbon forecasting can be highly effective for extracting insights from complex data structures and predicting trends. Since there are many factors affecting carbon emissions, the Decision Tree algorithm can analyses these factors and make predictions about how carbon emissions may be in the future.

As a result, the use of Decision Tree in carbon forecasting can be an effective tool for environmental sustainability and carbon emission management. However, it is important to consider factors such as data quality and accuracy of the model.

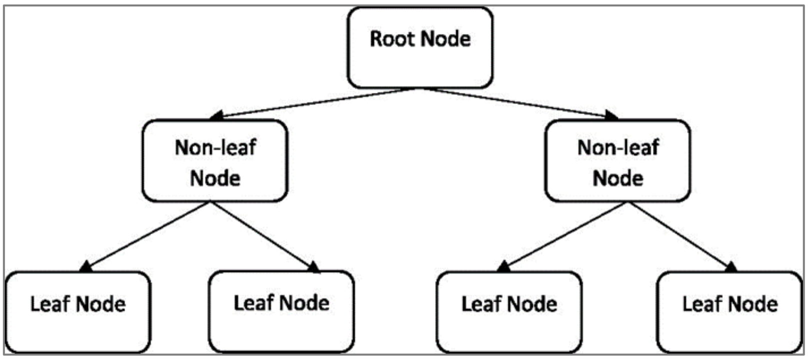

Figure 1. Decision tree layout.

3.3.2. Random forest (RF)

Random Forest is a flexible, easy-to-use machine learning algorithm that often produces a large result, even without hyperparameterisation. It is also one of the most widely used algorithms because of its simplicity and because it can be used for both classification and regression tasks. In recent years, the development and popularity of machine learning methods has led to many methods that can provide benefits in modelling. However, only a few of them have been preferred or proposed by researchers. Among these methods, discriminant analysis (DA), logistic regression analysis (LR), generalized additive model (GAM), classification and regression tree technique (CART), maximum entropy approach (MAXENT), genetic algorithms for rule set prediction (GARP) and random forest (RF) are the most common ones. Among the mentioned methods, except RF, the others have been frequently used until recent years, while RF method has started to be preferred more frequently especially with the widespread use of R programmed (Austin, 2007; Özkan et al., 2015; Beaumont et al., 2016, Mert et al., 2016).

Operation of random forest algorithm:

Before understanding how random forest works, we should look at the ensemble technique. Ensemble simply means combining multiple models. Therefore, a collection of models is used to make predictions rather than a single model.

Enseble uses two types of methods:

a) Bagging: Creates a training subset different from the sample training data with replacement and the final output is based on majority voting. For example, Random Forest.

b) Boosting: Combines weak learners into strong learners by building sequential models such that the final model has the highest accuracy. For example, ADA BOOST, XG BOOST

Bagging: Bagging, also known as Bootstrap Aggregation, is the enseble technique used by random forest. Bagging randomly selects a sample from the data set. Therefore, each model is generated from the samples provided by the Original Data (Bootstrap Samples) by substitution, known as row sampling. This step of row sampling with replacement is called bootstrap. Each model is now trained independently, which produces results. The final output is based on majority voting after the results of all models are combined. This step, which involves combining all results and producing output based on majority voting, is known as aggregation (Figure 2).

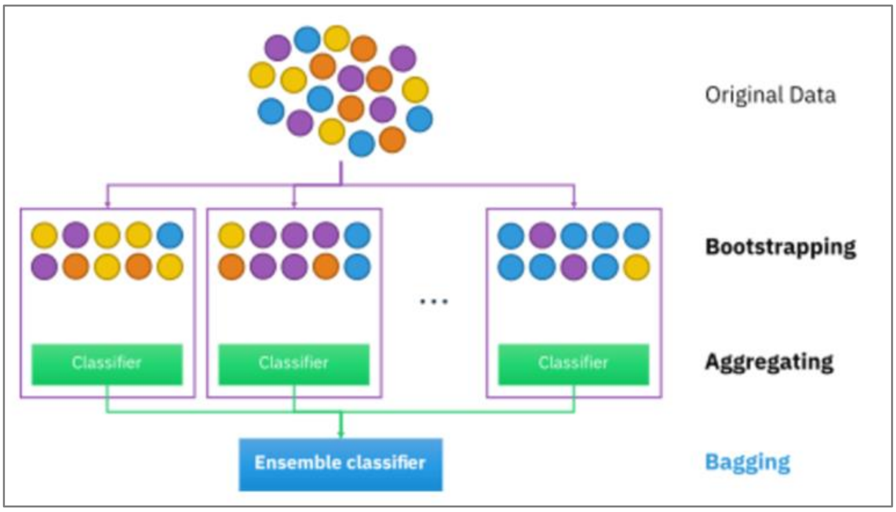

Figure 2. Bagging technique.

Steps in the random forest algorithm:

Step 1: Random Forest n random records are taken from the dataset with k records.

Step 2: Separate decision trees are created for each sample.

Step 3: Each decision tree will produce an output.

Step 4: The final output is evaluated based on majority vote or average for classification and regression respectively (Figure 3).

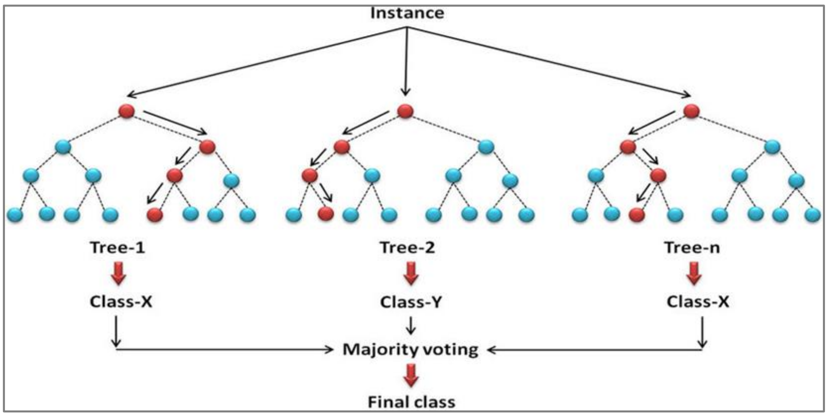

Figure 3. Random Forest algorithm setup.

Random Forest is a machine learning algorithm that can be used in carbon forecasting. In carbon forecasting, a set of measurements, such as carbon emissions in the atmosphere, need to be correlated with environmental and climatic factors.

The Random Forest algorithm is an ensemble model consisting of many trees, and each tree is trained on random subsets of the data set. To estimate carbon, this algorithm is used to build a model that considers various environmental factors such as soil type, vegetation cover, climate data as well as previous carbon measurements.

The Random Forest model learns a relationship that determines the effects of these different factors on carbon levels. Then, when you give new data as input to the modelling, the Random Forest model can estimate carbon based on this input.

In this way, the Random Forest algorithm can create a carbon prediction model that considers complex environmental and climatic influences. This model can be used for many different purposes, such as estimating carbon emissions, monitoring carbon emissions, or evaluating policies related to climate change.

Difference between decision trees and random forest:

- In the random forest algorithm, the process of finding the root node and dividing the nodes is random.
- As the number of trees increases, the rate of obtaining a precise result increase.
- The random forest algorithm reduces the problem of overlearning if there are enough trees. It requires little data preparation (Figure 4).

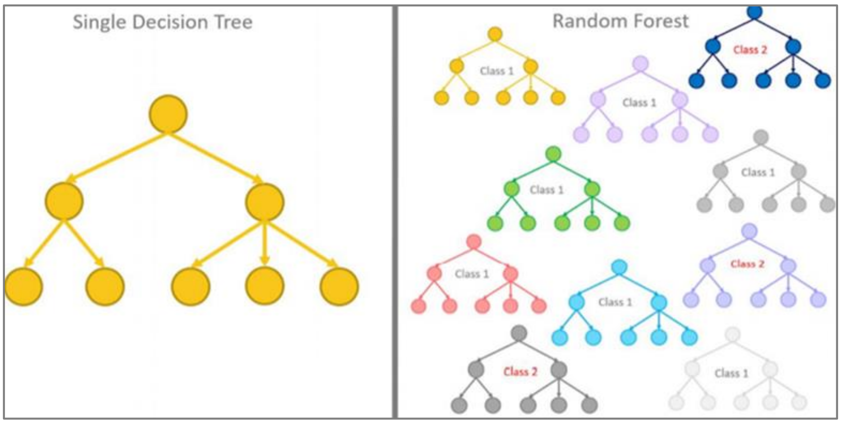

Figure 4. Decision tree and random forest difference.

3.3.3. Artificial neural networks (ANN)

Artificial neural networks (ANN), one of the most preferred models in big data, is a type of technology created by imitating the biological nervous system. ANN can be considered as a collection of systems in which neurons transmit messages between each other.

A simple neural network consists of interconnected artificial neurons. Mimicking the principle of the human brain, each neuron receives various inputs to combine them, process them and eventually produce an output. (Figure 5) ANNs are very powerful and popular tools in data mining and business analytics. Since ANNs are applicable to prediction, classification and clustering and are used in a wide variety of industries, they have proven to be useful. The most important feature of ANNs compared to other algorithms is their ability to learn highly complex relationships in data (Gaur, 2012).

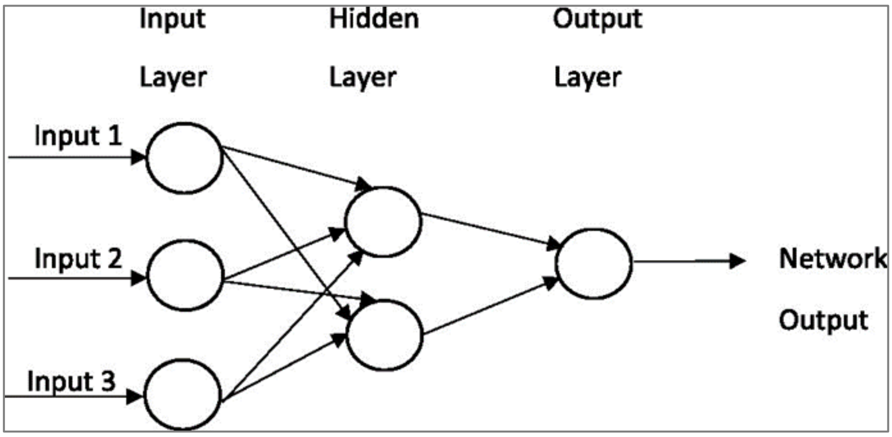

Figure 5. Neural network architecture.

The prediction phase of neural networks has two phases: training and learning. In the training phase, the network is trained using historical data containing information about the input and output. After the training phase, the model is subjected to learning on test data. In this phase, the network travels between input and output to update the weights and errors. In general, the learning phase can be considered as an optimization process and hence this minimization process continues until an acceptable error level is reached.

Artificial neural networks (ANN) are another artificial intelligence method used to determine carbon sequestration potential. Artificial neural networks can be used effectively in carbon estimation thanks to their ability to analyze complex data sets (Tsai & Kuo, 2013). These networks improve the ability to predict carbon emissions by learning based on training data sets with many input parameters. This method models the complex relationships related to the carbon cycles of forest ecosystems and estimates the carbon sequestration potential of forests.

3.3.4 Convolutional neural networks (CNN)

Convolutional neural networks are an artificial neural network model used to perform high-performance processing on images and visual data and to solve computer vision problems with deep learning algorithms. Therefore, it can also be used in solving some environmental or climatic problems such as carbon estimation (Figure 6).

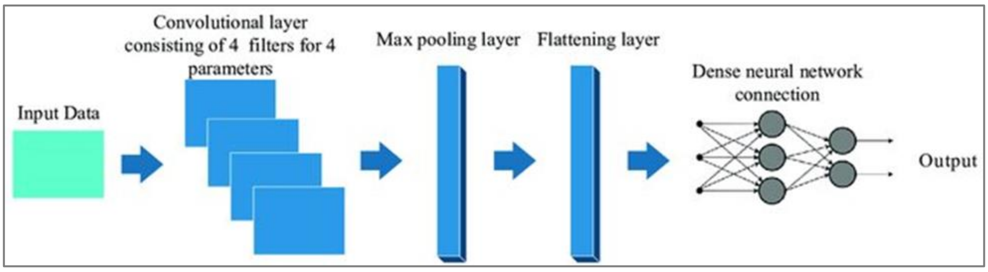

Figure 6. Convectional neural network structure.

When trained on environmental data sets, convectional neural networks can analyse images of various parameters affecting CO_2 emission and find patterns to predict these parameters. For example, factors such as the settlement of forests, agricultural areas, power plants, industrial plants, and vehicle traffic affect CO_2 emissions. CNNs can extract patterns to predict future carbon emissions by analyzing images of these factors and using previous carbon emission data.

However, the accuracy and reliability of such predictions depend on the quality and diversity of the data sets used, the training process of the model and other factors. In an important topic such as carbon prediction, it can be combined with other methods or combined with various machine learning techniques to improve accuracy.

4. CONCLUSION

Forests play an important role in combating global climate change, and understanding carbon cycles, identifying, and monitoring their carbon sequestration potential is fundamental to this endeavor. In addition to traditional methods, new approaches are increasingly being used to determine the carbon sequestration potential of forests. Technologies such as remote sensing and artificial intelligence have great potential in the processes of estimating and monitoring the carbon stock of forests.

Remote sensing methods are an important tool in determining the structure and dynamics of forest ecosystems and estimating their carbon sequestration potential. Therefore, the use of remote sensing methods should be encouraged for the assessment and conservation of carbon stocks in forests.

In conclusion, artificial intelligence methods in the field of forestry play an important role in the process of determining the carbon sequestration potential of natural forests. Methods such as machine learning, artificial neural networks and genetic algorithms are used in data analysis and modelling processes to estimate the carbon sequestration capacity of forest ecosystems. These advanced analytical tools are recognized as an important tool in combating climate change and developing sustainable forestry practices.

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Some Dendrological Phenomena in Mavrovo National Park, North Macedonia

Bojan Simovski✉, Jane Acevski

Ss. Cyril and Methodius University in Skopje, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering, Skopje/NORTH MACEDONIA

✉***Correspondence**:* bsimovski@sf.ukim.edu.mk

Abstract: This research relates to occurrence of some morphological and ecological features of native woody plants in Mavrovo National Park situated in north-western Republic of North Macedonia on an area of about 73,000 ha. The Park represents more than 45% of the dendroflora and nearly 19% of the forest communities in the country. The observations were done during the past fifteen years covering different aspects of both individual and social life of the dendroflora, and various ecological conditions. In this context, dozen dendrological phenomena were found to be important to note. Namely, very old individual trees of the Balkan endemic species and Arcto-Tertiary relic of horse chestnut (*Aesculus hippocastanum*) thriving as riparian population were found; old European hop-hornbeam (*Ostrya carpinifolia*) individuals on remote sites; old Austrian pine (*Pinus nigra*), and sycamore (*Acer pseudoplatanus*) trees; old groves of common ash (*Fraxinus excelsior*), and of Austrian pine; firs (*Abies borisii-regis* and *A. alba*) with form of smooth or rough bark and aggressive territorial expansion on thermo-mesophilic sites. European beech (*Fagus sylvatica*) with oak-bark form ('quercoides') also was found. Furthermore, the occurrence of the hemiparasite juniper dwarf mistletoe (*Arceuthobium oxycedri*) on savin juniper (*Juniperus sabina*) was identified. In addition, finding site of *Cotoneaster parnassicus* was found. A few phenomena were observed concerning the spruce-fir forest community (ass. *Abieti-Piceetum scardicum*): dieback of Norway spruce individuals (*Picea abies*), emergence of Balkan pine (*Pinus peuce*) initial population in the vicinity and presence of barberry (*Berberis vulgaris*) as steppe floral element together with expressed mesophilic species.

Keywords: Woody species, Phenomena, Mavrovo.

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An Analysis on the Impact of Spatial Structure Factors on Travel Behavior in Tabriz City with a Low Carbon City Approach

Rasoul Ghorbani✉, Rahim Golamhossaini, Somayeh Alizadeh
University of Tabriz, Faculty of Planning and Environmental Sciences, Tabriz/IRAN
✉***Correspondence***: rghorbani@tabrizu.ac.ir

Abstract: With the growth of the city population and the intensity of human activities in them, air pollution in cities has become one of the major issues in urban development, which affects both the quality of life of city residents and the global environment by affecting global warming. This has made the reduction of carbon production in cities an important issue at the global level and has led to the development and expansion of the low-carbon city approach at the global level. The purpose of this article is to study the relationship between the spatial structure of the city and the travel behavior of Tabriz residents and its role in reducing carbon production. In order to achieve this goal, in this article, the effects of spatial structure components of Tabriz city on travel behavior have been investigated. Two Moran models and geographic weighted regression method have been used to set and process the research data. The results of Moran's model show that Moran's index reaches its highest value in the variable of access to bus stations and metro stations, and has the lowest value in the indicators of the mix land uses and access to the commercial center of the city. These two variables mostly have a random pattern and their spatial autocorrelation is very weak, and the distribution pattern of the mentioned variable generally has spatial clustering. Also, the results of the geographic weighted regression method show that the two factors of the mix land use and access to commercial centers have the highest correlation with the use of cars for travel (R2=4.04) and access to metro stations in Tabriz metropolis due to the low expansion of metro routes. It has a small effect on traveling by car (R2=4.20). Based on research findings; With the balanced distribution of commercial cores at the level of urban neighborhoods and the appropriate mix of land uses, city managers can greatly reduce car travel and increase the use of bicycles and pedestrians at the level of neighborhoods and urban areas for traveling. Also, by improving the level of public transportation services, the dependence on cars for city trips in Tabriz will be reduced. thus, the amount of carbon production will be reduced in city of Tabriz.

Keywords: Low carbon city, Travel behavior, Tabriz city.

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Changes in Forest Biomass Carbon Storage Between 1971 and 2018 in Tonya

Süleyman Borucu[1], Uzay Karahalil[2]✉

[1]Karadeniz Technical University, Faculty of Forestry, Trabzon/TÜRKİYE

[2]General Directorate of Forestry, Chief of Şenyuva Planning Unit, Pazar, Rize/TÜRKİYE

✉***Correspondence****:* uzay@ktu.edu.tr

Abstract: Climate change is seen as one of the most common problems of the world today. Countries, organizations are making extraordinary efforts to reduce the negative effects of this phenomenon. Forests are accepted as the biggest mechanism with the advantage of storing large quantities of carbon as well as having the opportunity to increase their carbon content through increasing the size, apply rehabilitation in the degraded stands, or doing interventions. Therefore, monitoring the forests, taking measures and applying forestry activities when needed is utmost important. In this regard, temporal monitoring of the amount of carbon in forest biomass offers advantages as it is easy to implement and understand. In this study, forest biomass carbon was displayed for Tonya Planning Unit (PU), works under Trabzon Forest Enterprise for the periods between 1971 and 2018, meaning nearly half century. Tonya PU is covering a total area of 12,532.3 ha, of which 5620.7 ha (44.8%) is forested landscape. The vegetation type is primarily composed of Oriental Spruce (*Picea orientalis* Link), Oriental Beech (*Fagus orientalis* Lipsky) and Alder (*Alnus glutinosa sub. barbata* Mey). There is also certain amount of Anatolian Chestnut (*Castanea sativa* Mill.), and Hornbeam (*Carpinus orientalis*) dominated stands. Tree specific biomass expansion factors were used in the calculation of above and belowground biomass carbon content. In addition to determining the amount of total carbon, the outputs were handled in the context of forest dynamics represented by temporal changes of land cover. Quantitative evidence showed that there were drastic changes of carbon storage in above and below ground forest ecosystems between two periods.

Keywords: Forest biomass, Biomass expansion factors, Carbon storage, Temporal change, Tonya.

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Some Features of Climate Change in the Coastal Zone of Adjara

Guguli Dumbadze✉, Davit Baratashvili, Khatuna Chichileishvili, Tsıra Kamadadze
Batumi Shota Rustaveli State University, Batum/GEORGIA
✉***Correspondence**:* dumbadze.guguli@bsu.edu.ge

Abstract: Ajara stands out among Georgia's other regions due to its unique physical and geographical conditions. The strong humid subtropical climate, beginning with seaside beaches and swampy lowlands and ending with Alpine meadows - a set of diverse landscapes, rich water, and forest resources, almost evenly distributed resorts and other resort-related places throughout the entire territory of the region - the wealth concentrated in a relatively small area resulting in a growing interest in the economy and natural ecosystems of Ajara. It is crucial to investigate the dynamics of climatic parameters in the Adjara region. The dynamics of air temperature and sea level changes from 1956 to 2015 were analyzed at a distance to assess the level of climate change in the Adjara region. The study was based on observation data from the National Environment Agency and weather stations operating on the Black Sea coast in the past and present. Long-term meteorological data processing was analyzed statistically, climatologically, and graphically to determine climatic changes. As a result of the research, it was discovered that the air temperature in the Ajara coastal area fluctuates dramatically against the backdrop of global climate change, with noticeable warming and cooling periods. The average annual temperature in Adjara's coastal zone (Batumi and Kobuleti) is 14.65 °C/30 years (1986-2015). Batumi's 30-year average temperature is 0.5 degrees Celsius higher than Kobuleti's. When temperatures on the Adjara coast were compared over two thirty-year periods (1956-1985 and 1986-2015), it was discovered that they increased by 0.49-0.69 °C/60 years, while sea level increased by 235 mm/60 years.

Keywords: Climate change, Batumi, Black Sea, Temperature, Sea level.

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Assisted Migration of *Pinus brutia* in Türkiye: A Potential Tool for Sustaining Growth in the Face of Climate Change

Fatih Temel

Artvin Çoruh University, Faculty of Forestry, Artvin/TÜRKİYE

***Correspondence**:* ftemel@artvin.edu.tr

Abstract: Forest tree populations deal with climate change either by increasing frequency of alleles contributing to adaptation to new conditions through natural selection or by migrating to places where they can establish and survive. In order for either mechanism to work, changes in allele frequencies or rate of migration should be able to keep up with the rate of climatic changes. For most forest tree populations, however, rate of climate change is faster than their genetic adaptation or migration rates. One potential solution to this problem is human assisted migration of forest tree species and involves moving forest tree species or seed sources of a forest tree species into areas where they would be better adapted to future climatic conditions than the local species or seed source. *Pinus brutia* is the most important forest tree species in Türkiye, covering 5.1 million ha (23% of total forests), and accounting for 9.3 million m^3 (34%) of annual timber production. Over 50 million *P. brutia* seedlings are produced annually (~20% of total forest tree seedling production). Current seed transfer is based on the country's six current seed zones, developed in the absence of provenance test data, are based on relative humidity during the vegetation period, and are partitioned into two to six sub-zones within each main zone (22 in total) on the basis of the length of vegetation period. Most of the *P. brutia* range in Türkiye is located in places where the effects of climate change are prominent. In 1988, a comprehensive provenance testing program was initiated where 50 *P. brutia* populations from Türkiye and Northern Cyprus were tested on 26 sites in Türkiye and Northern Cyprus. Trees in these tests were measured for survival, growth and form at ages three, five, 10 and 20. We used population mean growth data from these provenance tests to develop transfer functions from which safe seed transfer distances were calculated. On average, DBH at age 20 (DBH20) had the strongest relationship with the transfer distances. For each site, growth relative to local population was calculated and plotted across all climatic transfer distances for all sites. Transfer distances for summer precipitation (PPT_sm), mean warmest month temperature (MWMT) and annual heat moisture index (AHM) were found to have significant relationship with DBH20. *P. brutia* seed sources can be transferred within 105 mm PPT_sm, 10 °C MWMT and 36 units AHM without sacrificing volume growth more than 5% compared to that of local seed source. Provenance test data can be used to determine suitable seed sources for a given plantation site for different future climatic condition scenarios. This approach can help sustaining growth in *P. brutia* plantations in the face of climate change.

Keywords: *Pinus brutia*, Seed transfer, Assisted migration, Climate change, Adaptation.

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Suggestions on Preventing Deforestation and Erosion due to Global Climate Change in Türkiye

Ercan Oktan[1✉], Aysen Kalender[2]

[1]*Karadeniz Technical University, Faculty of Forestry, Trabzon/TÜRKİYE*

[2]*Çukurova University, Department of Forestry and Forest Products, Adana/TÜRKİYE*

✉***Correspondence****:* oktan@ktu.edu.tr

Abstract: The rapid increase in the world's population from the past to the present has led to an increase in the demand for natural resources, resulting in the deterioration of the forest ecosystem and the emergence of many problems such as global warming. During this period, the changes brought by the industrial revolution have caused an increase in the amount of carbon dioxide (CO_2) released into the atmosphere by adversely affecting the ecological balance. The role of forest ecosystems will increase in order to eliminate the negativities caused by the continuous increase in the amount of carbon dioxide (CO_2) in the atmosphere and climate change. Within terrestrial ecosystems, soil and vegetation hold and store carbon. Forests, meadows, pastures and agricultural areas constitute the part kept in vegetation. Some of the most important factors affecting the amount and duration of carbon sequestered in terrestrial ecosystems are climate, vegetation type, soil properties, erosion, bedrock and land use changes. As a matter of fact, these changes in land use have triggered desertification, dryness and erosion along with soil losses. In particular, soils transported by erosion are a great loss for nature and cause disruption of the ecological balance. Therefore, in order to maintain this balance, the natural species in the region should be protected and a forest ecosystem consisting of natural species should be created. In this case, we need to understand forest ecosystems very well and to correctly identify the silvicultural interventions that can be applied. In this study, it was aimed to create a road map for silvicultural interventions that can be applied by evaluating carbon losses in areas where desertification, drought and erosion occur in Türkiye. In addition, in line with this road map, general recommendations that are thought to be useful in preventing and combating carbon losses are given.

Keywords: Carbon sequestration, Carbon storage, Erosion, Desertification, Drought, Forest ecosystem, Silviculture.

1. INTRODUCTION

Soil, which constitutes the top and thinnest layer of the earth's surface (Mutlu et al., 2021), is used by humans as production material. In fact, soil is defined as a dynamic entity in terrestrial ecosystems that contains a wide range of living organisms, contains a certain amount of water and air, lives and sustains (Celilov & Dengiz, 2019; Ünal, 2011). In particular, soil is one of the most important carbon sequestrators of terrestrial ecosystems. The largest reserves of terrestrial carbon are found in soil. Therefore, organic carbon is stored under the soil for a long time (Yılmaz & Dengiz, 2021). However, soil is constantly undergoing erosion, transportation and accumulation processes under the influence of different edaphic and ecological conditions (Yalçınkaya et al., 2022; Görcelioğlu, 1976). The situations in which these processes occur are defined as erosion (Karaoğlu, 2016). As a matter of fact, erosion is the phenomenon of transportation and accumulation of soil particles to another place by natural factors such as water and wind (Issaka & Ashraf, 2017; Aykır & Fıçıcı, 2022).

Erosion is increasing as a result of factors such as destruction of natural vegetation, industrialization, urbanization, improper land use, climate change and overuse of pastures (Ikiel et al., 2020). In addition, the rapidly increasing human population in recent years has deteriorated the quality and natural regulatory properties of soil, water and air resources. This situation causes land degradation and desertification in nature, which has a dynamic and complex structure (Dengiz et al., 2023). Desertification is defined as land degradation that causes almost irreversible loss of biological productivity in arid and semi-arid regions (Mutlu et al., 2013; ÇEM, 2013a). Drought, on the other hand, is a natural phenomenon in which significant hydrological imbalances occur when precipitation is below normal levels and/or irregular, and consequently the natural productivity of land is adversely affected.

Türkiye's topographical structure, climate, geographical location, soil characteristics, erosion and changes in land use affect the amount and duration of carbon. Especially with the effect of climate change, the ecological balance is adversely affected and the amount of carbon dioxide released into the atmosphere increases. The role of forest ecosystems will increase in order to eliminate the negativities caused by the continuous increase in the amount of carbon dioxide (CO_2) in the atmosphere and climate change. One of the most effective ways to prevent these negativities is to ensure that carbon remains in the "soil". Combating desertification, halting biodiversity loss and stabilizing land degradation are considered as critical steps for carbon to be stored in the soil.

Türkiye, which is located in an arid and semi-arid climate zone and faces serious desertification and erosion problems, should determine comprehensive policies and strategies on soil conservation, development of soil resources, combating desertification and erosion, avalanche and landslide control, afforestation, elimination of salinization, and implement them with a large number of projects. This study aims to create a road map for silvicultural interventions that can be applied by evaluating carbon losses in areas where desertification, drought and erosion occur in Türkiye.

2. EROSION PREVENTION STUDIES IN TÜRKİYE

Türkiye is one of the countries in the world where the severity of erosion is high (Balabanlı et al., 2005). The most important reason for this is that it has high and rugged terrain in terms of landforms (Hatipoğlu, 2020; Tunç & Schröder, 2010). Especially with the increase in anthropogenic impacts, the severity of erosion increases. Erosion severity is directly proportional to the slope of the land (Özşahin, 2011; Kanar & Dengiz, 2015; Aykır & Fıçıcı, 2022).

With erosion, the organic matter in the soil is transported (Cebel & Akgül, 2011). As a result, soil fertility decreases. The lifespan of dams is shortened with the transported soil, floods and overflows occur. For this reason, erosion control measures should be taken against erosion problems. In Türkiye, a number of measures have been taken since 1946 to protect soil fertility and prevent erosion (ÇEM, 2013b). These are;

•Afforestation and erosion control works

•Rehabilitation of degraded forest areas

•Rehabilitation of pasture areas.

Until the end of 2012, afforestation activities were carried out on 1,070,435 hectares for erosion control in Türkiye. In addition, afforestation works have been carried out on 2 million 420 thousand hectares of land through watershed rehabilitation projects, increasing forest areas and erosion control works carried out in recent years (ÇEM, 2013b).

However, some institutions and organizations in Türkiye have carried out successful studies on erosion prevention. Today, these efforts have prevented erosion, but artificial forests have been established because plant species suitable for the existing ecosystem were not selected (ÇEM, 2005). These are:

•Windbreaks in Konya Karapınar region (Figure 1)

•Watershed Rehabilitation Studies in Eastern Anatolia Region

•Adana Akyatan-Ağyatan Dune Afforestation Works (Figure 2).

The most important erosion study carried out in Türkiye is the Wind Erosion Risk Assessment study in Konya and Karapınar district with the Renewed Wind Erosion Equation at Regional Scale (YREE/RWEQ) supported by TÜBİTAK (Erpul et al. 2012). The importance of this study is that it is the first systematic regional wind erosion study conducted in our country. The findings obtained from this study have provided extremely important data and approaches for basin and regional scale erosion studies.

Figure 1. Konya Karapınar Dune afforestation area (Çat, 2021).

Figure 2. Adana Akyatan Dune afforestation area (T. C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, n.d.).

The General Directorate of Forestry carried out a study in the Adana Akyatan sand dune area starting in 1972 and ending in 1985. First of all, non-living windbreaks (reed, oleander, myrtle plants) were created to prevent wind erosion. After the dunes were stabilized, Cypriot acacia was planted in the area, eucalyptus, pistachio pine, coastal pine, and individually mountain cypress and acacia were planted on the plains called warehouses. As a result, wind erosion was prevented and a productive forest plant was established (T.C. Orman Genel Müdürlüğü, n.d.).

Yılmaz and Gül (2012) stated that natural pasture areas should be reclaimed in his study conducted in Çankırı region. He suggested the use of plant species suitable for the region within the scope of reclamation measures. In order for these areas to be used as pasture, he suggested that they should be reclaimed from species belonging to the families Wheataceae (Gramineae), Leguminosae (Leguminosae), Chenopodiace, Compositae, Solanaceae, Euphorbiaceae, Scrophulariaceae.

In the study conducted by Göktürk et al. (2004) in Artvin-Çoruh Valley, soil erosion has reached serious dimensions. In order to ensure the continuity of soil and vegetation cover, afforestation works on an average of 380.8 ha and erosion control works on 1009.2 ha were planned between 1992-2003. As a result of the study, 35.4% and 104.5% of these were realized.

In his study, Pekal (2009) evaluated the afforestation activities carried out for erosion control purposes in Sümbüllü and Salkımlı regions in the Çoruh valley of Artvin Province. In Salkımlı and Sümbüllü regions, experimental studies were carried out in the planting of pistachio pine seedlings (1+0 years old), Taurus cedar seedlings (1+0 years old) and bare-rooted false acacia seedlings (1+0 years old). As a result of the study, it was envisaged to use species such as oak, hawthorn, blackthorn, cotoneaster and wigwam, which grow naturally in the Artvin region, in the afforestations where erosion control is carried out.

Yalçınkaya et al. (2022) carried out an erosion control study with afforestation in the Atatürk Dam basin. In 2053.93 ha area, the afforestation area was given protection status. Within the scope of afforestation, ground cover plants were used as well as pine species. As a result of the study, they determined that ground cover plants should not be used due to possible forest fires and single species plantations should be included.

Kaba (2019) evaluated 431,200 false acacia saplings, 94,860 common birch saplings, 65,370 spindle saplings and 157,300 yellow pine saplings planted between 2012-2014 in the afforestation study conducted for erosion control in Ağrı Province. As a result of the evaluation, he stated that the use of species such as rosehip, hawthorn, maple, poplar and willow in afforestation works for erosion control will ensure the continuity of the genetic diversity and populations of these species.

3. DESERTIFICATION AND DROUGHT PREVENTION STUDIES IN TÜRKİYE

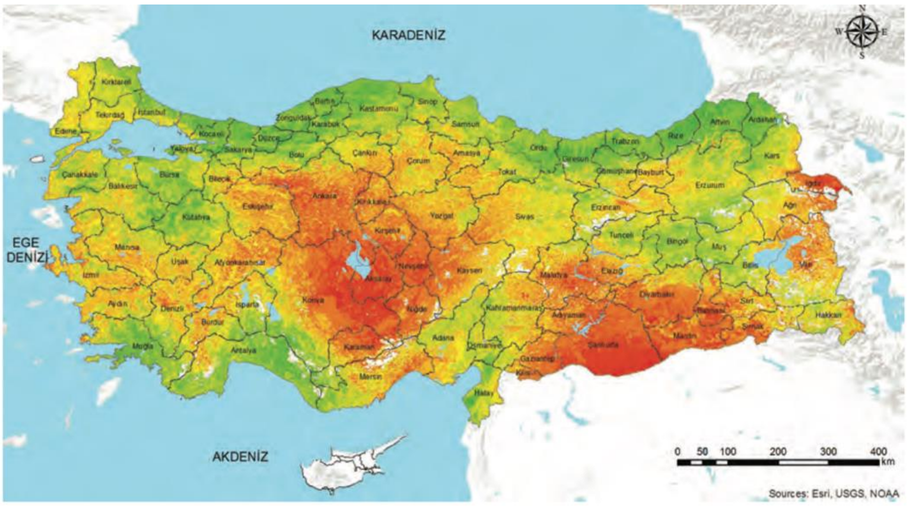
Türkiye's geographical location, topography, climate and soil conditions increase the impact of drought and desertification. Drought and desertification, especially with the impact of climate change, is one of the most important global and regional environmental issues that must be taken seriously (Türkeş, 2012a). The damages caused by the factors that constitute desertification are not seen in our country. However, in Türkiye, situations such as desertification in agricultural lands, degradation of species diversity in forest areas, wrong land uses, destruction of pasture areas will increase the risk of desertification and drought with the effect of climate change. In this context, many local, regional, national and international studies are being carried out in Türkiye to combat desertification and mitigate the effects of drought.

In his study, Türkeş (2012b) made evaluations and recommendations according to Türkiye's tendency to be affected by desertification and drought. These recommendations are

- Türkiye has insufficient water resources in terms of its climate characteristics. For this reason, he emphasized that water policies should be established to increase water resources in order to prevent drought.
- The impact of aridification should be reduced by preventing forest fires.
- Water resources in Türkiye and their potential impacts on drought and desertification should be continuously monitored and evaluated.
- Considering that forests are carbon sinks, the principle of sustainable forestry should be adopted.

Gül et al. (2019) carried out afforestation works to prevent desertification in arid and semi-arid areas. In the study area, the desertification risk ranged between 1.69 (low risk) and 4.87 (medium risk) in the parts where afforestation works were carried out between 1998-2008, and between 2.07 (low risk) and 5.25 (medium risk) in the parts where afforestation works were carried out between 2009-2015. As a result of the study, it was stated that desertification risk values will be minimized by protecting and increasing herbaceous and woody plants.

In order to monitor desertification, the Ministry of Forestry and Water Affairs and the General Directorate of Combating Desertification and Erosion (GDEM) developed the Basin Monitoring and Evaluation System (HDIS). With this system, a GIS-based desertification model was created and Türkiye Desertification Risk Map was made (Dengiz & Oztas, 2020) (Figure 3).



Hassasiyet Sınıfı	Sınıf	Sınıf Aralığı	Tanımı	%	Hassasiyet Sınıfı	Sınıf	Sınıf Aralığı	Tanımı	%	Hassasiyet Sınıfı	Sınıf	Sınıf Aralığı	Tanımı	%
ZAYIF	1	1,00-1,27	Düşük	0,2	ORTA	1	1,41-1,45	Düşük	17,0	YÜKSEK	1	1,55-1,60	Düşük	15,7
	2	1,28-1,34	Orta	5,1		2	1,46-1,48	Orta	12,3		2	1,61-1,67	Orta	6,5
	3	1,35-1,40	Yüksek	12,7		3	1,49-1,54	Yüksek	21,6		3	1,68-2,00	Yüksek	0,3
			Toplam	18				Toplam	50,9				Toplam	22,5

Figure 3. Desertification Risk Map of Türkiye (ÇEM, 2019).

Since 1946, Türkiye has carried out many successful efforts to combat desertification, erosion and drought (ÇEM, 2019). In this context;

- 8.9 million hectares of afforestation and erosion control work as of the end of 2018
- Rehabilitation of 2,899,912 hectares of degraded areas in the period 1998-2016,
- In the period 1962-2018, pasture improvement activities were carried out on 250,443 hectares.

In order for Türkiye to combat and successfully manage drought, desertification and erosion, it is necessary to formulate the necessary strategies and strengthen the capacities of relevant institutions.

4. CONCLUSION

Forest ecosystems are important components of global climate change and carbon exchange in the atmosphere. As it is known, forests play an important role in mitigating the impact of climate change by sequestering carbon as they are potentially net carbon sinks. In this study, carbon losses in areas where desertification, drought and erosion occur in Türkiye were evaluated and a road map was created for silvicultural interventions that can be applied. In addition, in line with this road map, general recommendations that are thought to be useful in preventing and combating carbon losses are given. These recommendations are

- In Türkiye, billions of tons of soil are transported by water and soil erosion. The amount of organic carbon in these eroded soils is also decreasing. Therefore, carbon pools need to be expanded.
- Silvicultural interventions such as afforestation of vacant and open areas and rehabilitation of hollow closed areas will directly expand carbon pools.
- Silvicultural interventions should be carried out in a timely manner and in accordance with its nature.
- Reforestation of hollow closed forest areas and forest openings should be accelerated. This strategy is at the forefront of all strategies, mainly because it implies a net increase in carbon.
- In areas with erosion, desertification and drought, natural species should be protected and a forest ecosystem consisting of natural species should be created.

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Effects of Silvicultural Interventions on Carbon in High Mountain Forests in Türkiye

***Ercan Oktan*[1✉], *Aysen Kalender*[2]**

[1]*Karadeniz Technical University, Faculty of Forestry, Trabzon/TÜRKİYE*
[2]*Çukurova University, Department of Forestry and Forest Products, Adana/TÜRKİYE*
✉***Correspondence**:* oktan@ktu.edu.tr

Abstract: High montane forests are defined as forests between high montane (oreal) and subalpine ranges, which are under pressure against extreme climatic conditions and anthropogenic influences and have difficulty in regenerating themselves under these conditions. High montane forests, which are constantly struggling with poor growing environment conditions, have difficulty in regenerating themselves and cannot respond to the forestry activities implemented. However, due to unfavorable terrain and climatic conditions, carbon accumulation in both subsoil and above-ground vegetation in high mountainous areas remains in very low amounts. Therefore, silvicultural interventions that can be applied by increasing the carbon stock capacity of high mountain forests and revitalizing the ecological role of high mountain forests should be done in accordance with their nature. In order to increase the amount or potential of carbon storage, conservation and sustainable use of forest ecosystems are important for combating climate change and global carbon balance. Therefore, special planting practices should be implemented in high mountain forest areas to accelerate carbon storage. As a result, the potential production, biomass increase and carbon sequestration capacity of high mountain forest areas can be better utilized. Within the scope of this study, the effects of silvicultural interventions on carbon in high mountain forests in Türkiye will be evaluated.

Keywords: Carbon storage, Carbon sequestration, Silviculture, High mountain forest, Special planting practices.

1. INTRODUCTION

High mountain forests are understood as forests located on the high mountain forest step, which have unique biological, physiological, sociological and growing environment characteristics, which can survive under extreme living and existence conditions, and which react very significantly to destruction (Çolak & Pitterle, 1999). High mountain forests, which are constantly struggling with poor growing environment conditions, have difficulty in renewing themselves and cannot respond to forestry activities. Therefore, it is very important to know the forest boundary in order to protect these forests and to restore the disturbed balances (Yücesan et al., 2014). The concept of forest boundary constantly varies against microclimatic effects and creates transition zones. In general, when moving from the forest to the alpine and polar zones, it is seen that the closure of the forest deteriorates first and then the tree height shortens (Figure 1). This phenomenon is typical for undisturbed borders. In this zone, three boundaries are distinguished as "forest boundary", "tree boundary" and "crippled tree boundary" and the part between the forest boundary and the tree boundary is called "battle zone" (Saatçioğlu, 1976).

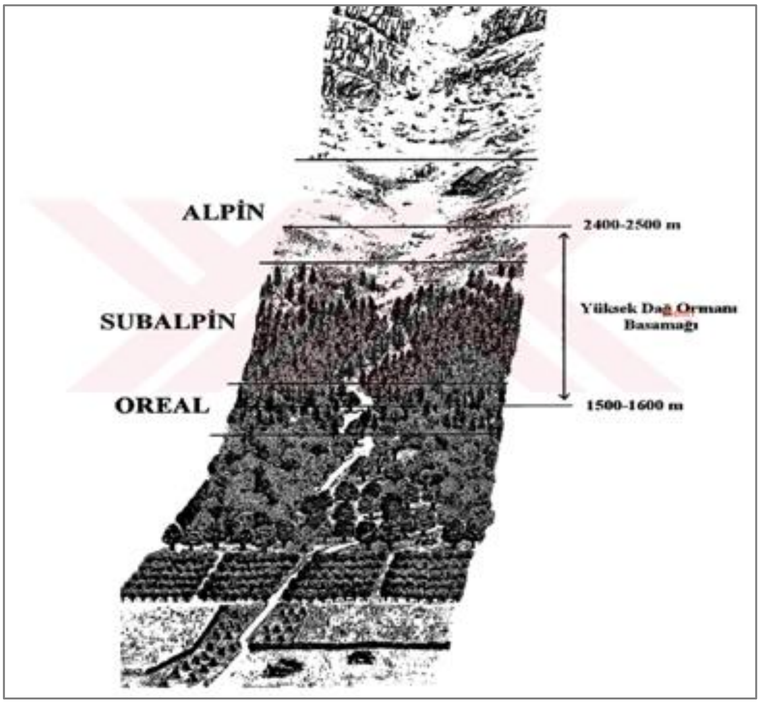

Figure 1. High mountain forest step (Sag, 2002).

The height difference between the forest boundary and the tree line is often 100-150 m (Yücesan, n.d.). The forest in the war zone has become vulnerable to many factors and the forest structure has deteriorated. The most important reasons for this deterioration are the slope due to the altitude, erosion and the rocky nature of the forested areas. The fact that the mountain forest boundary is close to the plateau areas causes it to be under constant threat by human beings. With the opening of many plateaus to tourism and animal grazing, the battle zone has disappeared and the forest boundary has been destroyed. In this context, harsh ecological conditions and anthropogenic impacts will continue to prevail in high mountainous areas and will continue to push the potential forest boundary downwards (Üçler, 2002). Therefore, due to unfavorable terrain and climatic conditions, carbon accumulation in both subsoil and above-ground vegetation in high mountain areas remains very low. Therefore, the carbon stock capacity of high mountain forests needs to be increased. For this reason, forest form should be created in accordance with its nature. Forests are the most important renewable energy sources and constitute the largest carbon pool (Mısır et al., 2015).

The climate factor is very important for forests to grow up to a certain elevation in mountainous areas (Yücesan, 2000). Especially climate change has a negative impact on forests. It pushes the forest boundary in high mountainous areas towards the lower slopes. Therefore, in order to reduce the impact of climate change on forests and protect biodiversity, silviculture studies should be carried out in accordance with their nature (Valencia, 2019). In this context, the continuity of the dynamics of forests, which have a very important function in preventing climate change and mitigating its negative effects, including carbon storage, should be ensured.

Special planting practices should be implemented in high mountain forest areas to accelerate carbon storage. As a result, the potential production, biomass increase and carbon sequestration capacity of high mountain forest areas can be better utilized.

2. SPECIAL PLANTING PRACTICES IN HIGH MOUNTAIN AREAS

Since high mountain ecosystems cannot fulfill some of their functions in the upper zones of forests due to unfavorable conditions, the afforestation techniques that should be applied in these areas should be very different from the afforestation techniques applied in the lower zones of forests (Çolak & Pitterle, 1999). For this reason, afforestation of high mountainous areas falls under the category of afforestation for conservation purposes (Anonymous, 2004).

Microclimatic influences and soil condition play an important role on the planting spacing of upland plantations. In such locations, natural young growth is consistently characterized by clusters (Schönenberger, 2001; Schönenberger et al., 1990). Therefore, many saplings collectively coexist in suitable locations at irregular intervals (Schönenberger, 1978). Thus, in high mountainous areas, cluster afforestation should be preferred over regular and widely spaced afforestations (Brang et al., 2004, Schönenberger, 2001, Yücesan, 2006; Schönenberger & Wasem, 1999). Before afforestation works are carried out, the area to be afforested should be well analyzed and some precautions should be taken (Yahyaoğlu & Ölmez, 2006). First of all, a small growing environment suitable for afforestation should be determined. Then, land preparation should be started with terracing, tripod stakes, trunks extended parallel to the equal elevation curves to prevent avalanches against snow movements and strong wind effects in the determined growing environments (Çolak & Pitterle, 1999). After these preparations are completed, according to Schönenberger (2001), the space between tree collectives should be planned so that two collectives do not merge. In cluster plantations, plantings should be carried out in the form of collectives consisting of 20-30 saplings with a diameter of 2-4 meters. The saplings to be used in afforestation should be planted 50-100 cm apart, close to each other. The clusters should lie in an oval shape and perpendicular to the wind direction. For this reason, the collective length should be planned between 10-15 m and the collective width between 8-15 meters. Thus, small tree collectives in high mountain areas will form the targeted cluster unit within 20-30 years (Schönenberger, 2001) (Figure 2), (Figure 3).

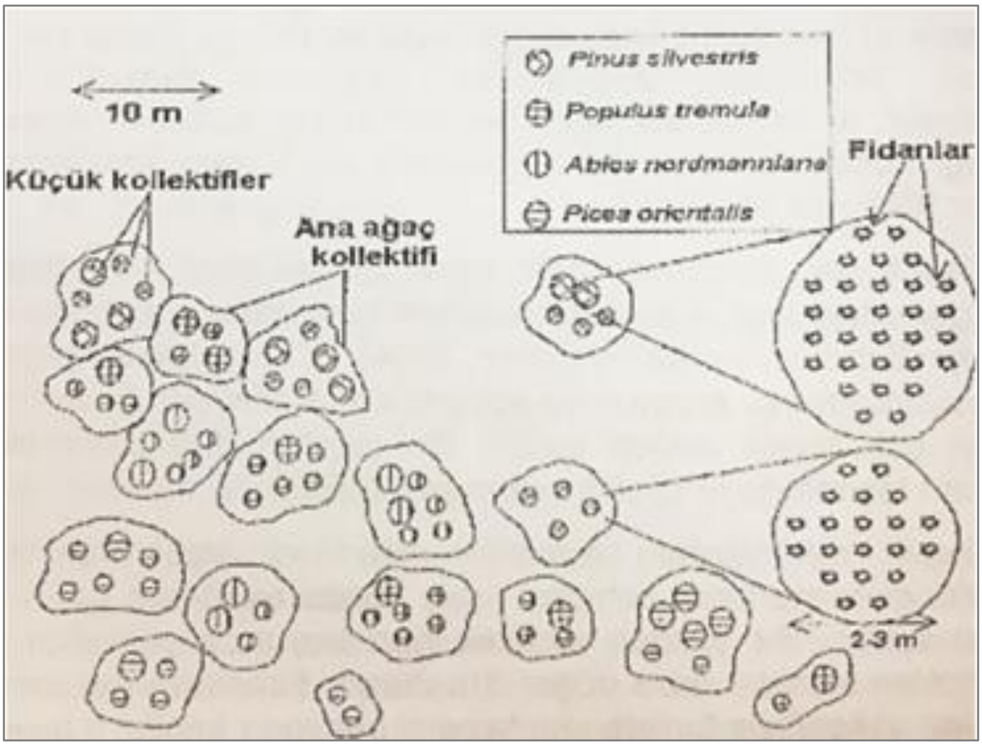

Figure 2. Theoretical schematic layout of 17 cluster plantations of 20-30 saplings (Schönenberger, 2001 cited in Yahyaoğlu & Ölmez, 2006).

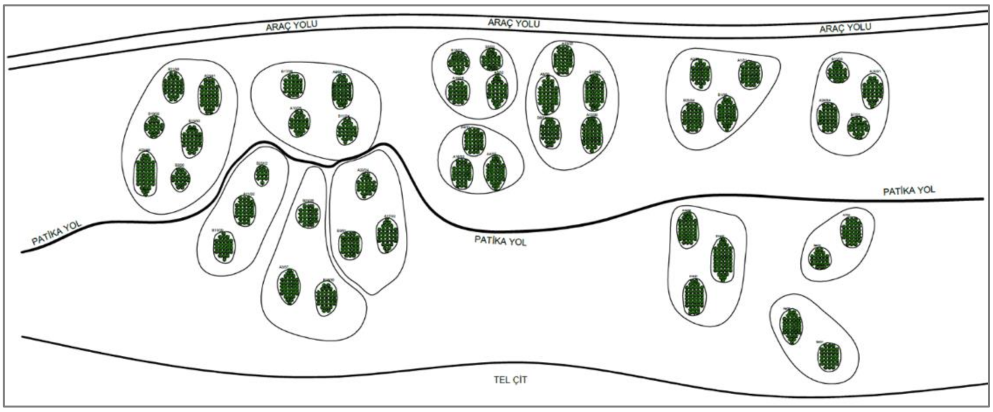

Figure 3. Terrain model of eastern spruce (*Picea orientalis* L.) cluster afforestation in the subalpine zone (Kalender, 2020).

3. CONCLUSION

It is seen that the primary factor in carbon storage is to slow down and prevent deforestation and to afforest high mountainous areas in accordance with their nature. Considering such benefits, it is understood that cluster afforestation should be used to increase the planting success and carbon amount in afforestation in high mountain areas. As a result, potential production, biomass increase and carbon sequestration capacity can be better utilized by cluster afforestation in high mountain forest areas. With cluster afforestation in high mountain areas;

- Cluster afforestation in degraded areas in high mountainous areas helps to sequester carbon in the soil by preventing floods, floods, avalanches and landslides.
- Forests play an important role in combating climate change by sequestering more carbon than other ecosystems. Cluster afforestation in high mountainous areas will increase the amount of carbon by creating a forest form.
- High mountainous areas have extreme climatic conditions. Therefore, by using appropriate species in the afforestation works to be carried out, both subsoil and above-soil carbon sequestration capacity will be better utilized.

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Effect of Carbon Nanotube Reinforcement and Porosity on Mechanical and Viscoelastic Properties of Polylactic Acid in Material Extrusion Additive Manufacturing

***Kamil Feratoğlu*[1✉], *İlyas İstif*[2]**

[1]*Kırklareli University, Faculty of Engineering, Kırklareli/TÜRKİYE*

[2]*Yıldız Technical University, Faculty of Engineering, İstanbul/TÜRKİYE*

✉***Correspondence***: kamilferatoglu@klu.edu.tr

Abstract: This study investigates the production of Polylactic Acid-Carbon Nanotube (PLA-CNT) nanocomposite filaments intended for use in fused deposition modeling (FDM). The research delves into the comprehensive analysis of the nanocomposite's thermal degradation behavior, mechanical characteristics, viscoelastic-viscoplastic properties, and porosity. The weight percentages of Carbon Nanotubes (CNTs) within the filaments were accurately determined through advanced thermogravimetric analysis (TGA), indicating a uniform and well-dispersed CNT reinforcement within the PLA matrix. Scanning Electron Microscopy (SEM) analysis provided valuable insights, revealing an enhanced interfilament adhesion, and a notable reduction in porosity with the augmentation of CNT reinforcement. Notably, the incorporation of CNTs yielded a significant improvement in the mechanical properties of the nanocomposite materials, resulting in heightened tensile strength and elastic modulus. Nevertheless, it was observed that higher CNT contents contributed to a reduction in fracture strain, suggesting an increase in material brittleness. In-depth loading-unloading tests showcased a linear viscoelastic behavior, with increased strain rates yielding higher material strength. Furthermore, the investigation of energy consumption during deformation unveiled that at a strain rate of 1E-3, energy consumption was notably higher compared to the rate of 1E-4. Additionally, creep tests conducted demonstrated a decrease in creep compliances with CNT reinforcement, highlighting the nanocomposite's heightened resistance to deformation over time. However, certain exceptions were identified, attributed to CNT agglomerations and insufficient interfacial adhesion. In a broader context, the incorporation of CNT reinforcement yielded a positive impact on the nanocomposite material's thermal, mechanical, and viscoelastic properties. Notably, this study underscores the feasibility of producing PLA-CNT nanocomposite filaments for FDM applications, thereby presenting potential avenues in diverse fields. The comprehensive findings of this research enrich the understanding of the influence of CNT reinforcement on PLA-based materials, while also providing valuable insights for refining the fabrication process and optimizing material properties.

Keywords: Additive manufacturing, Nano-composite polymers, Carbon nanotube, Viscoelastic properties.

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Determination of the Effect of Forest Road Construction on Existing Forest Assets with Geographic Information Systems

Gizem Misirlioglu*✉, *Taha Yasin Hatay, Selcuk Gumus
Karadeniz Technical University, Faculty of Forest, Trabzon/TÜRKİYE
✉***Correspondence****:* gizemyorulmaz@ktu.edu.tr

Abstract: Many expectations such as benefiting from forests all year round, providing transportation for people, protecting forests, transporting wood raw materials are only possible with forest roads that provide access to forests. Today, with the increase of global warming, forest fires have affected the whole world. If the forests cannot be reached and intervened during the fire, the forests that hold carbon start to release carbon during the fire. This situation reveals the importance of forest roads, which make it possible to fight fires. In this study, the effect of forest road construction on existing forest asset will be tried to be revealed by using geographic information systems. For this purpose, analyzes were carried out on a forest road built in 2019 in Osmangolu Forest Management Directorate, which is within the borders of Kastamonu Regional Directorate of Forestry Ilgaz Operation Directorate. Controlled classification was made using SNAP software on two satellite images of 2018 and 2023 and the current forest change was revealed. By determining the differences between these two situations, the effect of this change on forest carbon, the effects of the road construction area on the surrounding stands and the condition of these stands after the road construction were evaluated. As a result, the relationship between the construction of a forest road and the existing vegetation and thus forest carbon has been tried to be revealed.

Keywords: SNAP, Forest road construction, Vegetation, Classification.

1. INTRODUCTION

As a result of the increasing levels of carbon dioxide in the atmosphere, which have led to climate change and exacerbated global warming, forest fires have become a worldwide issue. When forests cannot be accessed and intervened during a fire, carbon-storing forests begin to release carbon during the fire. This underscores the importance of forest roads that enable firefighting efforts.

Beyond their role in protection, forest roads, which are also fundamental to the opening up of forests for exploitation, are used throughout the year for the purpose of transportation and the execution of forestry services by vehicles (Erdaş, 1997). The planning, construction, and maintenance of the forest road network that will open up forest areas for exploitation are of significant importance due to their technical and economic characteristics as well as their ecological problems (Çalışkan & Çağlar, 2010). Planning routes that are as close to nature as possible is an absolute consideration. This is because there are direct or indirect effects on living areas between the starting and ending points of road construction (Lugo & Gucinski, 2000; Tunay, 2006; Gümüş et al., 2008; Eker & Coban, 2010; Boston, 2016; Gülci et al., 2017). During the construction and maintenance of forest roads, various forms of damage occur in the natural environment. The most significant of these include forest area loss, injury to trees leading to insect infestations, and preparing the ground for erosion and landslides (Acar, 1999).

In Regulation No. 292 titled "Planning, Construction, and Maintenance of Forest Roads," the adverse effects of forest roads are identified based on an improperly planned 1 km long road as follows:

a) Depending on road types, a minimum of 4,000-8,000 m^2 of forested area is cleared, and 400-3,500 trees are cut down depending on the age of the stand.
b) As a result of excavation material flowing downhill, there is breakage, injury, and damage to standing trees on the lower slope, leading to insect damage.

c) By breaking the support structure on slopes, landslides are induced.
d) Changes in the flow directions of shallow groundwater result in the inability to meet the water needs of natural stands, leading to negative alterations in the ecosystem.
e) Wind corridors are created, increasing the breakage and uprooting of trees.
f) The increase in surface runoff distance triggers erosion.
g) With transportation comes artificial and intense pressure on pristine areas, disturbing wildlife and limiting their right to live.
h) The construction and maintenance costs of roads burden the national economy in this manner (OGM, 2008a).

Generally speaking, infrastructure works in the construction of forest roads; It consists of cleaning the building area (cutting down trees, protecting the topsoil and removing logs), disintegrating rocks with explosives and soil leveling. (Çalışkan & Çağlar, 2010) This stage causes the most damage.

Forest roads cause the transportation of fertile topsoil, change the soil properties and microclimate, and increase erosion, resulting in a decrease in the productivity of the growing environment. (Megahan, 1987) It has been stated that the construction impact area of roads planned in forested areas in Türkiye (sum of ditch and platform width multiplied by the road length) cannot be more than one percent of the forest area (OGM, 2008b).

In this study, it was tried to determine how much the forest existence was affected after the construction of forest roads using geographical information systems. In this way, the effect of this change in the vegetation of the areas where forest roads providing access to the forests were built on forest carbon, the effects of the road construction area on the surrounding stands and the status of these stands after the road construction were evaluated.

2. MATERIALS AND METHODS

In this study, the effect of a forest road built in 2019 in Osmangölü Forest Management Directorate, which is within the borders of Kastamonu Regional Directorate of Forestry Ilgaz Operation Directorate, on the forest existence was determined (Figure 1).

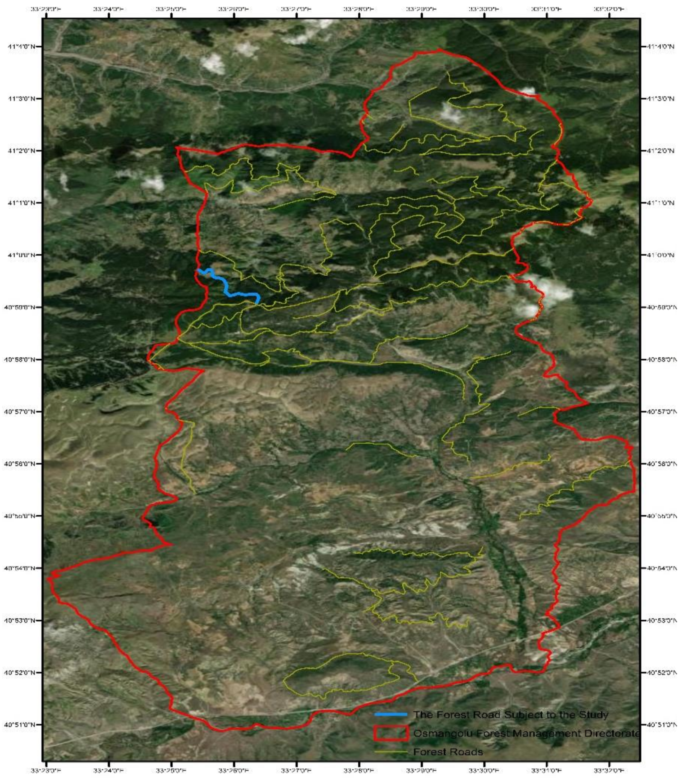

Figure 1. Study area.

For this, controlled classification was made using SNAP software on two satellite images of 2018 and 2023 and the current forest change was revealed (Figure 2).

Figure 2. Satellite images of 2018 and 2023.

In controlled classification, separate control parcels were determined for 3 classes (forest area, forest roads and bare land) (Figure 3 and Figure 4).

Figure 3. Controlled classification for 2018 satellite images (Blue: forest area, orange: bare land, light blue: forest roads).

Figure 4. Controlled classification for 2023 satellite images (Green: forest area, light green: bare land, purple: forest roads).

According to the results of these processes performed separately on the satellite images of 2018 and 2023, comments were made on the forest area change.

3. RESULTS AND DISCUSSION

3.1. Results

As a result of the controlled classification process carried out for 2018, the forest area was determined as 74.076% of the existing area, the presence of forest roads was 6.487% and the bare land was 14.437% (Figure 5).

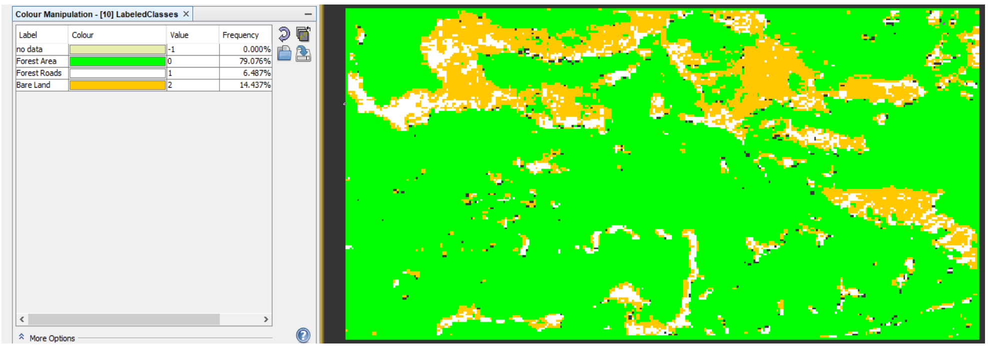

Figure 5. 2018 controlled classification result.

As a result of the controlled classification process for 2023, it was determined that 83.188% of the existing area was forest area, 10.998% was forest road presence and 5.813% was bare land (Figure 6).

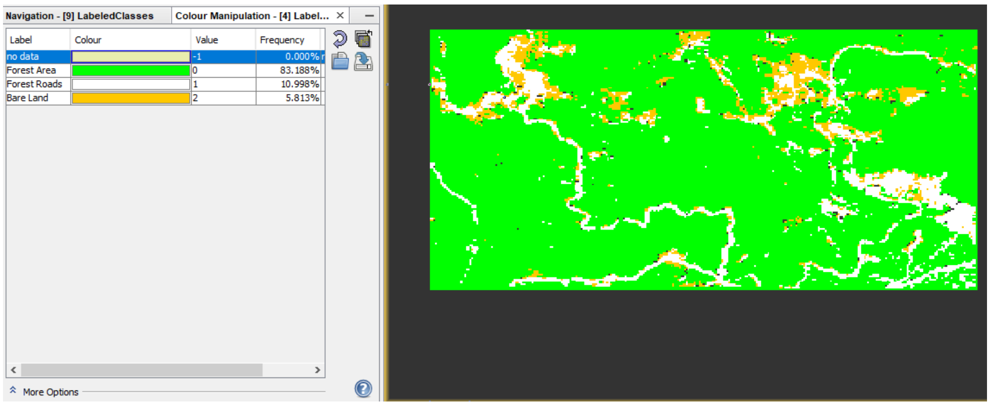

Figure 6. 2023 controlled classification result.

When looking at the 5-year forest area change in this process carried out through satellite images; There is a 4% increase in forest area. Likewise, the forest road built in 2022 affected the current situation as a 4% increase (Table 1).

Table 1. 5-year land use change.

	2018	2023
Forest Area (%)	79.076	83.188
Forest Roads (%)	6.487	10.998
Bare Land (%)	14.437	5.813

According to these results, it is understood that the most changing land use is bare land.

3.2. Discussion

Since it is known that the length of the newly built road in 2022 is 2900 meters, it is thought that a 4% increase may be normal. An increase in the forest area will be possible as the community consisting mostly of herbaceous plants and shrubs, which appeared as bare land in 2018, will create a closure within 5 years.

4. CONCLUSION

In this study, conducted on satellite images using SNAP software, the effect of a newly constructed forest road on the existing forest area was revealed using the controlled classification technique. This study, conducted on 2018 and 2023 satellite images, revealed that the ratio of forest area and forest roads increased and the bare land decreased significantly.

It is known that forest roads harm the environment. However, access to forests is only possible via forest roads. As can be seen from this study, it is understood that forest roads built with an approach close to nature and in accordance with the technique have less impact on the environment than bare land.

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Silvicultural Practices in the Process of Climate Change in Turkish Forests

Sena Yavruoğlu*✉, *Zafer Yücesan

Karadeniz Technical University, Faculty of Forestry, Trabzon/TÜRKİYE

✉***Correspondence**:* senayavruoglu@gmail.com

Abstract: Forests are important ecosystems in mitigating the effects of climate change and combating climate change. Forests, which are the most important renewable energy sources, are the largest carbon pool after the oceans. Türkiye's forests, which are spread over three different plant geographies, are densely forested areas where arid and semi-arid climatic conditions are observed and which may be sensitive to climate change stress. On the other hand, forest fires in the Mediterranean basin also pose a significant threat to Turkish forests. Within the scope of combating climate change, it is important to prevent deforestation, to preserve the natural stand structures in existing forest areas, to improve the growth and increment characteristics of stands under appropriate stand structures to the extent permitted by the growing environment characteristics of the stands. Guaranteeing natural regeneration conditions through stand tending works and preferring natural regeneration in forest areas where it is possible are important principles of silviculture. On the other hand, there is an important amount of forest area in the Turkish forests where the canopy is none or degraded and which should be subjected to rehabilitation and restoration works in this context. In today's world where habitat and forest area losses are experienced, it is of great importance to carry out pioneering studies to protect forest genetic resources against climate change, to carry out tree breeding studies and to eliminate the problem of seed migration that may occur in the future due to climate projections. Silvicultural techniques, depending on the sustainable management approach in forestry, constitute an important assurance within the scope of combating climate change. Forest tending works are very important for forests to act as an important carbon sink. Mixed stands in which broad-leaved species are also included in the mixture sequestrate more carbon than pure stands. Especially the presence of individuals with thick diameters in the stands increases the carbon sequestration even more. The duration of the rotation period in even-aged stands and the length of the rotation period in uneven-aged stands are determinant in the amount of carbon sequestration of forest ecosystems. The repetition time and intensity of silvicultural treatments are also directly affected carbon sequestration. In this study, general evaluations were made about the silvicultural practices that should be concentrated in order to increase carbon sequestration in forest areas in Türkiye, the issues that should be considered in practice in stands were evaluated and recommendations were made considering future projections.

Keywords: Forest, Climate change, Silviculture, Carbon sequestration.

1. INTRODUCTION

Since the 1950s, the warming of the climate system has accelerated and many of the observed changes such as warming of the atmosphere and oceans, decrease in snow and ice, rise in sea water level, increase in greenhouse gas concentrations are taking place at an unprecedented rate (IPCC, 2014). Especially in recent years, there has been an increase in greenhouse gas emissions due to reasons such as urbanisation, land use change, deforestation and industrialisation. The increase in greenhouse gases in the atmosphere has led to the emergence of many problems. As a result of global warming, it is stated that biodiversity will be negatively affected together with humans in the future (Verburg et al., 1999; Wakeel et al., 2005). Türkiye is located in the Mediterranean basin, and it is one of the regions that will be affected highly from climate change, temperature increase, water scarcity, drought, etc. It is possible to say that this situation affects the living organisms and socio-economic sectors living in the region.

Forests' role in climate change is two-fold. They act as both a cause and a solution for greenhouse gas emissions. Around 25 per cent of global emissions come from the land sector, which is the second largest source of greenhouse gas emissions after the energy sector. Deforestation and forest degradation account for about half of the greenhouse gas emissions from the land sector. On the other hand, forests are also one of the most important solutions to mitigate the effects of climate change. Therefore, increasing the amount of forest areas and sustainable management of forests are very important in order to minimize the effects of climate change. In this case, planning new perspectives in forestry, including silvicultural approaches, is very important in reducing the future effects of climate change. At the same time, new models should be created by taking risk factors into account in planning (IUCN, 2021). In order to guarantee the continuity of the products and services provided by forest ecosystems, it is very important to complete the technical, social and economic infrastructure works necessary for achieving new forest areas as well as improving the vital quality of existing forests (Pretzsch et al., 2002; Zell, 2016).

In the recently published "State of the World's Forests" report, it is stated that forests cover 31% of the world's terrestrial area with a total area of 4.06 billion hectares, and 7% of forest areas with 294 million hectares consists of afforestation (FAO, 2022). In Türkiye, the forest area is 23,2 million ha and the forest area per capita is 0.27 ha Moreover, the ratio of forest areas to terrestrial areas in Türkiye is around 29,4%. However, the total forest area with a degree of closure of 10 percent and above constitutes a total of 13.7 million hectares according to economic, ecological and socio-cultural function distinctions. Full compliance with natural regeneration methods is not possible in approximately 3 million hectares of the total 13.7 million hectares of forest area with a degree of canopy closure above %10 (OGM, 2022). Approximately 1,2 million hectares of forest land, devoid of tree cover and without canopy, have been transformed into productive forest areas within a period of twenty years between the years 1999 and 2000. However, forestry authorities state that the current 9.7 million hectares of forest land has the potential to be transformed into ecologically productive forests. So, support from artificial rejuvenation, afforestation, rehabilitation and restoration workings are needed in Turkish forestry.

In this study, general evaluations were made about the silvicultural practices that should be concentrated in order to increase carbon sequestration in forest areas in Türkiye, the issues that should be considered in practice in stands were evaluated and recommendations were made considering future projections.

2. IMPORTANCE OF SILVICULTURE IN THE PROCESS OF CLIMATE CHANGE

Management of existing forest dynamics through successful regeneration efforts has a very important role in the sustainable management of forests, which are of great importance in preventing carbon sequestration and climate change. In this sense, it is necessary to examine the ecological conditions of the growing environment in detail, to determine and monitor both short-term and long-term climatic changes. This is also important in terms of analysing and evaluating the regional differences and impacts of climate change (Koenig et al., 2015).

Natural and artificial regeneration workings alone are not sufficient to ensure the sustainability of forests. It is very important to regulate the increment-growth relations in the stand at an optimum level with all maintenance workings applied in the stand after regeneration in order to achieve the best management goals. Thus, the level of benefit of the trees in the stand from the existing ecological opportunities will be maximized. As a matter of fact, global warming and its effects can have significant effects on the natural succession in the ecological unit area, as well as cause the processes to end significantly. Therefore, individual developments in the stand should be closely monitored after regeneration. Even regeneration and maintenance workings should be revised when necessary depending on climate change effects on the habitat (Bogdziewicz et al., 2021). If the potential negative effects that may arise after climate change are not completely eliminated, it will be possible to construct stands that are more resistant to adverse conditions in the forest ecosystem with new silvicultural approaches.

Considering the effects of climate change, the symbiosis between living organisms forming the forest ecosystem may weaken and species may move horizontally and vertically towards ecological unit areas with more favourable growing environment conditions due to the stress factor. This change may manifest itself as a change in the number of species forming the population or a change in the composition of the species forming the forest community. An increase in the number of invasive species can be observed (Gougherty et al., 2021; Stockdale et al., 2019; Varol, 2023; Ayan et al., 2022; Aitken et al., 2008; Brewer et al., 2002; Magri et al., 2006). Changes in the distribution range of tree species (Watling et al., 2015), shifts of tree species to northern regions and higher altitudes, as well as significant declines in biodiversity and ecosystem functioning are among the consequences of climate change. However, forest growth is increasing rapidly in some mountainous regions (Silva et al., 2016). Although the establishment of new forests in some regions is a beneficial consequence of climate change, in contrast to other regions, climate change can lead to deforestation and geographical change with seed migration and even species extinction (Taleshi et al., 2019). In this context, the selection of species and origins resistant to stress factors and studies in this field are of great importance. The most important features that increase the adaptation of a forest area to climate change are species composition, the self-renewal power of species, the presence of destruction processes in natural succession, richness in terms of genetic diversity, and the width of the distribution areas of species horizontally and vertically, the richness and frequency of the abundant seed year, the ability of the seed to fly, the resistance of the species to drought stress, the percentage and speed of seed germination, the tendency of the formed young to be tolerant to the ecological conditions of the growing environment and whether the species has a pioneer tree character (Johnston et al. , 2006; Aitken et al., 2008). It would not be misleading to think that the stands formed by tree species that meet these criteria will be among the forest areas that are less likely to be affected by future climate projections in terms of adaptation to climate change. Therefore, the use of these forest areas as a seed source and the use of tree species with these characteristics in the rehabilitation of deforested or degraded forest areas will be beneficial in the establishment of forest areas resistant to climate change. In order to grow forests with the highest yield in terms of quality and quantity in accordance with the demands of the economy by utilising the hereditary characteristics and variations of the species in afforestation studies, the use of seeds obtained from improved seed sources in appropriate areas is foremost. However, seed and sapling quality is also of great importance in afforestation works. In addition to the determination of morphological characteristics of seeds and seedlings, determination of physiological characteristics such as determination of frost and drought resistance in seeds and seedlings is important for success in afforestation (Kaplan et al., 2023).

Silvicultural practices carried out in forest resources not only cause significant changes in the dynamics of forests, but also have significant effects on macro and micro fauna and other vital elements, which are important elements of the forest ecosystem. In this context, considering the effects of climate change, the results of silvicultural practices should be evaluated in terms of forestry and silvicultural techniques, as well as in combination with the effects of global climate change. Terrestrial and aerial tracking and monitoring systems should be used in these evaluation studies (Thrippleton et al., 2018). Moreover, conversion of coppices into groves, rehabilitation of degraded forests and increase in youth are also known to have a positive effect on carbon sequestration (Tolunay, 2011).

Forest resources sometimes suffer irreversible and irreparable damages in events that occur based on both anthropogenic impact and natural processes and have many negative effects on forest resources. In this sense, climate change and global warming always have significant effects on the formation, increase or decrease of the effects of many harmful factors, especially snow, storm, wind, fire, insect and fungal damages. This situation closely affects and changes forest dynamics. For this reason, the new generation at different ages should be evaluated with the help of modelling and the effects of global warming should be revealed objectively (Dyderski et al., 2018).

In Türkiye, forest fires are mostly observed in the Aegean, Mediterranean and Marmara regions. Seasonal climatic elements such as temperature, precipitation, relative humidity and wind create a favourable environment for fires (Doganay & Doganay, 2004). Human-induced fires also occur. However, climate change and population density in areas with fire risk cause the risk to always exist. In order to minimise the damage of forest fires, it is recommended to make forests more resistant to fire risk and to adopt fire management planning (Avcı & Korkmaz, 2021).

One of the important effects of global warming is pollination, fertilisation and seed formation, which is one of the vital processes of forestry. Serious interruptions in this important process always cause serious interruptions in the formation and shaping of future generations in forests. In this direction, no matter how successful silvicultural techniques are applied, inefficient progeny formation and inability to transfer genetic material to future generations due to the effects of global warming always minimise the level of success. For this reason, researches revealing the effects of climate change on gene flow and transfer in our country, especially in our forests, should be supported in this sense (Burkhart & Tome, 2012).

3. CONCLUSION

As a result of the evaluations made, it is possible to say that in growing environments where an increase in drought stress is observed due to climate change, it is absolutely necessary to use the shelterwood system effectively among natural regeneration methods. While planning the regeneration works with shelterwood system, both for increasing the mast capacity and for protecting the seedlings from the sun effect during the first few years, canopy closure should be increased by 10% in accordance with the biology of the tree species, especially in the southern aspects during the seed cutting phase. Again, in these growing environments, repetitive overhead release felling should be made gradually and the biological independence processes of the young generation should be carried out in coordination. Size of the regeneration areas in Turkish red pine, which shows great success in clear cutting system due to its biology, should be re-evaluated depending on the climate change process. In this context, it may be recommended not to apply clear cutting system in areas larger than 1-3 hectares. In artificial regeneration workings and in afforestation areas, the most resistant individuals to stress conditions should be included in the stand composition and new forest areas resistant to external influences should be established by planting saplings with high genetic gain obtained after determining suitable origins. The growth of individuals with healthy growth tendency should be supported by appropriate tending workings (tending during the thicket stage and cleaning) without delay by removing the individuals with negative selection principles. In line with the principles of negative selection, it should be avoided as much as possible from approaches that are based on the distribution of individuals at equal distances in the unit area by subjectively selecting individuals that do not have negativity indicators. It is very important that the stand closure is kept at 0.8-0.9 levels and that the stands are located under the normal density level. Until the end of the management period, regardless of the biology of the stands, it should be ensured that this degree of closure and normal density should be maintained during thinning. In the case of stands of suitable tree species, the value increase or reserve management must be deducted. Pruning should be carried out in young stands to support biomass increase. In the rehabilitation of burnt forest areas, the formation of natural stand compositions should be supported. When necessary, rehabilitation works that will enable the transition from pure stands to mixed stands should be supported in order to increase biodiversity and support the formation of fire-resistant forests. In the rehabilitation of forest areas with decreased productivity, the point of view of ignoring the trees with damaged trunks depending on the wood production efficiency and removing them from the area by cutting, and planting sapling material that can produce qualified wood production in their place brings some drawbacks. It is clear that old trees have an important carbon sequestration capacity with their deep root structures. Therefore, they should be kept in the area regardless of their wood quality, provided that they are absolutely healthy in rehabilitation works. Taking into account the horizontally and vertically changing distribution areas of the species in line with future climate projections, it is of great importance for future forestry strategies to establish pioneer populations and monitor their development in line with the approaches of transferring the genetic material required to increase the resistance of forest ecosystems to climate change from other regions.

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Effects of Forest Litter Reduction on Soil Respiration Rates Across a Chronosequence of Black Pine Forest

***Randell Keith Amarille*[1,2✉]*, Renato S. Pacaldo*[1,2]*, Miraç Aydın*[1]**

[1]*Kastamonu University, Faculty of Forestry, Kastamonu/TÜRKİYE*

[2]*Mindanao State University-Main Campus, College of Forestry and Environmental Studies, Department of Forestry, Marawi City, Lanao del Sur/PHILIPPINES*

✉***Correspondence***: randellkeith.amarille@msumain.edu.ph

Abstract: One of the strategies to alleviate forest fire intensity is the reduction of fuel loading through regular pruning and collection of forest litter. The critical question, however, is whether the regular removal of forest litter in a well-managed black pine (*Pinus nigra* Arnold) plantation significantly affects the soil respiration rates (Rs) as the forest plantation ages. This study aims to determine the Rs rates across a chronosequence of well-managed plantations of black pines, which have been subjected to regular pruning and collection of forest litter resulting in reduced forest litter inputs. A field experiment in a split-plot randomized block design with five replications was established to measure Rs rates using an automated soil respiration machinery (LI-8100 A). Results showed significant differences in soil Rs rates ($p < .0001$) across the chronosequence of P. nigra forest, with the oldest stand (60-year-old) showing a significantly highest Rs (2.39 µmol m^{-2} s^{-1}) compared to the 15-year-old (1.87 µmol m^{-2} s^{-1}), 30-year-old (1.99 µmol m^{-2} s^{-1}), and control (1.98 µmol m^{-2} s^{-1}). Significant differences in Rs rates were also detected across time ($p < .001$), but not with the interaction effects between age and time ($p = 0.85$). The Rs showed a positive correlation with soil temperature ($r = 0.67$), suggesting that it tends to increase with soil temperature. In contrast, the Rs negatively correlated with soil moisture ($r = -0.45$), suggesting an inversely proportional relationship. We concluded that the impacts of regular removal of forest litter to reduce fuel load are unlikely to significantly affect the soil Rs rates at younger to intermediate age classes. But the Rs tends to increase at a mature age (60 and up), suggesting the tendency of higher Rs rates in mature forests regardless of regular pruning and collection of forest litter removal.

Keywords: Forest fire, Forest litter, Soil temperature, Soil moisture, Well-managed plantation.

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Soil CO_2 Effluxes in Post-fire and Undisturbed *Pinus nigra* Forests: A Soil Moisture Manipulation Study

Renato S. Pacaldo[1,2]✉, Miraç Aydın[1], Randell Keith Amarille[1,2]

[1]*Kastamonu University, Faculty of Forestry, Kastamonu/TÜRKİYE*

[2]*Mindanao State University-Main Campus, College of Forestry and Environmental Studies, Department of Forestry, Marawi City, Lanao del Sur/PHILIPPINES*

✉***Correspondence**:* renato.pacaldo@msumain.edu.ph

Abstract: Climate change impacts are driving hydrological extremes and frequent occurrences of forest fires. Whether these impacts result in dramatic changes in the soil CO_2 efflux (F_{CO2}) remains poorly understood. This study seeks to understand the changes in the soil F_{CO2} in recently burned forest (post-fire) and an undisturbed black pine (*Pinus nigra*, Arnold) forest in Türkiye. A field experiment in a three-way factorial randomized complete block design experiment was established with four replications and three factors; shaded (west) and exposed (east), types of forest fires (surface, crown, and control) and soil moisture regimes (dry, wet, and control). A dynamic survey chamber soil respiration machinery (LI-8100A) was employed to measure simultaneously the soil Fco_2, the soil temperature, and the soil moisture for a total duration of one-year. The soil F_{CO2} showed significant differences among treatments ($p<0.0001$), time ($p<0.0001$), and moisture regimes ($p<0.0001$), but not with the interaction effects between treatment and time (p = 0.0058), aspects (p = 0.95410), and types of forest fires (p = 0.0059). A dry soil in the crown fire site situated in the exposed aspect exhibited a significantly different and lowest soil F_{CO2} compared to other treatments. No statistically significant differences in the F_{CO2} in the wet soil were detected among treatments. The soil and air temperatures showed a strongly positive correlation (r = 0.78), suggesting that a near-surface air temperature provides a good approximation of the soil temperature. This piece of information is a vital input for the projection of future trajectory of soil CO_2 emissions and conservation of C stocks in the forest fire and undisturbed forests.

Keywords: Forest fire, Climate change, Soil temperature, Air temperature, Dry soil, Wet soil.

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Winter Soil Respiration, Temperature, and Soil Moisture in Snow-Manipulated Postfire and Undisturbed Black Pine Forests in Taşköprü, Kastamonu District, Türkiye

Renato S. Pacaldo[1,2]✉, Miraç Aydın[1], Randell Keith Amarille[1,2]

[1]*Kastamonu University, Faculty of Forestry, Kastamonu/TÜRKİYE*

[2]*Mindanao State University-Main Campus, College of Forestry and Environmental Studies, Department of Forestry, Marawi City, Lanao del Sur/PHILIPPINES*

✉***Correspondence***: renato.pacaldo@msumain.edu.ph

Abstract: Climate change has been fueling forest fires worldwide and driving warmer winters in temperate countries. Recently, wildfires devastated large track of forest lands in Canada and Hawaii, resulting in the unfortunate loss of lives and properties. A warmer climate forecast not only increases the occurrence of forest fires but also brings about a snow-free warm winter season. Given these consequences of a warmer climate, a critical question is whether these climate change-related impacts significantly enhance soil respiration (R_s) in forest fire areas and standing undisturbed forest ecosystems. We conducted a field experiment in one of the recently burned black pine forest (*Pinus nigra* Arnold). We employed an automated soil respiration machinery (Li-8100A, LiCor BioSciences) to measure the soil CO_2 emissions, soil temperature, air temperature, and soil moisture simultaneously. We found that a warmer winter results in higher soil respiration rates and warmer soil temperatures in undisturbed forests, indicating its less sensitivity to snow cover. In contrast, the snow-free post-fire treatment exhibited significantly reduced soil respiration rates and freezing soil temperature at the height of the winter season. We concluded that the complementary effects of lack of snow and forest fire resulted in a significant decrease in soil respiration rates, and, thus, potentially resulted in the conservation of soil C stocks during the winter period. The higher soil respiration and warmer soil in the undisturbed forest could accelerate the decomposition of soil organic matter and increase the contribution to atmospheric CO_2, thus providing positive feedback to climate change. Given the global concerns about climate change impacts and the frequency of forest fires, the findings of this study would help us understand the impacts of forest fires and lack of snow in climate-soil respiration feedback.

Keywords: Climate change, Forest fire, Warm winter, Snow-free, Carbon dioxide.

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Evaluation of Carbon Sequestration Capacities Across Varied Forest Types: An Empirical Study in Northern Part of Bangladesh

Md Shafiqul Bari✉, Farhana Mim, Md Manik Ali

Hajee Mohammad Danesh Science and Technology University, Department of Agroforestry and Environment, Dinajpur/BANGLADESH

✉***Correspondence***: barimdshafiqul@gmail.com

Abstract: The aim of this study was to assess the ability of several distinct forestry systems in Bangladesh's northern region to sequester carbon. Three different agro-ecological zones (AEZs) were covered by the experiments: AEZ 1 (Old Himalayan piedmont plain), AEZ 3 (Tista meander flood plain), and AEZ 25 (Level barind tract). Experimental plots with three replications were randomly selected from each AEZ using a randomized complete block design (RCBD). Factor A, which represented five forestry models (Shal forest, social forest, eucalyptus cropland-based agroforestry, and mango and litchi orchard-based agroforestry systems), and Factor B, which represented the three aforementioned AEZs. To determine the total biomass accumulation, undergrowth vegetation (including herbs, shrubs, and crops) and tree growth parameters, like height and diameter at breast height (DBH), were studied. In terms of parameters like tree height, DBH, tree density, understory vegetation, and carbon sequestration in both trees and soil, the results showed significant differences across forestry systems. Notably, the Litchi orchard-based agroforestry system sequestered the least carbon, at 67.82 t/ha, whereas the Shal forest system did so at a rate of 2310.04 t/ha. Regarding the AEZs, AEZ 25 had the highest potential for sequestering carbon, measuring 644.98 t/ha, while AEZ 1 had the lowest potential, measuring 503.21 t/ha. Variability in carbon sequestration was also revealed by the interaction between AEZs and forestry systems. The Shal forest system and AEZ 3 were found to have the highest capacity at 2661.09 t/ha, while AEZ 1 and the Litchi orchards-based agroforestry system had the lowest capacity at 66.09 t/ha. In conclusion, the Shal forestry system demonstrated the highest capacity for conserving carbon and is, therefore, a promising strategy for reducing atmospheric carbon in the area. AEZ 25 demonstrated the best capacity for carbon sequestration of all the AEZs examined. Additionally, at $115,502/ha, the Shal forestry system provided the highest economic return on carbon sequestration. These findings suggest that the Shal forestry system should be given importance in Bangladesh's northern region for ecological reasons. Additionally, to balance carbon sequestration capacities between the zones, strategic tree planting programs should be implemented in AEZs 1 and 3.

Keywords: Carbon sequestration, Dinajpur District, Agro-ecological zones, Forestry systems.

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Breaking Carbon Bonds of the Colors Existing in the Industrial Wastewaters and Color Reduction by Plant-Based Coagulants

Hanieh Mirbolooki*✉, *Shamim Moghadami

The Academic Center for Education, Culture and Research (ACECR), Environmental Research Institute, Rasht/IRAN

✉***Correspondence***: mirbolooki@acecr.ac.ir

Abstract: Colored effluents destroy aquatic lives because of existing non-biodegradable aromatic hydrocarbons which lead to serious threats for human and environment. Using chemical coagulants for industrial wastewater treatment is one of the conventional methods which, secondary pollution caused by residual sludge, limited removal of dissolved organic carbon in wastewater, high volume of sludge and bad effect on human health has faced a challenge applying this type of coagulants. Therefore, the purpose of this research is the production of coagulants using available and local plants, including *Spinacia oleracea* and *Hibiscus cannabinus* as eco-friendly coagulants which are able to remove these hard to treatment pollutants by breaking carbon bonds in aromatic rings as the main components of the colors' chemical compounds existing in industrial wastewaters. The plant extracts of *Spinacia oleracea* and *Hibiscus cannabinus* were obtained through maceration method (soaking and shaking the plant seeds in water at a given time) and 5 doses of 50, 100, 200, 500, and 1000 mg/L of plant coagulants were prepared. In this research, the coagulants were used to treat the real-colored industrial wastewater. In the optimum treatment conditions of 100 mg/L coagulant dose and pH 7, high color reduction (>74%) were obtained by both plant extracts (plant coagulants). FT-IR spectra were performed on the plant extracts to identify the existing carbon destruction agents in active extracts. It should be mentioned that the only applied solvent for extracting the natural coagulant seeds was distilled water, and none of the other solvents such as NaCl and NaOH were used.

Keywords: Carbon bonds, Plant coagulant, Color reduction, Aromatic hydrocarbons, Colored effluents.

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Estimating Above-Ground Carbon of Taurus Cedar Stands Using Sentinel-2 Satellite Image: A Case Study of Elmalı Forest Enterprise

Döndü Demirel[1]✉, Alkan Günlü[2], Oytun Emre Sakıcı[1]

[1]*Kastamonu University, Faculty of Forestry, Kastamonu/TÜRKİYE*

[2]*Çankırı Karatekin University, Faculty of Forestry, Çankırı/TÜRKİYE*

✉***Correspondence***: ddemirel@kastamonu.edu.tr

Abstract: Most terrestrial carbon (C) is stored in forests, an important source of fiber and fuel for humans. Therefore, forests play an essential role in mitigating the effects of climate change by reducing the carbon level in the atmosphere. Field measurements and remote sensing techniques determine the stored above-ground carbon (AGC). This study used Sentinel-2 satellite image to estimate the amount of AGC in pure Taurus cedar (*Cedrus libani* A. Rich.) stands in Elmalı Forest Enterprise. Regression models were developed for AGC estimation with the reflectance and vegetation indices obtained from the Sentinel-2 satellite image. Within the scope of the study, the field measurement data obtained from 120 sample plots were used and AGCs of their corresponding stands were estimated with an allometric equation. The sample plots data was randomly divided into modeling (70%, 84 sample plots) and control data (30%, 36 sample plots) to fit the regression models and to test the accuracy of the models, respectively. Multiple linear regression analysis were conducted to develop the models, and three goodness-of-fit statistics (R^2, *RMSE* and *MAE*) were used to compare the success of these models. When the achievements of the models were evaluated, it was revealed that the model containing the MSR vegetation indice gave more successful results (R^2=0.488). Consequently, it was determined that the developed models were moderately successful in estimating AGC.

Keywords: *Cedrus libani*, AGC, Remote sensing, Vegetation indices, MSR, Sentinel.

1. INTRODUCTION

The Paris Climate Agreement stipulates the reduction of fossil fuel emissions and net neutral carbon emissions by balancing source and sink areas by 2100 (Walsh et al., 2017). At the same time, one of today's most significant issues is reducing greenhouse gas (GHG) emissions by phasing out the infrastructures and technologies that produce fossil carbon emissions (Berndes et al., 2016). Determining the potential of carbon sinks and reducing emissions is crucial (Vashum & Jayakumar, 2012). Oceans, wetlands, rocks and forests are the leading carbon sinks. At the same time, these areas are critical in emission reductions (Dixon et al., 1994; Moomaw et al., 2018). Terrestrial ecosystems are currently a significant net sink for atmospheric CO_2 on a global scale (approximately 1 gigaton C annually) [Canadell & Raupach, 2008].

Forestry is more responsible for a fifth of the world's carbon emissions than the global transport industry. According to Climate Change: Global Forest Financing, a total of $3.7 trillion in long-term savings could be achieved by halving deforestation. However, if nothing is done about deforestation on a global scale, the worldwide economic cost of climate change will be predicted to reach 12 trillion USD (Eliasch, 2008). To monitor and examine climate change, which is directly related to carbon emissions, in temporal and spatial terms, the amounts of carbon released and stored must be determined (Vashum & Jayakumar, 2012).

Traditionally, a forest's above-ground carbon (AGC) stock is obtained through field measurement. This method is expensive, often labor-intensive, time-consuming, and limited area. Instead of traditional methods, remote sensing offers a faster, repeatable, objective and effective way (Myeong et al., 2006). In addition, it allows working in larger areas with less cost and labor. Band reflectance, vegetation indices and various remote sensing data are commonly used to estimate carbon stock with remote sensing (Aricak et al., 2015; Günlü & Ercanlı, 2020; Günlü et al., 2021; Keleş et al., 2021; Turgut & Günlü, 2022; Bulut et al., 2022; Oktian et al., 2022; Sivrikaya & Demirel, 2022).

This study aimed to investigate the possibilities of using Sentinel-2 satellite images in estimating the AGC stock for pure Taurus cedar stands spread in Elmalı Forest Enterprise, Antalya/Türkiye.

2. MATERIALS AND METHODS

2.1. Study Area

The study area includes pure Taurus cedar stands of Elmalı Forest Enterprise, located in the Mediterranean region of Türkiye. This enterprise consists of Çığlıkara, Elmalı and Tekke Planning Units (PU). It is situated between 29°39′00″ and 30°18′00″ Eastern latitudes and 36°27′00″ and 37°00′00″ Northern longitudes (Figure 1). The elevation of the study area varies from 1015 to 3054 m. The study area is 180884.4 ha; approximately 36% (64623.7 ha) of this area consists of forests and 64% (116260.7 ha) of open areas. 42% (26723.8 ha) of the forest area consists of high forests and 58% (37899.9 ha) of degraded forests. The study area has Mediterranean climate. In addition, Brutian pine, Taurus cedar, black pine, Taurus fir, juniper and oak species are common. According to the Köppen climate system, the study area is in the C (temperate) climate group, Csa class, representing the hot summer Mediterranean climate. The C indicates cold, dry and hot summer in the Csa climate type. The coldest month is above 0 °C, the hottest month is above 22 °C, and the average temperature for at least four months is over 10 °C, according to monthly averages. The wettest month of the year experiences at least three times as much rain as the driest month of the year. The driest month of summer sees less than 30 mm of precipitation (Beck et al., 2020).

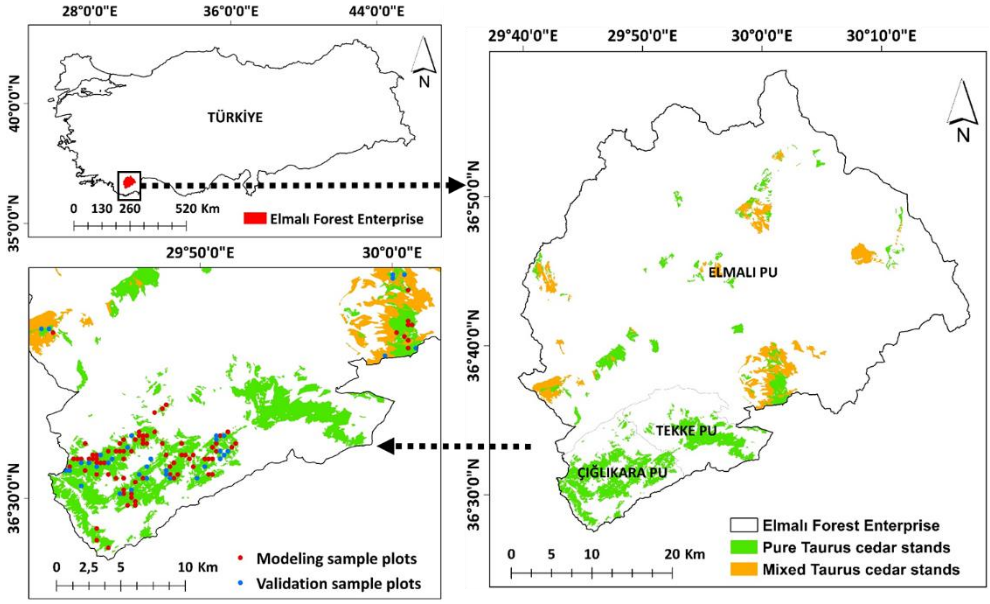

Figure 1. Study area and sample plots**.**

2.2. Field Measurement

In the study, the data obtained from 120 sample plots of pure Taurus cedar stands, taken in 2016 to make the Forest Management Plans of the Planning Units of the Elmalı Forest Enterprise, were used as field measurement data (Anonymous, 2016). Sample plots were taken as circular sample plots of 800 m^2 in stands with 11-40%, 600 m^2 in stands with 41-70%, and 400 m^2 in stands with more than 71% crown closure. The diameter at breast height (*dbh*, cm) of all trees 8 cm and above in each sample plot was measured. The volumes and above-ground carbon amounts of all trees measured in the sample plots were calculated using allometric equations (Equation 1 and 2) developed by Durkaya et al. (2013) for pure Taurus cedar stands in Elmalı region. Then, above-ground carbon stocks of all trees in each sample plot were summed, and stand-level above-ground carbon stocks (t ha^{-1}) were calculated.

$$V = 0.0676 + (-0.0134 * dbh) + (0.001 * dbh^2) \quad (1)$$

$$AGC = 1.518083 + (343.1626 * V) \quad (2)$$

Where; *dbh*, diameter at breast height (m); *V*, stem volume (m^3); *AGC*, above-ground carbon stock (kg).

To create data sets for model development and validation, 120 sample plots were randomly divided into two groups: the modeling data (70%, 84 sample plots) and the validation data (30%, 36 sample plots). Table 1 provides summary statistics of field measurement data.

Table 1. Descriptive statistics of sample plots.

Statistics	Stand volume (m^3 ha^{-1})	AGC (t ha^{-1})
Modeling data (84 sample plots)		
Minimum	18.020	6.639
Maximum	439.560	151.410
Mean	189.991	66.024
Standard deviation	99.850	33.385
Validation data (36 sample plots)		
Minimum	10.393	3.997
Maximum	413.680	142.756
Mean	191.404	66.551
Standard deviation	109.026	37.740

2.3. Remote Sensing Data and Processing

The Sentinel-2 satellite image used in this study was downloaded free of charge from https://dataspace.copernicus.eu. Sentinel-2, starting from 2015, has extended to visible four spectral bands (Bands 2, 3, 4, and 8) at 10 m, near-infrared six bands (5, 6, 7, 8a, 11, and 12) at 20 m and shortwave infrared three bands (1, 9 and 10) at 60 m spatial resolution. Since the field measurements given the data used in the study were obtained in 2016, the Sentinel-2 satellite image dated 24.07.2016 was used to collect remote sensing data. The strip width of this image is 290 km and the temporal resolution is 10 days. Sentinel-2 satellite image was obtained in Level-1 C format, which includes atmospheric, radiometric, and geometric corrections.

The remote sensing data used in this study were reflectance values and vegetation indices. The reflectance was calculated at each sample plot for ten bands (2, 3, 4, 5, 6, 7, 8, 8a, 11 and 12) of the Sentinel-2 satellite image. In order to obtain reflectance values, the satellite image was calibrated using QGIS 3.8.1. To calculate the reflectance values of the sample plots, a "buffer zone" was created according to the sample plot sizes (11.28, 13.82, and 15.96 m radius) using ArcGIS 10.8.1. Reflectance values were obtained by averaging the pixel values within the sample plot boundaries with the "zonal statistics tabulated" command for each band. 32 different vegetation indices obtained from the literature were calculated. The reflectance values of the Sentinel-2 satellite image were used to calculate these indices (Table 2).

Table 2. Calculated vegetation indices.

Vegetation Indice	Reference
BNDVI (Blue-normalized difference vegetation indice)	Yang et al. (2007)
Clgreen (Chlorophyll content)	Gitelson et al. (2003)
Clrededge (Chlorophyll indice rededge)	Gitelson et al. (2003)
CTVI (Corrected transformed vegetation indice)	Perry Jr and Lautenschlager (1984)
CVI (Chlorophyll vegetation indice)	Vincini et al. (2007)
DVI (Differenced vegetation indice)	Richardson and Wiegand (1977)
EVI (Enhanced vegetation indice)	Huete et al. (2002)
EVI2 (Enhanced vegetation indice 2)	Miura et al. (2008)

Table 2. (continued)

Vegetation Indice	Reference
EVI2.2 (Enhanced vegetation indice 2.2)	Jiang et al. (2008)
GARI (Green atmospherically resistant vegetation indice)	Gitelson et al. (1996)
GBNDVI (Green-Blue normalized difference vegetation indice)	Wang et al. (2010)
GEMI (Global environment monitoring indice)	Pinty and Verstraete (1992)
GNDVI (Green normalized difference vegetation indice)	Gitelson et al. (1996)
GLI (Green leaf indice)	Gobron et al. (2000)
GOSAVI (Green optimized soil-adjusted vegetation indice)	Rondeaux at al. (1996)
GRNDVI (Green-Red normalized difference vegetation indice)	Gitelson and Merzlyak (1996)
GSAVI (Green soil adjusted vegetation indice)	Sripada (2005)
GVMI (Global vegetation moisture indice)	Ceccato at al. (2002)
LCI (Leaf chlorophyll indice)	Thenkabail at al. (1999)
MNDVI (Modified normalized difference vegetation indice)	Jurgens (1997)
MSR (Modified simple ratio)	Chen (1996)
NBR (Normalized difference NIR/SWIR normalized burn ratio)	Key and Benson (2005)
NDVI (Normalized difference vegetation indice)	Rouse et al. (1974)
NDWI (Normalized difference water indice)	McFeeters (1996)
NLI (Nonlinear vegetation indice)	Goel and Qin (1994)
PNDVI (Pan normalized difference vegetation indice)	Wang et al. (2007)
PVR (Photosynthetic vigor ratio)	Metternicht (2003)
SAVI (Soil adjusted vegetation indice)	Huete (1988)
SARVI (Soil and atmospherically resistant vegetation indice)	Kaufman and Tanre (1992)
TCARI (Transformed chlorophyll absorption ratio)	Daughtry et al. (2000)
WDVI (Weighted difference indice)	Clevers (1989)
WDRVI (Wide dynamic range vegetation indice)	Gitelson (2004)

As a result, 42 remote sensing data were produced for each sample plot, including 10 reflectance values and 32 vegetation indices using Sentinel-2 satellite image.

2.4. Modeling and Model Validation

Multiple linear regression (MLR) was used to fit the relationships between above-ground carbon (AGC) and remote sensing data (reflectance values and vegetation indices obtained from the Sentinel-2). The stepwise variable selection method was used to generate MLR models for the least squares method. Thus, the success of reflectance and vegetation indice values in AGC prediction was tried to be revealed.

The goodness-of-fit measures used to assess the MLR models included coefficient of determination (R^2), root mean square error (*RMSE*), and mean absolute error (*MAE*).

$$R^2 = 1 - \frac{\sum(y_i - \hat{y}_i)^2}{\sum(y_i - \bar{y})^2} \quad (3)$$

$$RMSE = \sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{n-1}} \quad (4)$$

$$MAE = \frac{\sum|y_i - \hat{y}_i|}{n} \quad (5)$$

These equations use the variables y_i and $\hat{y}_i$ to represent observed and expected AGC, respectively.

The suitability of the models developed to estimate AGC was tested with an independent validation data group. For this purpose, a comparison was made with the Paired Samples *t*-Test using the data obtained from field measurements from the sample plots allocated for validation data and the prediction data calculated for the relevant sample plots with the help of the models developed.

3. RESULTS AND DISCUSSION

The correlation analysis resulted that the DVI, GOSAVI, and GSAVI indices didn't show significant correlation with AGC (p>0.05). During the modeling phase, the other reflectance values and vegetation indices were considered as independent variables (Table 3).

Table 3. Correlations between AGC and Sentinl-2 data.

Variable	*r*	Variable	*r*	Variable	*r*
SB4	-0.668**	WDRVI	0.669**	NDWI	0.565**
SB11	-0.634**	GEMI	0.667**	Clrededge	0.477**
SB2	-0.633**	GRNDVI	0.663**	NLI	0.471**
SB12	-0.631**	ChlGreen	-0.649**	SARVI	-0.452**
SB3	-0.598**	GNDVI	0.649**	SAVI	0.427**
SB5	-0.581**	PVR	0.647**	CVI	0.422**
SB8a	-0.461**	GBNDVI	0.639**	EVI	0.378**
SB8	-0.453**	GLI	0.639**	EVI2.2	0.367**
SB6	-0.449**	PNDVI	0.624**	TCARI	0.327**
SB7	-0.434**	BNDVI	0.618**	EVI2	0.294**
GARI	0.672**	LCI	0.604**	WDVI	-0.292**
CTVI	0.669**	GVMI	0.602**	DVI	0.082
MSR	0.669**	MNDVI	0.569**	GOSAVI	-0.069
NDVI	0.669**	NBR	0.569**	GSAVI	-0.076

**Correlation is significant at the 0.01 level. *Correlation is significant at the 0.05 level.

Firstly, the MLR models for AGC were fitted separately for reflectance values and vegetation indices. In the models developed with reflectance values, the coefficient of determination of the model with Band 4 was 0.423, while the model success was 0.456 with the inclusion of Band 6 in the model. The other reflectance values did not make significant contributions. In the models fitted using vegetation indices, the most successful model contained only the MSR indice (R^2=0.488). Then, all remote sensing data (reflectance values and vegetation indices) were tried to fit, but the MSR indice was also an alone independent variable within the final model. As a result, among the developed models, the model with the MSR indice has the highest R^2 and the lowest *RMSE* and *MAE* values (Table 4).

Table 4. Multiple linear regression results for AGC.

Independent variable groups	Independent variables (xi)	Coefficients (bi)	R^2	*SEE*	*RMSE*	*MAE*
Reflectance	Constant	117.107	0.423	25.657	26.673	22.313
	B4	-904.712				
	Constant	73.507	0.456	25.080	25.797	21.511
	B4	-1299.940				
	B6	440.594				
Vegetation Indice	Constant	-17.802	0.488	24.173	24.027	19.926
	MSR	71.593				
Reflectance-Vegetation Indice	Constant	-17.802	0.488	24.173	24.027	19.926
	MSR	71.593				

Paired *t*-test results showed no statistical difference ($p>0.05$) between the estimated values of AGC and those obtained by field measurements (Table 5). The developed models are suitable for pure Taurus cedar stands from which the data obtained to develop these models.

Table 5. t-test results for models developed for AGC predicted.

Model	Variables	Mean	Standard Deviation	Standard Error of Estimation	*t*	*p*-value
1	B4	70.629	34.318	5.720	-0.712	0.481
2	B4 and B6	72.341	36.358	6.110	-0.948	0.350
3	MSR	70.047	38.289	6.381	-0.548	0.587

According to the residual graphs of the developed models, the estimated AGC values in the model developed with Band 4 show systematic residuals. Similarly, the systematic residual was also observed in the model graph generated with Band 4 and 6. The model developed with MSR, however, shows random residual distribution, in contrast to the models with reflectance values (Figure 2).

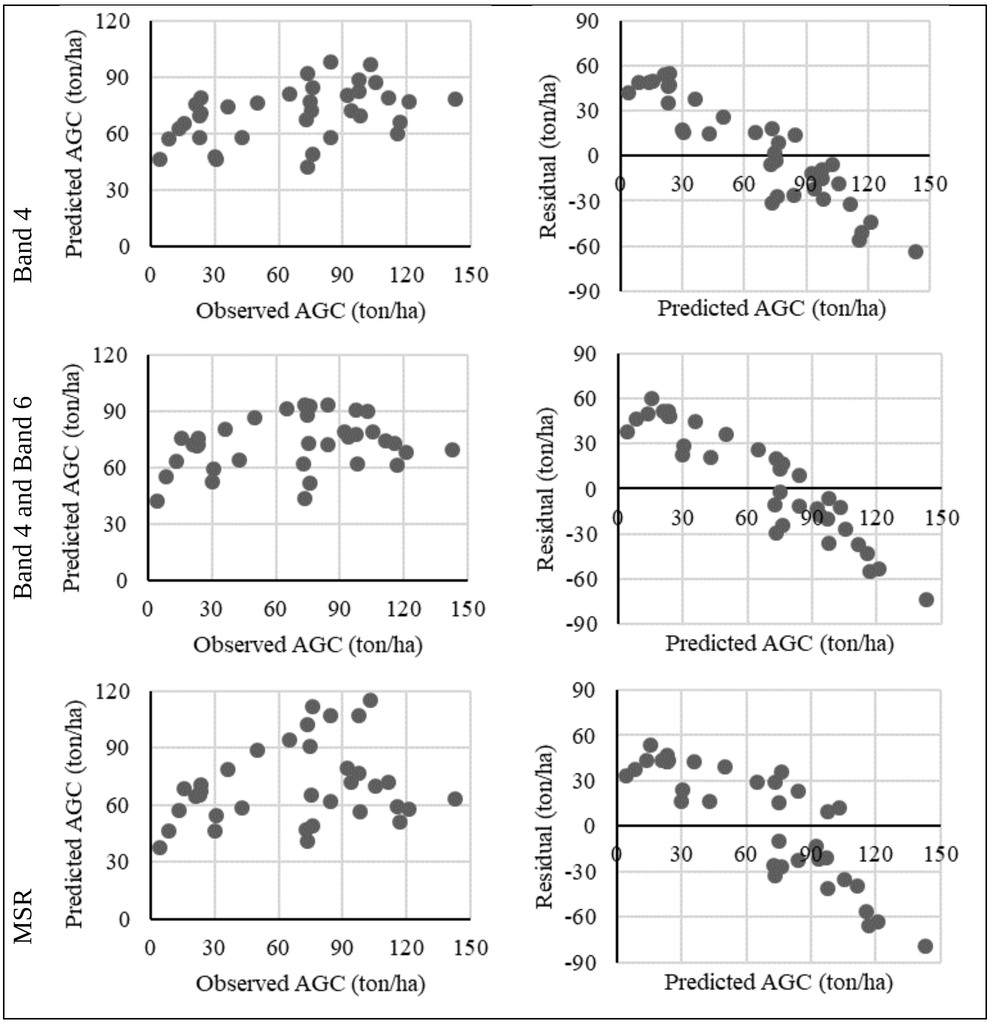

Figure 2. Observed vs. predicted graphs and residual distributions of the models developed.

The best model results for AGC estimations were obtained with independent variable group including the MSR indice (R^2=0.488). On the other hand, model success increased with the inclusion of Band 6 to the reflectance-based models that contained Band 4 (R^2=0.456). In the model with all remote sensing data, i.e., reflectance and vegetation indices were together, the resulting model had the MSR indice only. There are some studies in the literature use Sentinel 2 images and remote sensing data in modeling the AGC, and this study showed similar results to the literature. Moradi et al. (2022) estimated the AGB in the Hyrcanian forests with the Sentinel-2 satellite image using stepwise regression, and Band 6 gave the most successful model (R^2=0.547). In our study, model success increased also with introducing Band 6 into the model. Nuthammachot et al. (2022) developed the most successful model (R^2=0.820) with NDI45 and Band 6 to estimate AGC with Sentinel-2 satellite image. Keleş et al. (2021) estimated the AGC with the reflectance values using Sentinel-2 satellite image for Hızardere PU in Türkiye. Among the reflectance values, they best predicted AGC with Band 4 (FI=0.454) as in our study. Pandit et al. (2018), in Nepal Parsa National Park, modeled the AGC with 23 different variables (R^2=0.810) using the Random Forest method backward technique with the reflectance and vegetation indices obtained from the Sentinel-2 satellite image. Askar et al. (2018) successfully modeled AGC with the MSR indice (R^2=0.750) using linear regression with Sentinel-2 in Indonesia's Jetis and Girisekar forests. Lu et al. (2022) used the MSR indice from the Sentinel 2 satellite image (R^2=0.580) to estimate the above-ground biomass with regression analysis in the Nan Da Gang Wetland Protected Area in China. Vegetation indices derived from various satellite images have also been researched. In the Bedul Mangrove Block, Purnamasari et al. (2021) predicted the AGC with DVI acquired from PlanetScope image (R^2=0.670). Sivrikaya and Demirel (2022) estimated the AGC in Burmahanyayla PU with Landsat-9. They developed a model to estimate AGC with NDVI obtained from Landsat-9 (R^2=0.623).

4. CONCLUSION

According to the results of this study, R^2 values of the MLR model generated from Sentinel-2 for AGC were found to be 0.488. The best regression result for AGC was obtained with the independent variable group including vegetation indices. The prediction success of AGC models is partially sufficient. The possible reasons for these deficiencies could be the spatial resolution of the satellite image, acquisition time and correction errors, mounting method, topographic and stand structure of the study area, etc. In addition, errors that may occur in measurements during forest inventory affect the model’s success. Satellite imagery with high spatial resolution and additional modeling techniques such as machine learning methods (SVM, ANN, RF, K-ENN, etc.) can be employed to improve the performance of regression models in AGC prediction. Sentinel-1 satellite images, which have a higher resolution than Sentinel-2, can be used and received without cost if price is a concern. The use of unmanned aerial vehicle images for remote sensing in forestry, which has lately gained popularity, requires new and updated research.

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ORAL PRESENTATION https://doi.org/10.61326/icelis.2023.46

Carbon Binding of Different Provenances of Douglas fir (*Pseudotsuga menziesii* Mirb. Franco)

Dalibor Ballian[1,2,3], Mirzeta Memisevic Hodzic[1]✉
[1]*University of Sarajevo, Faculty of Forestry, Sarajevo/BOSNIA AND HERZEGOVINA*
[2]*Slovenian Forestry Institute, Ljubljana/SLOVENIA*
[3]*Academy of Sciences and Arts of Bosnia and Herzegovina, Sarajevo/BOSNIA AND HERZEGOVINA*
✉***Correspondence***: m.memisevic-hodzic@sfsa.unsa.ba

Abstract: Forest tree species are very important in terms of carbon sequestration. Trees store 50% to 75% of the carbon they take up from the atmosphere in their wood, and the rest is released back into the atmosphere during respiration. Douglas fir is forest tree species native to North America, but shown successful growth and high productivity and quality in Europe. Douglas-fir is also considered as a species with high carbon sequestration, with the yearly average carbon storage of 46,46 kg CO_2/year and for this reason it is increasingly popular as a tree for planting. This research aims to select the best provenances of Douglas fir for carbon sequestration in the provenance test in Bosnia and Herzegovina. Material for this research were Douglas fir trees in provenance test in Bosnia and Herzegovina, locality Batalovo brdo near Sarajevo. The provenance test was established in 1966. by planting 2+2-year-old seedlings, and included 5 provenances from Washington, Oregon and Canada, and from altitudes of 150-900 m above the sea. Heights and diameter at breast height of 52-year-old trees were measured, and volumes of trees were calculated. The results showed that the lowest average volume had provenance from the altitude of 900 m, 83-3.0 (0.7313 m^3), and the highest provenance from 300 m, 65-1,0 (1.3410 m^3). If there are 625 trees per ha, provenance 83-3,0 would produce 457 m^3/ha, and provenance 65-1,0 838 m^3/ha, which indicates differences in carbon sequestration. The obtained results can be used in selection of provenance for using in introduction of Douglas fir in Bosnia and Herzegovina.

Keywords: Douglas fir, Provenances, Carbon sequestration.

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The Role of Monumental Trees in Carbon Storage

***Ercan Oktan*[1], *Neslihan Atar*[2]✉**

[1]*Karadeniz Technical University, Forestry Faculty, Trabzon/TÜRKİYE*
[2]*Artvin Çoruh University, Forestry Faculty, Artvin/TÜRKİYE*
✉***Correspondence****:* atarnesli@gmail.com

Abstract: Forest ecosystems are an important component of the global carbon cycle. Changes in the forest carbon cycle were determined by considering the biological structures at the leaf and stand level. However, there is no consensus on the nature of productivity at the individual tree scale. The mass growth rate of trees, and thus carbon deposition, differs depending on the size and age of the trees. In this study, the role of old monumental trees, which provide a wide variety of ecological functions and environmental benefits, in carbon storage was investigated. Because nowadays, the importance of monumental trees in carbon sequestration and protection of biological diversity in forest management has been better understood and accordingly, monumental old trees have become a significant research subject. Although monumental trees make up a small proportion of the number of stems in a given stand or vegetation, they contribute greatly to carbon biomass and help reduce global warming. Monument trees have special structures that allow long-term carbon accumulation to be sustained. Features such as slow growth, stress tolerances, mosaic structure, phenotypic plasticity, and rejuvenation potential allow for sustained age-related increases in growth, allowing for long-term carbon accumulation. In addition, changes in available resources due to global warming may be an indicator of increases in the biomass of these trees. However, these issues are still under discussion. The slow but continuous growth abilities of these trees in order to achieve longevity contribute significantly to the total carbon stock and wood production. In addition, when these trees are evaluated at the stand scale, they also make a significant contribution in terms of annual carbon sequestration. Monument trees are not just aging carbon stores. They are unique beings that can hold large amounts of carbon compared to young trees. Depending on the growth and development status, the carbon sequestration capacities show a high increase, although disproportionately. In some forest types, the largest and oldest trees continue to accumulate large amounts of biomass even though they are at the end of their natural life stages. On the other hand, there are many different opinions. These views are generally based on an assumption that older individuals have reduced biomass accumulation. Therefore, it is argued that younger trees can sequester more carbon. In line with the same view, there is a widespread opinion that carbon accumulation obtained by photosynthesis is lost by respiration due to stand development in old forests. This situation suggested that old forests are negligible as carbon sinks. There are studies showing that old forests can continue to accumulate carbon contrary to the long held view that they are carbon neutral. Numerous hypotheses have been developed to explain age- and size-related changes in biomass. In this context, the change in biomass; It has been attributed to the changing balance between photosynthesis and respiration, increased hydraulic resistance, decreased nutrient supply, differences in the access rates of resources necessary for growth, and genetic changes due to meristem age. However, these hypotheses expressing the change in growth may not be consistent as they vary depending on the species, vegetation period and growing environment. This situation falls short of explaining the physiological basis of the changes in the biomass size of these trees. The fact that the ecological role of these trees, which are rare in the world and disappear for various reasons, cannot be fulfilled by any other living thing, requires increasing the studies on these trees. In this context, when the average annual increase in diameter of a 2 m-diameter Oriental beech (*Fagus orientalis*) tree is assumed to be 0.5 cm, its annual increase is calculated as 0.182 m^3. The fact that this value is not to be underestimated shows that these trees can be considered as carbon storage areas. Therefore, the role of monumental trees in carbon storage should be re-evaluated.

Keywords: Monumental tree, Biomass, Carbon sequestration, Carbon storage, Growth.

1. INTRODUCTION

Known as "living fossils", large old trees play an important role in ecology, landscape, and culture and are an important part of ecosystems (Fu et al., 2022). Monumental trees are among the biggest and most long-lived organisms on earth (Lanner, 2002; Mattioni et al., 2020). The longevity, size, and spatial distribution of large old trees are dependent on evolutionary origins (Tng et al., 2012), long-term environmental changes (Phillips et al., 2008), and historical decay regimes (D'Amato & Orwig, 2008). Monumental trees have numerous ecological, physiological and evolutionary properties that provide many benefits at the ecosystem level due to their extremely long lifespan. Additionally, these trees are pioneers of change in a rapidly changing world and in the history of plant life, given their adaptations for stability and longevity, their specific environments and life histories. Centennial or millennial trees that can survive long-term are vital to maintaining the resilience and adaptive capacity of forests in an ever-changing environment. At the same time, monumental trees provide numerous ecological and environmental benefits for the development of all life forms and can preserve these benefits for a long time. Revealing the numerous benefits that monumental trees have developed depending on their different and superior features will be important for the protection of these trees and thus for the continuation of these benefits.

1.1. Ecological Roles of Monumental Trees

Monumental trees are critical organisms and ecological structures in forests, savannas, deserts, and agricultural and urban environments (Lindenmayer et al., 2012; Lindenmayer & Laurance, 2016). They are found individually or in small groups consisting of scattered trees in this ecosystem where they are found worldwide. Therefore, they are considered small natural features (Lindenmayer, 2017). Although they are limited in area, they play many ecological roles. At the same time, the ecological value of monumental trees increases with age. They play many important ecological roles, from storing large amounts of carbon to providing important habitat for wildlife. Besides; It is very important with its roles in ecosystem processes such as hydrological regimes, nutrient cycling, micro- and meso-climatic regimes, providing habitat and nutrients for various plant and animal species (Ligot et al., 2018). Therefore, they are biological legacies that represent the biological and ecological continuity of genetic resources and habitats for various organisms (Manning et al., 2009). They are in harmony with the ecosystem in which they live and have features that help control soil erosion, such as deep rooting or low water use. Monument trees are often reproductively dominant and contribute to the germination of disproportionate numbers of new plant communities in surrounding areas (Smith et al., 2013; Wenk & Falster, 2015). They are singled out by age, their small numbers and restricted distribution, regardless of the priority of its species, being confers as guarantors of the provision of seeds and vegetative material very suitable, with which contribute to natural forest regeneration.

Monument trees play critical roles in carbon storage and therefore in maintaining forest carbon stocks (Slik et al., 2013; Chen & Luo, 2015). Although monumental trees make up a small proportion of the number of stems in a given stand or vegetation, they contribute greatly to carbon biomass (Keith et al., 2009). In some forest types, monumental trees continue to accumulate large amounts of biomass even at the end of their natural life stages (Stephenson et al., 2011). Some of these roles cannot be replaced by other structures. Many of the ecological roles they play in their ecosystem cannot be fulfilled by other living things. Thus, large old trees play a key role (Tews et al., 2004), in terms of their disproportionate contribution to a wide range of ecological processes and their disproportionate value for biodiversity (Manning et al., 2006). They are considered essential components of forest ecosystems.

Monumental trees have a number of key characteristics in addition to extreme age, height, and environment. These features are unique to these trees and provide various benefits. Some important features of monumental trees, such as the presence of deep and widespread root networks, large cavities with large internal volumes, deeply cracked bark, large side branches, wide crown, and productive flowering, constitute their characteristic features (Ashton, 1975; Brokaw & Lent, 1999; Gibbons & Lindenmayer, 2002). Their unique structures provide nesting and sheltering cavities, create different microenvironments, and provide habitat and food for many animal species (Lindenmayer et al., 2012).

The importance of monument trees as habitat for animals and other plants is so great that they can act as 'biodiversity hotspots', supporting many more species than elsewhere in the surrounding landscape (Dean et al., 1999). Many animal species occur in a given area solely due to the presence of large old trees (Kavanagh & Turner, 1994). Monumental trees can continue to have important ecological roles even when they occur as individual trees. For example, they have profound effects on local microclimate conditions, soil moisture, and soil nutrient levels (Dean et al., 1999; Voight et al., 2015**).**

1.2. Monumental Trees and Their Role in Carbon Storage

Forest ecosystems have frequently been subjected to significant environmental changes throughout geological and historical periods. In particular, the pace and complex nature of current global change seem particularly difficult to overcome (Valladares, 2017). Climate changes, especially global warming trends, cause irreversible consequences all over the world. Increasing greenhouse gas emissions (GHG) such as CO_2 are now recognized as the main cause of recent increases in global average temperature and changes in the global hydrological cycle. It has been revealed by the IPCC that warming over the last half century is mostly caused by human activities (>95% probability). Climate change and environmental degradation have reached alarming levels, bringing to the fore the ecological and sociocultural functions of forests as well as their economic functions. Because forests play an important role in reducing global climate change. They remove CO_2 from the atmosphere through photosynthesis and store carbon in their biomass. Forests play a key role in reducing greenhouse gas emissions that cause climate change by serving as carbon sinks. Understanding the magnitude and drivers of the rate of CO_2 exchange between forests and the atmosphere has been a focus of research, given concerns about the effects of increasing atmospheric carbon dioxide levels on climate change (IPCC, 2007).

Forests provide a wide range of ecological services and functions. It is known that carbon sequestration has an important place among the ecosystem services provided by forests and plays a critical role in the fight against climate change (Pukkala, 2016). For this purpose, the scope of forest management today mainly focuses on carbon sequestration and biodiversity. Forests both combat climate change by sequestering carbon and adapt by reducing the effects of climate change. Forest ecosystems are an important component of the global carbon cycle (Gray, 2015). Carbon; It is kept in the trunks, leaves, branches, roots of trees, litter and living cover and forest soil (Houghton, 1999; Goodale et al., 2002).

Changes in the forest carbon cycle were determined by considering the biological structures at the leaf and stand level (Stephenson et al., 2014). However, there is no consensus on the nature of productivity at the individual tree scale. The carbon storage and sequestration rate are directly related to factors such as the species, height, age and leaf biomass and healthy condition of each tree (Gül et al., 2021). CO_2 consumption of forests varies depending on their health, age and location. In this sense, the mass growth rate of trees and therefore their carbon accumulation may vary depending on the size and age of the trees. For this purpose, the role of monumental old trees, which provide a wide range of ecological functions and environmental benefits, in carbon storage was investigated. Because today, the importance of monumental trees in carbon sequestration and biodiversity protection in forest management is better understood, and accordingly, old monumental trees have become significant as a research subject.

The importance of monumental trees is increasing due to global warming and other environmental changes. Because monumental trees are the most important organisms that cope with the negativities caused by changing and developing climatic conditions and biotic and abiotic stress factors in the world. These trees have survived in many stages, from all kinds of climate changes to changes in the surrounding stand structure, in their growth environment for thousands of years (Oktan & Atar, 2021). Although monumental trees make up a small proportion of the number of stems in a given stand or vegetation, they contribute greatly to carbon biomass (Keith et al., 2009) and help reduce global warming. By reconstructing the past climate and environment, these trees have preserved and continue to exist even in long contrasting climatic phases (Medieval Warm Period, Little Ice Age, global warming) [Caetano-Andrade et al., 2020]. Monumental trees are natural and human-made systems against a climatic stimulus and its effects; They constitute the most important group of living beings that adapt to this bad situation by adjusting or changing themselves to reduce the effects of harm or benefit from the benefits.

Atmospheric carbon dioxide (CO_2) has increased significantly during the current lifespan of these long-lived trees and old-growth forests. In the early twenty-first century, it was thought that a 500-year tree spent 70% of its life growing under pre-industrial CO_2 levels that were 30% lower than current levels. For this purpose, Phillips et al. (2008) investigated the question of whether old trees respond to the rapid CO_2 increase that has occurred in the last 150 years. Despite limited data, senescent trees have been shown to have a significant capacity for increased net growth following post-maturity growth decline. Increases and changes in key environmental resources, including CO_2, have been associated with growth and physiological functions in old trees. It was thought that this may indicate the potential for continued growth in old trees as a function of ongoing global climate change. In addition, there are opinions that CO_2-induced stimulation of tree growth (Körner, 2009; van der Sleen et al., 2015) is not certain. For this reason, it is not clear whether changes in available resources due to global warming are indicators of increases in the biomass of trees.

There are synergistic relationships between the longevity of monumental trees and the benefits they provide to the ecosystem. Because the ecological value of these trees increases with age. The longevity of monumental trees results from a combination of mechanisms that serve both to prevent senescence (modularity, continuous growth, dormancy) and to tolerate aging (stress tolerance), creating tremendous potential and resilience in longevity (Munne-Bosch, 2020). Several mechanisms have evolved in individual trees to enable extreme longevity and deal with negative effects of agein. Senescence implies a reduction in vigor. Therefore, continuous growth is the most effective mechanism in preventing aging (Cannon et al., 2022). The slow but continuous growth ability of these trees to achieve longevity makes a significant contribution to the total carbon stock and wood production. These mechanisms specific to monumental trees also allow the long-term carbon accumulation of monumental trees to be sustained.

Carbon stocks of forests are a result of both, carbon capture by biomass growth and the duration of carbon in biomass. It is stated that the carbon capital of forests is controlled by tree life rather than growth rate (Körner, 2017). Although carbon stock dynamics occur in quite large areas, they can be attributed to the dynamics of individual tree communities. Because monumental trees determine stand level dynamics (Newberry & Ridsdale, 2016), they play an important role in small-scale carbon accumulation and storage. Old trees simultaneously increase carbon capital with their long lifespan and continuous growth ability (Köhl et al., 2017). They store large amounts of carbon due to their high wood volume.

Although the ecological value of a monumental tree increases with age, its biological growth rate slows down with increasing age. So tree age and tree size are not necessarily related. The decrease in the growth rate, that is, the photosynthetic capacity, of monumental trees causes them to capture less carbon. However, it stores more carbon due to the increase in its biomass. Young trees have relatively low carbon accumulation. Young trees use the carbon they obtain through photosynthesis to convert it into growth energy rather than storing it. Young trees use biomass production to increase height rather than diameter growth until they reach the upper layer (Rozendaal & Zuidema, 2011; Newberry & Ridsdale, 2016).

Old trees store the majority of the carbon they obtain through photosynthesis. Old trees have low growth energy. Therefore, carbon accumulation is high. Young trees capture more carbon, while old trees store more carbon. In this context, when the average annual increase in diameter of a 2 m-diameter Oriental beech (*Fagus orientalis*) tree is assumed to be 0.5 cm, its annual increase is calculated as 0.182 m^3. The fact that this value is not to be underestimated shows that these trees can be considered as carbon storage areas. Therefore, the role of monumental trees in carbon storage should be re-evaluated.

Tree growth and longevity; are the main factors that manage the diversity, functions and productivity of forests (Lorimer et al., 2001; Köhl et al., 2017). Research on the factors controlling these is essential to improve forest management (Worbes et al., 2003). Studies to be carried out are extremely important, especially in terms of the uncertainty of how long monumental trees, which are rare in the ecosystem, can maintain the numerous ecological and environmental benefits that cannot be provided by other trees or plants.

2. DISCUSSION AND RECOMMENDATIONS

The growth behavior of monumental trees is not well known. Revealing the growth behavior of trees provides insights into forest ecology and plant physiology. It can also improve our understanding of forest productivity, carbon storage, and dynamics (Clark & Clark, 1996; Slik et al., 2013). However, the physiological basis of the growth patterns of monumental trees has not been adequately documented.

There are limited studies on how the mass growth rate and therefore carbon accumulation changes as the size and age of monumental trees increases. With regard to carbon accumulation the growth pattern of old trees is of particular importance

(Lanner & Connor, 2001; Johnson & Abrams, 2009). Regarding the growth of large trees, contrasting results can be found in the literature (Sheil et al., 2017). Decreasing biomass accumulation in the oldest and largest trees has classically been assumed (Vanclay, 1994, Avery & Burkhart, 2015) but increasing biomass accumulation with tree size has recently been claimed (Sillett et al., 2010, 2015; Stephenson et al., 2014).

Post-maturity decline in wood production is a long-standing premise in forest ecology. A widely held assumption is that after an initial period of increasing growth, the mass growth rate of individual trees declines with increasing tree size (Phillips et al., 2008; Meinzer et al., 2011; Piper & Fajardo, 2011). Theoretically, this is a necessary consequence of the sigmoidal nature of organismal growth (Weiner & Thomas, 2001). This type of behavior has been determined for diameter and length increase, but it is not sufficient to explain biomass growth. Although the results of a few single-species studies have been consistent with this assumption, the bulk of evidence cited in support of declining growth is not based on measurements of individual tree mass growth. Studies document well-known age-related declines in net primary productivity of most even-aged forest stands. A large amount of scientific effort has been devoted to understanding the potential causes of the post-maturity decline in wood production. However, the distinction between factors acting at the tree and stand level is often unclear and further studies are needed at the individual tree scale (Sillett et al., 2010).

The decrease in tree growth over time can be caused by changes in the supply of necessary resources (light, nutrients, water), the changing balance between photosynthesis and respiratory, increasing hydraulic resistance, decreased nutrient supply, or genetic changes with meristem age. However, these hypotheses expressing the change in growth may not be consistent as they vary depending on the species, vegetation period and growing environment. Delzon et al. (2004) report a height-related decrease in above-ground annual biomass increment per unit leaf area. The hydraulic limitation hypothesis (Ryan & Yoder, 1997), which proposed a physiological mechanism whereby a tree's height growth declines with increasing height, is often invoked to explain the age-related decline in stand-level wood production. Yet, even though a tree's height growth may diminish with increasing height due to hydrostatic and hydrodynamic effects, wood production of the entire tree (or stand) does not necessarily diminish at the same rate (Ryan & Yoder, 1997), and diameter growth of old trees may continue long after height growth has slowed (Phillips et al., 2008). For example, leaf water stress occurs in redwoods, the tallest tree in the world, due to hydraulic and mechanical constraints. As a result, leaf expansion and photosynthesis are limited. It is difficult to reach above 130 m even if there is sufficient soil moisture (Koch et al., 2004; Niklas, 2007; Pandey et al., 2017). So they cannot grow taller indefinitely. However, although height growth does not continue indefinitely, diameter growth can continue as long as the individual lives. They have also developed strategies to prevent mortality from water stress when trees reach their maximum height. Recent studies highlight sustained or continuously increasing mass growth rates with increasing tree size and emphasize the significant role of old trees for carbon accumulation (Carey et al., 2001; Stephenson et al., 2014).

The metabolic theory of ecology predicts that, under demographic and resource steady-state assumptions, the growth rate of individuals increases continuously with body size. Therefore, this theory predicts that at the forest level, large trees should contribute to forest biomass accumulation as much as small trees (Enquist et al., 1999). Supporting this theory with empirical findings, Stephenson et al. (2014) analyzed 403 tropical and temperate tree species and revealed that the mass growth rate and tree size of most species showed a continuous increase together. Monumental trees don't just act as reservoirs of aging carbon. They actively fix large amounts of carbon compared to smaller trees. A single monumental tree can add as much carbon to a forest in a year as an entire medium-sized tree. Also found 'published equations for diameter growth rate in the absence of competition' for 41 temperate tree species and highlighted that 35 of these equations indicate increasing biomass growth with size even at the largest sizes. The authors concluded that biomass growth continuously increases with tree size (Stephenson et al., 2014).

Sillett et al. (2010) assessed two of the world's tallest tree species: *Sequoia sempervirens* and *Eucalyptus regnans*. From the measurements, they concluded that wood production was highest in the largest and oldest trees. A closely related study on *E. regnans* drew comparable conclusions from similar data (Sillett et al., 2015).

There are different reasons for continuous growth with increasing age. These are: competition for space, which predicts a constantly increasing mass productivity with tree size (Pretzsch, 2009), increasing the total leaf area of the tree with tree growth (Bloor & Grubb, 2003; Rüger et al., 2011), or the process of adaptive reiteration which decreases the ratio of respiration to photosynthesis, rejuvenates apical meristems, and improves the hydraulic conductance by newly developed leaves (Ishii et al., 2007).

To conclude, there is considerable theoretical and empirical uncertainty regarding how biomass growth might vary with stem size. Further research will be required to clarify these issues. Monumental trees alone are a carbon sink. Due to their high wood volume, they store large amounts of carbon and preserve it for a long time. The long-term importance of monumental trees for accumulating and storing large amounts of carbon requires a better understanding of their growth behavior, particularly to prevent them from being replaced by faster-growing younger trees. Once lost from an ecosystem, populations of these trees, along with their many associated ecological and cultural roles, are inherently difficult or even impossible to recover. At the same time, it may take centuries to recover the benefits provided by these trees. The fact that the ecological role of these trees, which are rare in the world and disappear for various reasons, cannot be fulfilled by any other living thing, requires increasing the studies on these trees.

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Carbon Storage of Alder (*Alnus glutinosa* subsp. *barbata* L.) by Different Stand Structure

***Ercan Oktan*[1], *Öznur Özkan*[2]✉**

[1]*Karadeniz Technical University, Faculty of Forestry, Department of Forestry Engineering, Trabzon/TÜRKİYE*
[2]*Artvin Çoruh University, Faculty of Forestry, Department of Forestry Engineering, Artvin/TÜRKİYE*
✉***Correspondence**:* oznuryuruk92@gmail.com

Abstract: Forests are one of the important carbon sinks that struggle with the possible negative effects of global climate change. In this sense, it is very important to determine the carbon calculations in forests with the right methods in order to take measures against climate change. In many studies, it has been determined that the carbon stored in forest ecosystems varies according to the forest structure. Therefore, it is important to determine separately the effects of stand establishment, tree species, bedrock and soil characteristics on carbon storage. Features such as age, stratification, closure, density and mixing ratio that make up the stand establishment are effective on the amount of carbon stored and to be stored. For this purpose, carbon storage amounts of Alder *(Alnus glutinosa* L.*)* in different stand establishments were calculated in this study. This study was carried out on the Alder stands affiliated to Trabzon Forest Management Directorate, Düzköy Operation Chief. Since 2008, biomass and carbon calculations of our forest areas have been made with the method mentioned in the Ecosystem Based Functional Forest Management Plans (ETFOP). In this study, BEF coefficients developed based on FRA-2010 within the scope of ETFOP were used. In the study conducted with samples taken from three different sections in the stand, the amount of above-ground carbon storage (TUK) was found to be 1.7233 tons in section 1 with 0.4-0.5 confinement. The amount of TÜK was found to be 2.8208 tons in the 2nd compartment with 0.3-0.4 closure. The amount of TÜK was found to be 2,0557 tons in the 3rd compartment with a clearance of 0.2-0.3. In this context, carbon storage amounts for each stand differed depending on the changes in the factors that make up the stand establishment.

Keywords: *Alnus glutinosa* L., Stand structure, Carbon storage, Climate change.

1. INTRODUCTION

As a result of increasing population growth, industrialization and urbanization all over the world, there is a rapid increase in the demand for natural resources. While meeting the increasing demand, many problems have emerged such as the destruction of forest ecosystems, desertification, pollution and climate change. Global climate change, one of these problems, is one of the most important problems faced by people in the last century. Within the framework of climate change, it is shown that the amount of CO2 released into the atmosphere is increasing as a result of industrialization and land use differences, which are one of the reasons for global warming (Sivrikaya & Bozali, 2012). In the past, with the industrial revolution, the amount of greenhouse gases and CO2 emissions in the atmosphere increased as a result of the use of fossil fuels as an energy source in industry and heating, people destroying the forest ecosystem and opening new settlements for agriculture and urbanization, and the destruction of forests for fuelwood needs (UN, 1992). The fact that CO2 in the atmosphere as a result of human activities is not among the required reference values is shown as one of the most important causes of global warming (IPCC, 2013). Carbon is held in the trunks, branches, leaves, roots of trees, dead and living cover and forest soil (Brown & Schroeder, 1999; Houghton, 1999; Goodale et al., 2002). Within the terrestrial ecosystem, the forest ecosystem holds approximately 2/3 of the carbon. From this perspective, the forest ecosystem plays a significant role not only in mitigating the adverse effects of global warming but also in maintaining global climate stability (Woodwell et al., 1978; Hashimotio, Kojima, & Satohiko, 2000). arious methods have been developed for calculating carbon and biomass. Biomass is one of the most important parameters that can be used to determine the amount of carbon storage in forest ecosystems (Backeus, Wikström, & Lamas, 2005). One of the best ways to determine biomass is by using inventory data present in management plans. Inventory data is generally accurately determined statistically from forest ecosystems within a national area (Brown & Schroeder, 1999; Brown S., 2002). Based on the calculated stand volumes using inventory data (Birdsey, 1992; Kurz & Apps, 1993; Krankina, Harmon, & Winjum, 1996), biomass is calculated using equations developed based on tree species and ages (Yolasığmaz, 2004; Keleş & Başkent, 2006; Sivrikaya, Keleş, & Çakır, 2007), along with carbon conversion factors, to determine carbon storage capacity. Biomass determination based on tree wealth using inventory data is done in two ways. The first one is the Allometric Biomass Equations (ABE) Method. Determining the weight of each part of felled trees in biomass calculations yields more accurate results. However, when it is not preferred to cut the entire area for the operation, equations determined through samples taken are more commonly used. Allometric Biomass Equations, developed for each tree species with sufficient data, are utilized as a method for biomass models specific to the region (Schroeder et al., 1997; Van Camp et al., 2004; Durkaya, Varol, & Durkaya, 2014; Durkaya, Durkaya, & Ulu Say, 2016).

Another method for biomass determination is the Biomass Expansion Factor (BEF) method. With this method, the appropriate conversion factor is multiplied by the total biomass to determine the accumulated carbon in the stand (IPCC, 2003; Tolunay & Çömez, 2008). BEF coefficients can be used in carbon calculations on a species-specific basis. In reality, it is noted that these coefficients vary based on certain elements in the stand establishment (tree species, age, crown closure, stratification, and mixture ratio) (Lehtonen et al., 2004; Çömez, 2011).

Alder tree (*Alnus glutinosa* L.) is commonly found in Türkiye, especially in Thrace, the Marmara region, Western Black Sea, Eastern Black Sea, Southern Anatolia, and Hatay, particularly along riverbanks. It has a distribution as pure and mixed stands. The Alder generally grows up to 20-30 meters in height with a straight trunk, sometimes also in shrub form. It is a deciduous woody plant that sheds its leaves during the winter season. It has a preference for moist soils but can also grow on poor soils. Through root nodules that fix atmospheric nitrogen and microorganisms in its roots, it enhances soil fertility (Tarrant & Trappe, 1971; Benson & Sylvester, 1993; Yılmaz & Ekici, 2011; Yılmaz, 2020). Due to these characteristics, it is introduced as a pioneer tree in poor sandy soils, and as the soil becomes richer in nitrogen, other trees are introduced to the area (Harrington, 2006).

In this context, this study calculates the carbon storage amounts of Alder (Alnus glutinosa L.) in different Stand Structure. The aim is to reveal the differences in carbon storage amounts based on the characteristics that make up different Stand Structure using Biomass Expansion Factors (BEF), such as age, stratification, crown closure, density, and mixture ratio.

2. MATERIALS AND METHODS

2.1. Material

This study was carried out on the alder stand belonging to Trabzon Regional Directorate of Forestry, Düzköy Forest Management Directorate, Taşocağı Village, section 59. The study area, its location on the stand map and its location are given below (Figure 1).

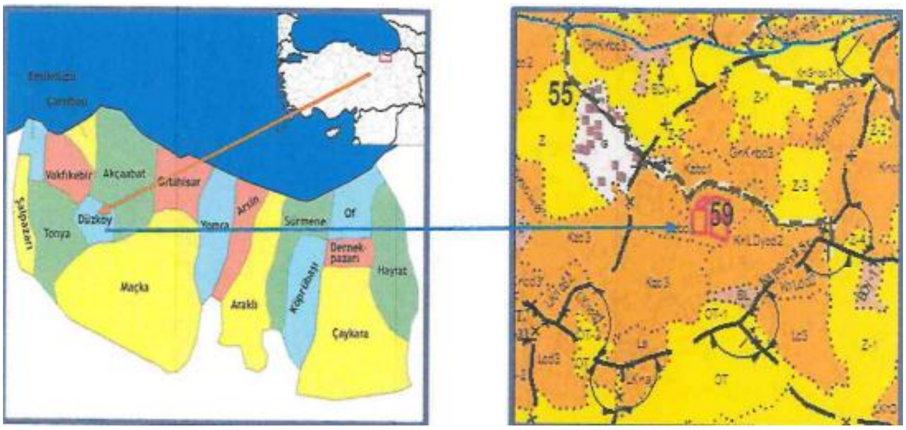

Figure 1. Location of the study area and its position on the stand map.

2.2. Method

To calculate the biomass and carbon amounts of the Alder stand, three different plots were selected. Within these plots, parameters such as diameter, height, age, crown closure, density, stratification, and branch length in four directions (East, West, North, and South) from the tree trunk were measured, which make up the stand establishment. Based on these measurements, biomass and carbon amounts were calculated by determining the standing volume (DGH) in the field using both the single-entry volume equation and the double-entry volume equation.

Single-Entry Volume Equation (1)

$V1 = -0.0188+7.00423\times d^2$ (Saraçoğlu, 1991) (1)

Double-Entry Volume Equation (2)

$$V2 = 0.404687 x d^{1.92886} x h^{0.91382} \quad (2)$$

According to the equation, the calculated volumes need to be multiplied by the correction factor: 1.005689 (Saraçoğlu, 1991).

Chart 1. Data for Plot 1.

Tree Number	d1.30 (cm)	Height (m)	Age
97	23,5	14,3	18
36	23,4	11,2	39
73	26,5	12,3	35
100	35,4	14,6	49
92	30,9	11,7	55
6	36,7	16,7	54
59	21,6	15	39
42	29,5	13,1	43

Chart 2. Data for Plot 2.

Tree Number	d1.30 (cm)	Height (m)	Age
12	15,1	8	16
1	41,9	23,3	80
84	44,1	17,8	56
80	13,5	9,4	22
64	38,5	15	41
96	33,5	17,8	40
100	46	13,8	72
84	44,6	17,8	56

Chart 3. Data for Plot 3.

Tree Number	d1.30 (cm)	Height (m)	Age
83	34,5	18,1	51
20	21,8	15,4	51
12	41,5	22,2	46
7	24,7	12,2	19
80	18,5	12,4	29
126	46,1	17,5	73
182	38,1	20,2	46

Since 2008, biomass and carbon calculations for our forest areas have been carried out using the Ecosystem-Based Functional Forest Management Plans (ETFOP) method mentioned. In this study, Biomass Expansion Factors (BEF) coefficients developed based on FRA-2010, which is within the scope of ETFOP, were used (OGM, 2014).

The FRA 2010 method employs the coefficients and calculation method outlined in the FRA 2010 guide prepared by the Food and Agriculture Organization of the United Nations (FRA, 2010). The stages of the method are provided in Table 1.

Table 1. Carbon calculation coefficients according to FRA (2010).

Carbon Pool		Calculation Method and Coefficient Numbers
Above Ground Biomass (AGB)	Broad Leaf	DGH x 0,638 x 1,24
Aboce Ground Carbon (AGC)	Broad Leaf	AGB x 0,48

In this study, a carbon conversion factor of 0.48 was applied to convert aboveground biomass values to carbon for broad-leaved species (IPCC, 2006; Tolunay, 2011).

The Biomass Expansion Factor (BEF) used has been used to demonstrate changes in carbon stock quantities in different Stand structure through calculations and graphs.

Chart 4. Results of stand stock, biomass, and carbon storage capacity for Plot 1.

Tree Number	d1.30 (cm)	Height (m)	Age	V1	V2	V1 AGB	V2 AGB	V1 AGC	V2 AGC
97	23,5	14,3	18	0,368009	0,20415	0,291139	0,161507	0,139747	0,077524
36	23,4	11,2	39	0,364724	0,161959	0,28854	0,128129	0,138499	0,061502
73	26,5	12,3	35	0,473072	0,224286	0,374257	0,177437	0,179643	0,08517
100	35,4	14,6	49	0,858942	0,458566	0,679526	0,362781	0,326173	0,174135
92	30,9	11,7	55	0,649971	0,28816	0,514205	0,227969	0,246818	0,109425
6	36,7	16,7	54	0,924593	0,555837	0,731464	0,439734	0,351103	0,211072
59	21,6	15	39	0,307989	0,181256	0,243657	0,143395	0,116955	0,06883
42	29,5	13,1	43	0,590743	0,292179	0,467349	0,231148	0,224327	0,110951
TOTAL				4,538042	2,366394	3,590136	1,872102	1,723265	0,898609

Chart 5. Results of stand stock, biomass, and carbon storage capacity for Plot 1.

Tree Number	d1.30 (cm)	Height (m)	Age	V1	V2	V1 AGB	V2 AGB	V1 AGC	V2 AGC
12	15,1	8	16	0,140903	0,051159	0,111472	0,040473	0,053506	0,019427
1	41,9	23,3	80	1,21087	0,973025	0,957943	0,769779	0,459813	0,369494
84	44,1	17,8	56	1,34339	0,839718	1,0627825	0,664318	0,510136	0,318873
80	13,5	9,4	22	0,108852	0,047764	0,086115	0,037787	0,41335	0,018138
64	38,5	15	41	1,019402	0,55265	0,806469	0,437213	0,387105	0,209862
96	33,5	17,8	40	0,76725	0,494128	0,606987	0,390915	0,291354	0,187639
100	46	13,8	72	1,463295	0,721862	1,157642	0,57108	0,555668	0,274118
84	44,6	17,8	56	1,374453	0,858179	1,087358	0,678922	0,521932	0,325883
TOTAL				7,428415	4,538486	5,876768	3,590487	2,820848	1,723434

Chart 6. Results of stand stock, biomass, and carbon storage capacity for Plot 3.

Tree Number	d1.30 (cm)	Height (m)	Age	V1	V2	V1 AGB	V2 AGB	V1 AGC	V2 AGC
83	34,5	18,1	51	0,814878	0,531022	0,644667	0,420102	0,30944	0,201649
20	21,8	15,4	51	0,314069	0,188998	0,248466	0,14952	0,119264	0,07177
12	41,5	22,2	46	0,187504	0,913893	0,939458	0,722999	0,45094	0,34704
7	24,7	12,2	19	0,408521	0,194734	0,323189	0,153773	0,155131	0,073811
80	18,5	12,4	29	0,22092	0,112972	0,174774	0,089374	0,083892	0,0429
126	46,1	17,5	73	1,469746	0,900621	0,162745	0,712499	0,558118	0,342
182	38,1	20,2	46	0,997941	0,710922	0,789491	0,562425	0,378956	0,269964
TOTAL				5,413579	3,552803	4,28279	2,810693	2,055739	1,349133

3. RESULTS AND DISCUSSION

The results obtained from the stand stock, aboveground biomass, and aboveground carbon capacity calculations as described in the methodology section have been compiled into tables (2, 3, 4) based on different Stand Structure and are presented below.

3.1. Results

Table 2. Above ground carbon storage data for Plot 1.

Plot 1	V1 AGC	V2 AGC
Crown Closure (0,4-0,5) Diameter (20cm-40cm) Age (18-55) Height (11m-17m)	1,723265 ton	0,898609 ton

Table 3. Above ground carbon storage data for Plot 2.

Plot 2	V1 AGC	V2 AGC
Crown Closure (0,3-0,4) Diameter (13cm-47cm) Age (16-81) Height (8m-24m)	2,820848 ton	1,723434 ton

Table 4. Above ground carbon storage data for Plot 3.

Plot 3	V1 AGC	V2 AGC
Crown Closure (0,2-0,3) Diameter (18cm-47cm) Age (19-73) Height (12m-23m)	2,055739 ton	1,349133 ton

As a result of the measurements taken in the sample plots, the crown closure (0.4-0.5), diameter range (20cm-40cm), age range (18-55), and height range (11m-17m) for Plot 1 are provided in Chart 1. When these values are processed considering the FRA-2010 guide, the aboveground carbon storage capacity is calculated as 1.723265 tons using the single-entry volume equation. When calculated using the double-entry volume equation, the aboveground carbon storage capacity is 0.898609 tons.

For Plot 2, the crown closure (0.3-0.4), diameter range (13cm-47cm), age (16-81), and height range (8m-24m) are provided in Chart 2. The aboveground carbon storage capacity for the plot is calculated as 2.820848 tons using the single-entry volume equation. When calculated using the double-entry volume equation, the aboveground carbon storage capacity is found to be 1.723434 tons.

For Plot 3, the crown closure (0.2-0.3), diameter range (18cm-47cm), age (19-73), and height range (12m-23m) are provided in Chart 3. The aboveground carbon storage capacity for the plot is calculated as 2.055739 tons using the single-entry volume equation. When calculated using the double-entry volume equation, the aboveground carbon storage capacity is found to be 1.349133 tons.

3.2. Discussion

Our country is rich in terms of climate structure, and hence, each area will be affected differently by climate change that may occur due to global warming (Öztürk, 2002). Therefore, the results of global climate change, even seen today, emphasize and enhance the importance of carbon storage.

There are several widely accepted methods for calculating biomass and carbon storage capacity both globally and in our country. The most commonly used methods among these are the allometric biomass equation and the biomass expansion factor coefficients that we used in our study (Brown et al., 1989).

As a result of various studies, allometric biomass equations have been developed for some tree species (Schroeder et al., 1997). The fact that an allometric biomass equation has not been developed for every tree species in our country is insufficient for the realistic calculation of carbon storage amounts. Particularly for deciduous species like alder, where there is no specific equation, calculations using biomass expansion factor coefficients cannot clearly reveal the results.

4. CONCLUSION

The study shows variations in carbon storage amounts based on stand establishment parameters. Even within species, differences arise in establishment parameters, emphasizing the need for a comprehensive study to create specific equations for each tree. More studies should be conducted at the species level to demonstrate how stand establishment characteristics affect carbon storage capacity and in what direction.

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Variation of Aluminum Concentrations in Annual Rings of Some Trees Growing in Ankara City Center Depending on Years and Species

Emine Emel Yayla[1], Hakan Şevik[2]✉

[1]*Kastamonu University, Graduate School of Natural and Applied Sciences, Department of Environmental Engineering, Kastamonu/TÜRKİYE*

[2]*Kastamonu University, Faculty of Engineering and Architecture, Kastamonu/TÜRKİYE*

✉***Correspondence**:* hsevik@kastamonu.edu.tr

Abstract: Heavy metal pollution is one of the most critical concerns threatening environmental and individual health worldwide in the last century. Heavy metals in the air have particular importance due to their effects on human health. Therefore, watching the difference in heavy metal pollution in the airborne is extremely important. Tree annual rings are the most efficient biomonitors used to define the differences in heavy metal concentration levels in the airborne during the years. However, the accumulation of each element in tree annual rings varies depending on the species. Therefore, it is necessary to determine the species that can be used as biomonitors separately in determining the difference in the concentration of each element in the air over the years. This study aimed to determine the variation of Aluminum (Al) concentration in the air in the last 30 years in Ankara city center by using the annual rings of *Platanus orientalis*, *Elaeagnus angustifolia* L., *Koelreuteria paniculata* Laxm, *Cedrus atlantica* (Endl.) Manetti ex Carr. *Ailanthus altissima* (Mill.) Swingle trees. As a result, the maximum aluminum concentrations were found in the outer bark of all species. The maximum concentrations were found in *Platanus orientalis* L. in the wood part.

Keywords: Aluminum, Ankara, Biomonitor, Heavy metal.

1. INTRODUCTION

Industrial movements have increased significantly in the last century due to industry developments worldwide. Mining activities carried out in order to provide the raw material resources required for increasing industrial activities have caused various elements to be extracted from the underground and released into nature (Ateya et al., 2023a, 2023b; Isinkaralar et al., 2022; Kuzmina et al., 2023). Population movement in parallel with the developments in the industry has caused population increases in urban areas (Dogan et al., 2023; Zeren Cetin et al., 2023); thus, urbanization has become one of the irreversible issues worldwide (Varol et al., 2022) along with global warming (Tekin et al., 2022; Cobanoglu et al., 2024). With the population density in urban areas, anthropogenic activities, especially traffic, have made air pollution the most critical threat to human health (Aricak et al., 2019; Elsunousi et al., 2021). Throughout these years, the concentrations of heavy metals in water (Ucun Ozel et al., 2020), soil (Elajail et al., 2022; Cetin et al., 2022a), and air (Koç, 2021; Istanbullu et al., 2023) have increased significantly.

Heavy metals are known as pollutants that do not break down easily in nature, bioaccumulate in living organisms, and some of them can be toxic, poisonous, carcinogenic, and fatal even at low concentrations (Key et al., 2022; Yayla et al., 2022). It is emphasized that heavy metals are much more harmful when inhaled into the body (Ghoma et al., 2022). It is stated that air pollution caused mass deaths in the past. Today, it causes serious health glitches such as stroke, lung cancer and heart disease, and the main reason for this effect is particles contaminated with heavy metals in the air (Turkyilmaz et al., 2020; Elajail et al., 2022). The WHO stated that more than 8 million individuals die yearly due to exceeding air pollution permissible limits (Isinkaralar et al., 2023a, 2023b; Sulhan et al., 2023).

Although heavy metals are dangerous, their concentrations in the air are constantly increasing. Therefore, monitoring changes in airborne heavy metal concentrations is essential, but airborne heavy metals are unstable, and their direct measurement is difficult and expensive. In addition, direct and instantaneous measurement of heavy metal concentrations in air does not provide information on the accumulation of heavy metals in the environment and their impacts on the environment. For these causes, biomonitors are used to monitor the variations in heavy metal concentrations in the airborne. Although different biomonitors are used for this purpose, tree annual rings are among the most suitable biomonitors that can be used to monitor the change of heavy metal contamination in airborne from past to present (Koç, 2021; Cesur et al., 2022; Key et al., 2022; Guney et al., 2023).

Aluminum (Al) is one of the most common and necessary nutrient elements for living things. Al is a soft and light metal and is found in some toothpaste, cigarette filters, food storage containers, aluminum foil, antacids used for the stomach, some cheeses and salts, sweat-protective deodorants, and is intensively emitted from industrial plants where it is used as raw material. In the body, Al accumulates mainly in the brain and liver tissue and can cause muscle aches, liver damage, psychosis, and loss of appetite. In addition, extra Al in the body can cause memory disorders (Kuzmina et al., 2023).

The present study aimed to determine the process- and species-dependent differences of aluminum (Al) concentrations, which is one of the heavy metals of great importance in terms of human and environmental health, in some trees growing in the capital city of Türkiye (Ankara), and one of the most densely populated provinces.

2. MATERIALS AND METHODS

The study was carried out on the annual rings of 5 tree species growing on the roadside in areas with heavy traffic in Ankara province. Ankara is Türkiye's capital and one of the provinces where anthropogenic heavy metal pollution, especially traffic density, is very high (Cetin et al., 2022a, 2022b). According to TUIK data, the population of Ankara is increasing rapidly, and the city's total population, which was 3.236.626 in 1990, reached 5.846.533 in 2023 (TUIK, 2023). For this reason, the study was carried out on plants collected from Ankara province. The species used in the study are given in Table 1.

Table 1. Tree species used in the study.

Latin Name	English Name	Species Abbreviation
Elaeagnus angustifolia L.	Silver berry	*El. an.*
Platanus orientalis L.	Oriental plane	*Pla. or.*
Koelreuteria paniculata Laxm	Golden rain tree	*Ko. pa.*
Ailanthus altissima (Mill.) Swingle	Tree of heaven	*Family. Alt.*
Cedrus atlantica (Endl.) Manetti ex Carr.	Atlas cedar	*Ced. at.*

The trees were cut in early December 2020 (end of the growing period) and transported to the laboratory. Stems were then cut into 1 cm thick discs in the laboratory, and the surface was sanded to make it smooth so that the annual rings could be seen clearly. Within the scope of the study, the annual rings of the trees were examined, and those suitable for the study purpose were divided into age categories according to their annual ring widths. Wood samples were taken from the determined sections with the help of a steel-tipped drill. The wood samples were crushed into sawdust. The samples were stored for 30 days until room dry and then dried in an oven at 50 ºC for one week.

0.5 g of the dried samples were taken, 6 ml of 65% HNO_3 and 2 ml of 30% H_2O_2 were added and placed in the microwave oven. The microwave program was set to rise up to 200 ºC in 15 minutes and stay at 200 ºC for 15 minutes. After the samples were burned in the Ethos one model microwave oven (Milostone brand), the samples in solution were taken into balloon tubes, filled to 50 ml with pure water, and made ready for elemental analysis with GBC Integra XL -SDS-270 ICP-OES device. Then, the plasma of the ICP-OES device was burned to analyze the samples, and pure water was circulated through the device system for 15 minutes to reach equilibrium.

Standard solutions were organized according to the Al (aluminum) element to be analyzed, and a calibration chart was formed. After, the samples were given to the system, and readings were taken. Since the sample was taken 0.5 g and completed to 50 g with water, the analysis results were multiplied by 100. According to the analysis results that did not fall into the calibration graph, different calibration graphs were created at ppm or ppb level and read again. This procedure is one of the most often used analysis methods in wood analysis in recent years (Erdem et al., 2023; Ghoma et al., 2023).

In the present study, all measurements were made in three repetitions, and the data obtained were evaluated with the help of the SPSS 21.0 package program. The study's data was evaluated by applying variance analysis with the help of the SPSS 22.0 package program, and the Duncan test was applied to the data with statistically significant differences at least at a 95% confidence level.

3. RESULTS

The organ-based differences in Al concentrations were evaluated separately according to the trees, and the mean values and statistical analysis results are shown in Table 2. The variation of Al concentration in all species organs was significant ($p<0.05$). The maximum values were found in *Platanus orientalis* L. 943226.0 ppb, *Elaeagnus angustifolia* L. 327260.0 ppb, *Koelreuteria paniculata* Laxm 309130.0 ppb, *Cedrus atlantica* (Endl.) Manetti ex Carr at 825988.6 ppb and *Ailanthus altissima* (Mill.) Swingle at 731598.0 ppb, and all these values were obtained in the outer bark. It is seen that the organ-wise variation of Al concentration is in the order of outer bark>inner bark>wood.

Table 2. Variation of Al concentration (ppb) by organs.

Organ	*El. an.*	*Pla. or.*	*Ko. pa.*	*Family. Alt.*	*Ced. at.*	F Value
Outer bark	327260.0Bb	943226.0 Eb	309130.0 Ac	731598.0 Cb	825988.6 Dc	53.482.5***
Inner bark	16937.0 Ba	47962.4 Da	63784.2 Eb	10130.8 Aa	43786.1 Cb	94.782.4***
Wood	21148.8 Aba	51267.8 Ca	15097.1 Aa	39778.3 BCa	13451.3 Aa	4.4**
F Value	500.0***	8840.2***	1196.3***	89.9***	76169.2***	

Note: Lower-case letter specifies to the vertical way within each row, whereas upper-case letter implies to the horizontal way within each column. ** means $p \leq 0.01$; *** means $p \leq 0.001$. This explanation also implies for Table 3.

The variation of Al concentrations in wood by species and period is shown in Table 3. As a result, the differences in Al concentration were significant ($p<0.001$) in all species by period and in all periods by species. When the values were analyzed, Al concentration varied between 7774.1 ppm and 310180.0 ppm. On a species basis, Al concentration varied between 8539.2 ppm and 67557.0 ppm in *Elaeagnus angustifolia* L., 34910.8 ppm and 78156.8 ppm in *Platanus orientalis* L., 4558.2 ppm and 42105.0 ppm in *Koelreuteria paniculata* Laxm. 105.0 ppm, 7774.1 ppm to 310180.0 ppm in *Ailanthus altissima* (Mill.) Swingle and 8986.1 ppm to 21483.0 ppm in *Cedrus atlantica* (Endl.) Manetti ex Carr. Notably, the Al concentration was higher in *Ailanthus altissima* (Mill.) Swingle in the 2012-2014 period. In addition, while there is only a 2.3-fold difference between the highest and lowest value in *Platanus orientalis* L., there is a 39.8-fold difference between the lowest and highest value in *Ailanthus altissima* (Mill.) Swingle. It can be interpreted that although Al transport in wood is relatively high in *Platanus orientalis* L., this transport is quite limited in *Ailanthus altissima* (Mill.) Swingle. The very high difference between Al concentrations in consecutive periods supports this result.

Table 3. Variation of Al concentration (ppm) by species and period.

Age	*El. an.*	*Pla. or.*	*Ko. pa.*	*Family. Alt.*	*Ced. at.*	F
2018-2020	19347.4 Cg	53489.3 Dg	LA	9680.5 Bd	8986.1 Aa	67197.3***
2015-2017	18412.4 Cf	40728.3 Eb	1869.3 Dh	9308.4 Acd	10649.0 Bc	74832.2***
2012-2014	15915.0 Bd	58872.5 Dh	1898.0 Cg	310180.0 Eg	15102.2 Ag	336512.9***
2009-2011	9319.7 Cb	34910.8 Ea	7974.7 Ab	8448.5 Bb	9788.2 Db	134918.8***
2006-2008	11326.3 Cc	45482.9 Ed	11472.3 De	9305.9 Acd	11171.3 Bd	150336.5***
2003-2005	8539.2 Aa	42371.4 Ec	11785.2 Cf	9521.8 Bd	14047.9 De	33739.8***
2000-2002	11305.6 Bc	59764.8 Ei	4558.2 Aa	14472.8 Cf	1671.0 Di	73006.0***
1997-1999	67557.0 Ei	51031.0 Df	9897.7 Bc	7774.1 Aa	13063.8 Cf	759038.3***
1994-1996	1849.6 Ce	47870.5 Ee	11313.6 Bd	10211.6 Ae	21483.0 Di	120208.8***
1991-1993	32915.7 Ch	78156.8 Ej	42105.0 Di	8879.4 Abc	16051.2 Bh	71408.8***
F	280114.1***	10847.8***	52643.2***	373519.1***	14292.4***	

4. DISCUSSION AND CONCLUSION

As a result, the change in Al concentration in the annual rings of 5 woody species growing in Ankara was determined based on species, organ, and period. Al is necessary for living things and is used in many areas. Exceeding Al limits for humans can cause some health disorders (Kuzmina et al., 2023). Therefore, it is vital to screen the difference of Al concentration in the air and reduce its concentration in polluted areas, such as urban sites and big towns.

Especially high-structured plants are essential tools in reducing heavy metal pollution in the atmosphere. However, studies show that each plant accumulates different heavy metals at different levels (Karacocuk et al., 2022; Sevik et al., 2023). Therefore, it is necessary to determine the species that can be used to reduce each heavy metal pollution separately. As a result, the highest Al values, especially in wood, were obtained in *Platanus orientalis* L. This result indicates that this species has a high potential to accumulate Al in the wood. Wood is the largest organ of plants in terms of mass. Therefore, *Platanus orientalis* L. is the most suitable species to reduce air pollution.

The most crucial feature sought in species that can be used as biomonitors in watching the difference of heavy metal contamination is the ability of the species to accumulate the elements subject to the study but limited transfer within the wood. As a result, although the uppermost Al concentrations in wood were obtained in *Platanus orientalis* L., it was determined that Al transport in wood was relatively high in this species, and it was not suitable for monitoring the change of Al contamination. The results of the study show that *Ailanthus altissima* (Mill.) Swingle is the most suitable species for monitoring the difference of Al concentration in the air. In plants, the element transfer in the wood section is primarily related to the cell wall and structure (Wani et al., 2018), and different elements in the wood differ in different species. In some studies to date, Cu in *Cedrus deodora* (Zhang, 2019), Ni, Cr, and Mn in *Cedrus atlantica* (Koç, 2021; Savas et al., 2022), Cd, Ni, Fe, and Zn in *Cupressus arizonica* (Cesur et al., 2021, 2022; Cobanoglu et al., 2023), Cd, Ni, Zn, Pb, Cr and Zn in *Corylus colurna* (Key et al., 2022; Key & Kulaç, 2022), which means that the displacement of these elements in the wood of these species is limited. However, in the same studies, it was reported that Pb and Zn in *Cedrus deodora* (Zhang, 2019), Co in *Cedrus atlantica* (Koç, 2021), Bi, Li and Cr in *Cupressus arizonica* could be displaced in wood (Zhang, 2019; Cesur et al., 2021, 2022; Cobanoglu et al., 2023). Therefore, suitable biomonitors should be determined separately to observe each element's process change. It was determined that *Ailanthus altissima* (Mill.) Swingle was the most appropriate species for watching the change in Al concentration among the species subjected to the current study.

As a result, all species obtained the maximum Al concentrations in the outer bark. Similar outcomes were acquired in different studies. For example, Savas (2021) determined that Al concentrations in *Cedrus atlantica* trunk were ordered as wood < inner bark< outer bark and Al concentrations in the outer bark could exceed 20000 ppm. Various studies have determined that heavy metal concentration levels in the outer bark are at high levels (Cesur et al., 2021; Ozel et al., 2021). This high concentration is generally due to the bark structure and the attachment of particulate matter polluted with heavy metals to the bark. First, particulate matter in the air is contaminated with heavy metals, and these particles can adhere to the bark surface due to the rough and cracked outer bark surface (Yayla et al., 2022). Al concentrations in the inner bark were greater than the concentrations determined in the wood in our study. This difference may be related to the entry of heavy metals into the tree. Heavy metals can enter the plant mainly through roots, leaves, and stem parts (Chen et al., 2022). It can be said that Al in the inner bark enters through the stem parts, and therefore, the concentrations in the inner bark, which is not in contact with air, are lower than in the outer bark but higher than in the wood.

The potential of plants to accumulate heavy metals is the product of a complicated mechanism shaped by the interaction of numerous factors. In this process, it is well known that many factors such as tree species, organ structure (surface area, texture, surface structure, etc.), the structure of the heavy metal, the interaction of the heavy metal with the plant and organ, the duration of exposure to heavy metals, atmospheric conditions (humidity, precipitation, wind, etc.) affect heavy metal entry into the plant body (Turkyilmaz et al., 2019; Aricak et al., 2020; Cesur et al., 2021). In addition, plant habitus and development also affect the uptake and accumulation of elements (Cesur et al., 2022). Therefore, all factors affecting plant habitus also affect the uptake and accumulation of elements into the plant, and plant habitus is shaped by the interaction of many interacting factors such as genetic structure (Ateya et al., 2023a; Kurz et al., 2023), environmental factors (Koç, 2022; Koç et al., 2022; Cetin et al., 2023), stress factors (Koç & Nzouko, 2022, 2023). Therefore, many of these factors, directly and indirectly, affect the uptake and accumulation of element potential in plants, and knowledge of this complex mechanism is still limited (Shahid et al., 2021; Isinkaralar et al., 2022).

In conclusion, the highest Al accumulation potential was in the 30-year-old *Platanus orientalis* tree. However, it has also been revealed that the Al element can be transferred within the wood in this species. Therefore, although *Platanus orientalis* is a suitable species for reducing Al pollution, it is not proper for monitoring pollution. The results also revealed that *Ailanthus altissima* (Mill.) Swingle is the most proper species for watching the difference of Al concentration in the airborne.

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ORAL PRESENTATION https://doi.org/10.61326/icelis.2023.53

Multistoried Fruit Production Model for High Carbon Sequestration: A Climate Change Mitigation Approach in Bangladesh

Md Helal Uddin[1], Md Main Uddin Miah[1✉], Md Giashuddin Miah[1], Sohag Ahammed[1], Anika Reza[1], Md Mizanur Rahman[2]

[1]*Bangabandhu Sheikh Mujibur Rahman Agricultural University, Faculty of Forestry and Environment, Gazipur/BANGLADESH*

[2]*Bangabandhu Sheikh Mujibur Rahman Agricultural University, Faculty of Agriculture, Gazipur/BANGLADESH*

✉***Correspondence***: mmumiahbsmrau@gmail.com

Abstract: The globe is now mostly concerned about climate change and its impacts on lives. The highly dense population and geographical location make Bangladesh most vulnerable to climate change. Concerning the issue, it's a big challenge making the agriculture sector adapt as well as sequestering more carbon from the atmosphere to mitigate climate change. To address climate change impacts, the study aimed to assess carbon sequestration potentials in different fruit production models developed by the Department of AFE, Bangabandhu Sheikh Mujibur Rahman Agricultural University. The study was arranged in a single-factor randomized complete block design. The treatments were open field (T_1), aonla (*Phyllanthus emblica*) (T_2), carambola (*Averrhoa carambola*) (T_3), lemon (*Citrus limon*) (T_4), aonla + carambola (T_5), aonla + lemon (T_6), and aonla + carambola + lemon (T_7). The vegetation data, soil data, and canopy data were collected to determine carbon sequestration and its response to the drivers. The study revealed that treatment T_7 had the highest biomass sequestration rates both above and below ground, as well as the total carbon content (64 tons/ha) which was followed by T_5 and T_6 treatments compared to T_2, T_3, and T_4 single strata treatments. The findings revealed that the total amount of carbon content showed a positive significant response to photosynthetically active radiation leaf area index (R^2 = 0.8591), total soil nitrogen content (R^2 = 0.9351), canopy coverage (R^2 = 0.9821) and litter fall (R^2 = 0.9606). This study also explores the role of agroforestry in carbon sequestration using the multistoried fruit production model, contributing to sustainable climate change strategies, land use management, environmental resilience, and policy making.

Keywords: Carbon sequestration, Environmental resilience, Land use management, Multistoried agroforestry model.

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The Chemical Composition of Birch Leaves and the Vital State of Birch Stands in the Gradient of Aerotechnogenic Emissions of JSC "Karabashmed"

Viktoria Gorbunova*✉, *Sergei Menshikov

Botanical Garden of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg/RUSSIA

✉***Correspondence***: viciacracca@mail.ru

Abstract: The aim of the work is to assess the vital state of silver birch stands and the content of macronutrients and heavy metals in the leaves of silver birch (*Betula pendula* Roth) in the gradient of aerotechnogenic emissions of JSC "Karabashmed" (Chelyabinsk region, Russian Federation). We selected five test areas of varying degrees of pollution at a distance of 1.5 km to 24 km from Karabashmed. The assessment of the condition of birch stands was carried out by the bioindication method, using the indicators of defoliation (loss of foliage) and dechromation (discoloration) of tree crowns and the category of weakness (sanitary condition). Birch forests located closer to the source of pollution (C-1.5) have the greatest degree of damage. The level of defoliation is 59.5%, dechromation is 52% and the damage index is 3.3, which is 1.5 and 2 times more than in more remote test areas. The sulfur content increased by 35% ($p<0.05$) on the test area closest to the source of pollution. Severe damage to birch leaves by sulfur dioxide in the affected area was indicated by an increased concentration of sulfur in the leaves, as well as deterioration of the vital condition of the stand. Macronutrients analysis results showed that the content of nitrogen varies from 22 to 24 mg/g, potassium from 9 to 15 mg/g, phosphorus from 6.5 to 7 mg/g, calcium from 5.5 to 8 mg/g, magnesium from 3.6 to 6.4 mg/g, sulfur from 1.7 to 2.7 mg/g, sodium from 1.8 to 2.5 mg/g. Heavy metal analysis results showed that the concentrations of cadmium, lead and zinc, copper and chromium in birch leaves in the area closest to the source of pollution increased by 2.8-8 times. The parameters of the vital state positively correlated with the content of sulfur, cadmium, lead, copper and zinc (correlation coefficients 0.4-0.6) and negatively correlated with the content of nitrogen, phosphorus, potassium.

Keywords: *Betula pendula,* Macronutrients, Heavy metal, Aerotechnogenic emissions.

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Ethical Value Issues in Corporate Sustainability Reports

Murat Yıldız✉

Anturia The School of Archeology and Social Environmental Ethics, Ankara/TÜRKİYE

✉***Correspondence****:* murat@anturia.com.tr

Abstract: This study aims to reveal the current ethical issues raised by corporate sustainability reports. Many texts such as the Paris Agreement, the European Green Deal, carbon regulations at the border, which have started to play a very important role in the economic and social pattern of the world, have been affecting daily lives of individuals across the countries. Beyond migrations, droughts and natural disasters, the armless war of the new millennium is a struggle for the civilization forced by these agreements. In addition to the European Union, which is gradually increasing its pressure on both member countries and suppliers within the framework of climate scenarios with the directives it has issued on impact value and due diligence, the USA is also making its own regulations binding for everyone. In addition to the scenarios of combating climate change, these two main economic powers also need different fictions that can sustain the social and economic comfort within their borders. In particular, the exponential growth of migration will be accompanied by the danger of disrupting the structure of the global economy, production, and the distribution of labor. While the EU considers the reporting of the companies in the member states to be inadequate in terms of quality and quantity, the companies that make a significant part of their trade to the member countries need a much more long-term and patient endeavor. Although the translations of the regulations consisting of numerous articles are often not easily comprehended in different cultures, it is a fact that ethics-based efforts will make this process permanent and understandable. In this context, sustainability studies and reporting of corporate firms, which are the core structures, have been analyzed in a way to include the supply chain. Many of the reports examined reveal the existence of knowledge and experience gaps that will lead to social and ecological problems as well as low impact value. The study brings an applied ethical suggestion to the ethical value analyses of the existing approaches and tries to reveal to what extent all these global efforts, the core subject of which is ethics, can overlap with ethical behavior.

Keywords: Environmental ethics, Corporate sustainability, Impact measurement, Carbon footprint, Applied ethics.

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Carbon Concentrations of Some Shrub Species Involved in Understory Vegetation in Istanbul-Durusu Sand Dune Afforestations

***Servet Pehlivan*[1✉], *Alper Gün Özturna*[2]**

[1]Çankırı Karatekin University, Faculty of Forestry, Çankırı/TÜRKİYE

[2]Istanbul University-Cerrahpaşa, Faculty of Forestry, İstanbul/TÜRKİYE

✉***Correspondence**:* spehlivan@karatekin.edu.tr

Abstract: Forests are one of the most significant carbon pools in terrestrial ecosystems. Forests store carbon not only in the tree biomass that composes them but also in pools such as dead wood, litter, and soil. Similarly, vegetation elements, which are components of forest ecosystems and are referred to as understory in forestry practice, are also constituents of the forest ecosystems' primary living biomass pool. On the carbon accumulation in forest ecosystems in Türkiye a substantial number of studies have been or are being conducted but this is still insufficient. However, the vast majority of these studies involve tree biomass (particularly above-ground biomass). Some subsequent studies have focused on carbon in litter and soil. But as stated previously, studies attempting to ascertain the amount of carbon stored in the understory biomass, which is a component of the living biomass pool and a part of the forest vegetation, are almost nonexistent. Consequently, the aim of this study is to determine the carbon concentrations of the shrub part of the vegetation on a coastal dune (Durusu (Terkos) Sand Dune) that had zero carbon stock prior to 60 years ago afforestation. During the biomass inventory of the maritime pine and stone pine plantations in Durusu Sand Dune, the carbon content of the shrub species was determined by collecting samples from a total of 18 sample plots. Both the above- and below-ground portions of the plants were sampled independently for shrubs. During the inventory investigations, the following species of shrubs were identified: arbutus (*Arbutus unedo*), heather (*Erica arborea*), cistus (*Cistus creticus*), laurel (*Laurus nobilis*) and broom (*Sarathommus scoparius*). Using the LECO TruSpec 2000 C/N Analyzer, the carbon concentrations of the leaves, branch/stem wood and root organs of these shrub species were determined via the dry burning method. The carbon contents of the leaf, branch/stem wood, and root components of arbutus species were measured and found to be 48.37%, 47.77%, and 47.47%, respectively. The carbon contents in heather species were found to be 51.62%, 50.26%, and 50.64%, while in laurel species, they were revealed to be 51.27%, 48.43%, and 48.28%. The carbon factors of the three biomass components in the broom species are 48.59%, 47.54%, and 48.98%, respectively. The present study investigated the biomass components of the cistus species, specifically classifying them into above-ground and below-ground categories. Additionally, carbon ratios were found for these components. The carbon ratio of the above-ground organs of the cistus species was found to be 48.96%, whereas the carbon ratio of the below-ground organs was determined to be 47.97%.

Keywords: *Arbutus unedo*, *Cistus creticus*, *Erica arborea*, *Laurus nobilis*, *Sarathommus scoparius*.

1. INTRODUCTION

Forests play an important role in the global carbon cycle and are globally valuable due to the services they provide to society (Denman et al., 2007; Pan et al., 2011). Because forests are pools that can reduce the carbon concentration in the atmosphere by storing carbon in their sub-pools (living biomass, dead organic matter and soil) (Pehlivan, 2017). Carbon dioxide (CO_2) has the most significant share of greenhouse gases in the atmosphere. Research shows that increasing concentrations of greenhouse gases (especially CO_2) in the atmosphere is one of the main reasons for climate change (Schimel et al., 2000; Nowak & Crane, 2002; Çömez, 2010).

Forests are the primary reservoirs where the most carbon accumulates among the terrestrial ecosystems in the world. Approximately 20-25% of the amount of carbon released into the atmosphere between 2000 and 2008 was stored in these ecosystems, which is very close to the amount of carbon stored in the oceans (Helin et al., 2013; Liu et al., 2012). Carbon pools on Earth are classified as atmosphere, terrestrial biosphere and oceans. The movement of carbon between these pools due to various processes is called the global carbon cycle (Le Quéré et al., 2012; Sabine, 2014). In forests, there are generally 5 sub-carbon pools classified as above-ground vegetative mass, sub-soil vegetative mass, dead wood, dead cover and soil (IPCC, 2003; IPCC, 2006; Özturna, 2022). Table 1 provides explanatory information regarding the sub-carbon pools found in forests. The information is provided in the given format.

Table 1. Carbon pools in forests (IPCC, 2003; IPCC, 2006; Özturna, 2022).

Main Pools	Sub-pools	Basic Components
Living Biomass	Above-ground	Stems, stumps, branches, leaves, bark and seeds above ground
	Below-ground (Roots)	All living roots of the living biomass, except roots less than 2 mm in diameter
Dead Organic Matter	Dead Wood (Planted dry)	All woody biomass found at the base or in the soil in a dry, planted state. It includes wood lying on the surface, standing leaves, dead roots and roots thicker than 10 cm.
Soils	Litter	On top of mineral and organic soil; It consists of all dead woody biomass, debris, humus and fumic layer that can form a layer of at least 10 cm in diameter. Living very small roots are also counted in this section.
	Soil Organic Matter	It contains organic carbon in minerals and organic soils. Living coarse roots are considered soil organic matter.

In recent years, there has been a growing body of research focused on quantifying the carbon sequestration potential of forest vegetation in Türkiye. While the primary focus of these studies pertains to quantifying the carbon sequestration potential of forest vegetation, a comparatively lesser emphasis is placed on assessing the carbon storage capacity of litter and soil. Nevertheless, it is evident from the data presented in Table 1 that there exists a scarcity of research endeavors focused on quantifying the quantity of carbon sequestered by the living cover. This particular component is an integral part of the "Living Biomass" reservoir, which is recognized as a crucial carbon pool within forest ecosystems. The forest component known as understory serves as both a reservoir of biodiversity, housing many plant species, and as a carbon sink, owing to the substantial amount of vegetative mass it generates.

The objective of this study is to determine the carbon levels in the shrub component of the vegetation in Istanbul-Durusu (Terkos) Kumulu maritime pine and stone pine afforestation. The study focuses on an area that was previously assumed to have no carbon content, namely 60 years after the afforestation took place.

2. MATERIALS AND METHODS

The research was carried out in Istanbul-Durusu (Terkos) Sand Dune maritime pine (*Pinus pinaster* Ait.) and stone pine (*Pinus pinea* L.) afforestation. The total area of Durusu (Terkos) Sand Dune is 3106.7 ha. 1647.2 ha of this area has been afforested. Afforestation started in the 1960s and has a history of approximately 60 years today (Tolunay et al., 2017). Durusu Sand Dune, located in the west of the Bosphorus and on the Western Black Sea coast, is located between Karaburun from the east, Kocaçeşme-Çayırburun from the west, Durusu Lake from the south and the Black Sea from the north (Figure 1) (OGM, 2013). It is a slightly rugged terrain where parallel ridges extending in the east-west direction rise and progress towards the south (Saraçoğlu & Bozkuş, 1996). Irmak et al. (1980) in the forest habitat classification of Thrace, Lake Durusu and its surroundings were evaluated as "Terkos Region" within the western part of the Çatalca Peninsula. The average elevation of the dune is 20 m and the highest point is Kabakum hill (70 m elevation) located in the east of the dune.

According to the data obtained from Kumköy Meteorology Station, which is the closest meteorological station to the study area, the lowest monthly average temperature was measured in January with -7.5 °C, and the highest monthly average temperature was measured in July with 41.4 °C. The annual average temperature was determined as 14.7 °C (Pehlivan, 2017; Tolunay et al., 2017). The period between April and December, called the vegetation period, when average monthly temperatures exceed 10 °C. The average annual total precipitation in Durusu Dune is 836 mm, and a significant part of this precipitation falls between September and March (Tolunay et al., 2017). The water deficit between June and October was calculated as 31.4 mm by some researchers (Saatçioğlu et al., 1978; Saraçoğlu & Bozkuş, 1996). In the study area, where the annual average relative humidity is around 77-78%, the dominant winds blow from the northeast with an average annual speed of 9.2-107 km/h (İMP, 2009).

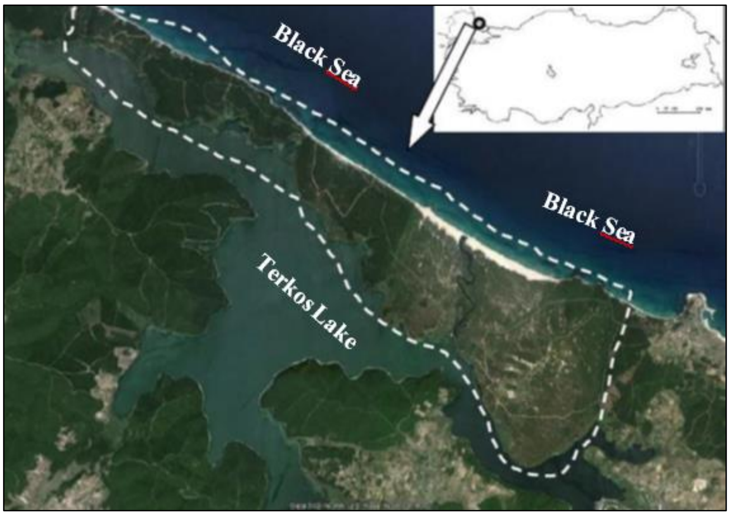

Figure 1. Research area.

Although no bedrock was found in the study area, old soils were found in areas far from the sea and close to Terkos Lake, and excavation depths of 60-70 cm could be reached. As a result of the fact that most of the soil in the research area is of marine origin, the presence of shells and their fragments belonging to marine creatures has been observed. As a result, soils contain significant amounts of lime (Özturna, 2022). Dunes, which have typical sand soil characteristics, have very low water retention capacity due to high water permeability. Abdalmoula et al. (2019) reported that the lime content in the soil of the research area increased up to 30% and the sand content varied between 95-98%. The pH of the soil of the research area can rise up to 8.5 and is slightly alkaline. The electrical conductivity of soils varies between 20-80 µS/cm (Özturna, 2022).

The material of this research consists of shrub species encountered in a total of 18 sample areas during the biomass inventory carried out in maritime pine and stone pine afforestation in Durusu Sand Dune. These shrub species were identified as Arbutus (*Arbutus unedo*), Heather (*Erica arborea*), Cistus (*Cistus creticus*), Laurel (*Laurus nobilis*) and Broom (*Sarathommus scoparius*) (Figure 2).

Sample numbers of shrub species are given in Table 2. These shrub species, which were found in 18 sample areas, were cut and their above-ground and below-ground organs were classified. This classification is made in the form of leaves, branch/stem wood and roots (below-ground) (Figure 3). Then, separate subsamples were taken from the three components of each shrub species.

Table 2. Sample numbers of shrub species.

Species	Number of Samples
Arbutus	2
Laurel	4
Heather	2
Broom	6
Cistus	4
Total	**18**

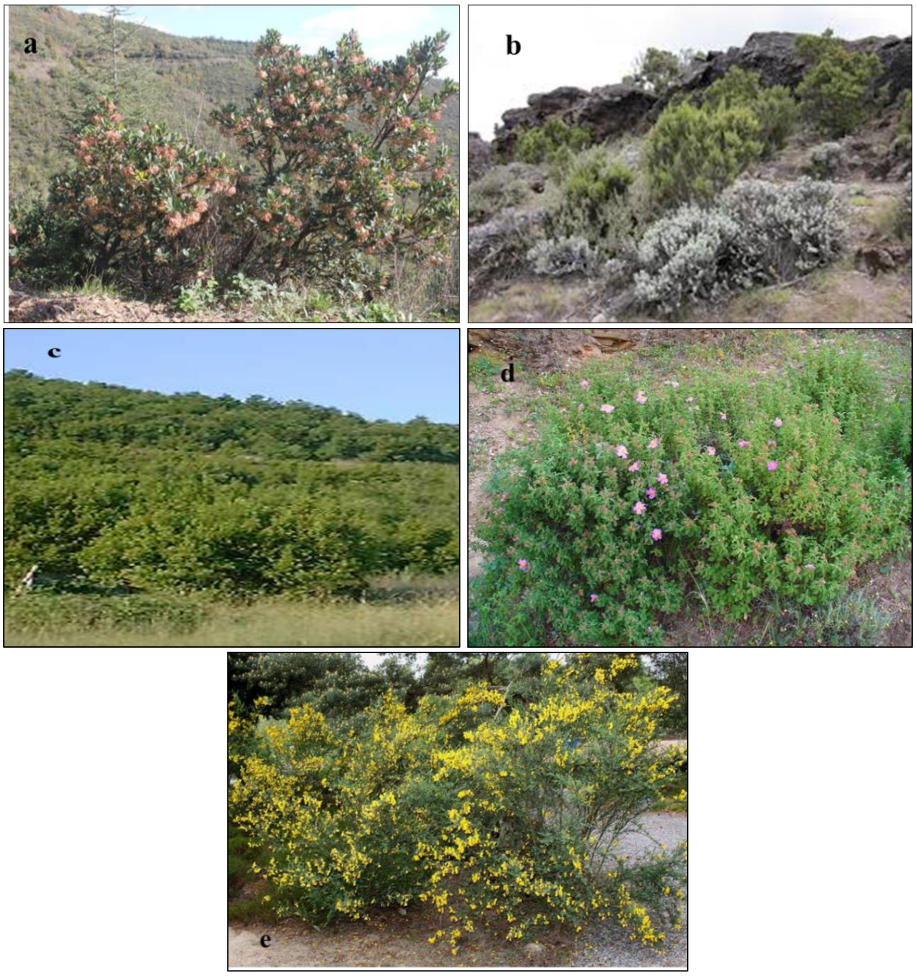

Figure 2. a) Arbutus (*Arbutus unedo*), b) Heather (*Erica arborea*), c) Laurel (*Laurus nobilis*), d) Cistus (*Cistus creticus*) and e) Broom (*Sarathommus scoparius*).

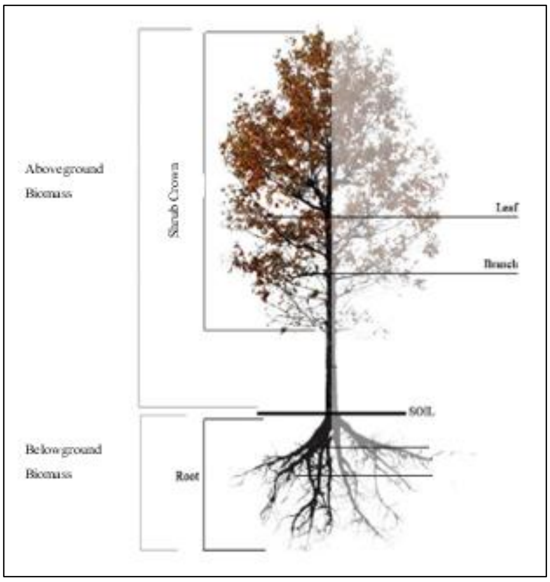

Figure 3. Classification of sap cover subsamples.

The subsamples taken were brought to the laboratory, dried at 70 °C until they reached a constant weight, and then ground to prepare for analysis. The carbon concentrations of these ground subsamples were determined by the dry burning method. For this purpose, LECO Truspec2000 C/N Analyzer device was used.

3. RESULTS AND DISCUSSION

3.1. Results

The study involved determining the carbon concentrations of the organs of the shrub species. These concentrations were expressed as percentage values, calculated by taking the arithmetic means (%). This study examined five distinct shrub species, namely arbutus, heather, laurel, broom, and cistus. Carbon concentrations were measured separately for leaves, branch/stem wood, and root organs in the arbutus, heather, laurel, and broom species. However, due to the biological properties of the cistus species, carbon concentrations were determined as above-ground total and below-ground, as it was not feasible to measure them separately. The carbon concentrations were determined and recorded in Table 3.

Table 3. Average carbon concentrations of subsamples of shrub species (%).

Tür	Leaf	Branch/Stem Wood	Below-ground
Arbutus	48.37	47.77	47.47
Laurel	51.27	48.43	48.28
Heather	51.62	50.26	50.64
Broom	48.59	47.54	48.98
Cistus	48.96*		47.97

*It was evaluated as total above-ground.

In Arbutus species, the highest carbon content was detected in the leaves with 48.37%, while the lowest carbon content was detected in the roots with 47.47% (Figure 4). In Laurel species, similar to arbutus, the lowest carbon rate (48.28%) was detected in the below-ground organs and the highest carbon rate (51.27%) was detected in the leaves (Figure 5).

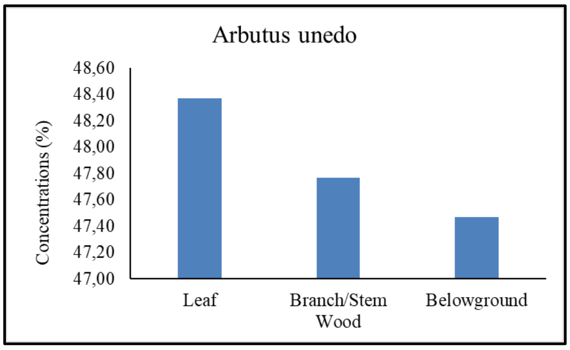

Figure 4. Carbon ratios of Arbutus species.

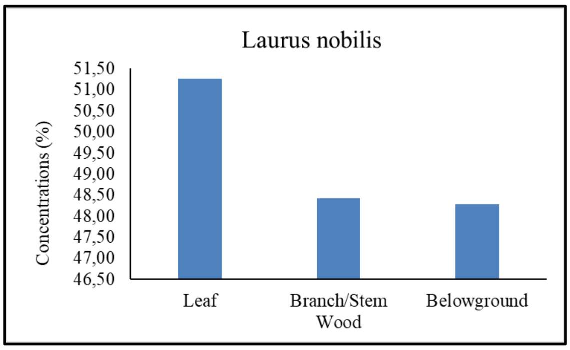

Figure 5. Carbon ratios of Laurel species.

While the roots have the highest carbon content in Heather (Figure 6) and Broom (Figure 7) species, the organs with the lowest carbon concentrations of these species were determined to be branch/stem wood (Table 3).

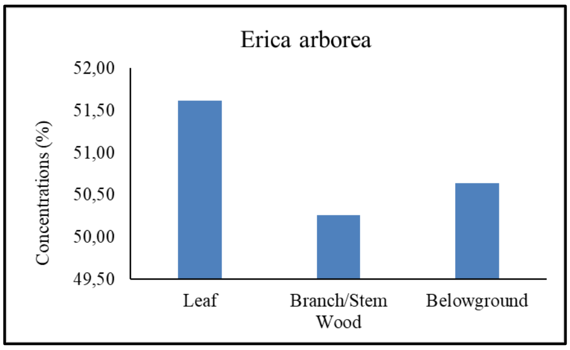

Figure 6. Carbon ratios of Heather species.

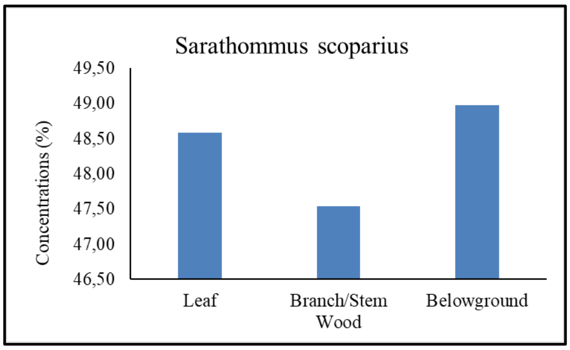

Figure 7. Carbon ratios of Broom species.

In the Cistus species, only the total above-ground and below-ground values were evaluated, and the carbon rates of these organs were determined as 48.96% and 47.97%, respectively (Figure 8 and Table 3).

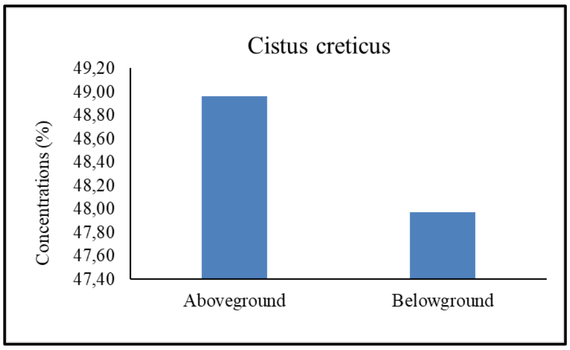

Figure 8. Carbon ratios of Cistus species.

3.2. Discussion

The carbon ratios of the shrub species added to the understory in Durusu Kumulu afforestation vary depending on the plant species and various organs of these species, but vary between 47.47% and 51.62%. The plant species with the highest carbon content in its leaves is heather with 51.62%. The lowest carbon content was found to be the arbutus species with 48.37%. Similarly, the highest and lowest carbon rates of under-ground organs were detected in heather and arbutus species, respectively. Lim (2012) conducted a study in Isparta to ascertain the carbon rates associated with the above-ground organs, namely leaves, branches and stem of Kermes oak exclusively within maquis areas that are predominantly characterized by the presence of Kermes Oak (*Quercus coccifera*). According to the results of the relevant study, the average carbon concentrations of leaves, branches and stem organs of Kermes oak are 50.65%, 49.12% and 48.58%, respectively. In this context, it can be said that the results obtained for Kermes oak are similar to the species detected in Durusu Sand Dune. In a study conducted in pure Scots Pine (*Pinus sylvestris*) stands in Bolu Aladağ, the average carbon rate for all above-ground organs of the understory was determined as 47.64% (Tolunay, 2009). Additionally, Çömez, (2012) determined the carbon rates of understory in Scots Pine stands in Eskişehir Sündiken Mountains. According to the results obtained for the overall understory, the average carbon content of the above-ground parts of the understory is 47.00%. The average carbon concentration of the below-ground parts of the understory in Scots Pine stands in the Sündiken Mountains was determined to be 42.90% (Çömez, 2012). In both studies, separate evaluations were not made for the species that make up the understory. Zheng et al. (2008) measured the understory carbon ratios in stands of different tree species and found it to be 42.08% in the *Camellia oleifera* stand, 42.55% in the *Cunninghamia lanceolata* stand and 44.33% in the *Pinus elliottii* stand. Falkengren-Grerup et al. (2006) measured the carbon contents of *Dryopteris filix-mas*, *Milium effusum* and *Stellaria holostea* species, which they sampled from the *Quercus robur* stand, as 44.2%, 41.5% and 41.6%, respectively. Bing et al. (2006) determined the carbon rates of the stem part in the understory to be between 32.7-46.7%, and the carbon rates of the root part to be between 41.2-46.7%. Both Falkengren-Grerup et al. (2006) and Bing et al. (2006) shows that living carbon concentrations are lower than the results obtained in Durusu Sand Dune. It is considered that the carbon ratios were determined to be low because the understory sampled in these studies consisted mostly of herbaceous species and therefore their lignin content was low (Bert & Danjon, 2006; Çömez, 2012).

4. CONCLUSION

Carbon concentrations of both above-ground and below-ground organs of shrub species participating in the understory vegetation in Durusu Sand Dune afforestation were revealed in this study. In previous studies conducted in Türkiye, carbon ratios of understory components were not examined on a species basis. In addition, studies on determining the carbon ratios of the below-ground organs of the understory are very few both in Türkiye and in the world. This study, in which carbon concentrations are determined both on a species basis and for below-ground and above-ground, will make a significant contribution to the literature with the mentioned features.

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Seed Reduplication of the Flowering Plants of the Disturbed Landscapes in the Northern of Far-East of Asia

Evgeny Tikhmenev[1], Pavel Evgenievich Tikhmenev[2]✉

[1]*Russian Academy of Sciences, Ural Branch: Institute Botanical Garden, Ekaterinburg/RUSSIA*
[2]*North Eastern State University, Magadan/RUSSIA*
✉***Correspondence**:* etikhmenev@bk.ru

Abstract: The results of studies of anthropogenic landscapes functioning with an assessment on the processes natural self-revegetation and effectivity of reclamation in tundra, forest-tundra, larch forest complexes are summarized. The principles of accelerated restoration of the ecological and aesthetic value of disturbed landscapes at the permafrost zone are substantiated, based on the data obtained during studying the self-revegetation and reclamation processes on disturbed complexes. Development of placer and ore deposits of mineral resources is leading to deep transformation of landscape and to destruction of soil-vegetation complexes. The processes caused by mining activity are leading to variable mechanisms of degradation of soil and vegetation often having complex impact. Results of study of sustainability of soil-vegetable complexes to the impact of mancaused activity have showed the dependence from the structure of soil profile and it characteristic, from the character of genetic horizons, frozen status of the landscape elements, form of the structure, biomass and seed productivity. The rate of fertilization and fruiting regularity of perspective some species of native flora for introduction as medical, nutritive or fodder plants was also determined.

Keywords: Pollination, Generative system, Permafrost landscapes, Disturbed sites, Soil-vegetation complexes, Rehabilitation.

1. INTRODUCTION

As a result of mining operation there are more than 124.000 hectares of disturbed lands in permafrost zone of North-eastern Asian. Especially large scale disturbances of native ecosystems have taken place in tundra and the boreal zone of basin of Kolyma river. Very cold climatic condition, when annual temperature everywhere below zero degree, predetermine imbalance of natural ecosystem under the impact of technogenic pressure. Technogenic formation range in size from 200-500 m^2 to several hectares and include flood plain, river terraces and mountain slopes. The natural landscapes of region under investigation are characterized by mountain systems. Process of self-revegetation of the diturbed sites come extremely slow and active thermokarst erosion on disturbed sites are sources of long-term pollution of the Arctic ocean basin. Exploration of reproductive biology of flowering plants started earlier on Wrangel Island was continued at the plant communities of Yakutia, continental areas of the Kolyma basin and in Kamchatka (Pugachev, Tikhmenev, 2011). The study was undertaken according to generally accepted technique developed by A. N. Ponomarev (1964, 1970). Special attention was given to ecological morphology and biology of inflorescence, effectiveness of different types of seed production, role of the flora anemophily and enthomgamy species on the natural and disturbed sites.

2. MATERIALS AND METHODS

The main aim of the research was to determine the species range of the local flora acceptable for reclamation of technogenic formations and cultivation of highly-productive artificial meadows and grass seeds in the North-Eastern Russia. Fodder production was and is hampered actually by absence of experience of recultivation and seed farming. Exploration of reproductive potential of flowering plants started earlier on Wrangel Island was continued at the plant communities of Yakutia, continental areas of the Kolyma basin and in Kamchatka (Pugachev, Tikhmenev, 2011). The study was undertaken according to generally accepted technique developed by Ponomarev A. N. (1964, 1970). Special attention was given to ecological morphology and biology of inflorescence, effectiveness of different types of seed production, role of the flora anemophily and enthomophyly species' on the natural and disturbed sites. The rate of fertilization and fruiting regularity of perspective species for introduction as medical, nutritive or fodder plants was also determined.

3. RESULTS

The development of mineral deposits radically changes the lithogenic structure of landscapes, leads to deep deformation or destruction of their biological components, including soil and vegetation complexes. During the development of deposits, disturbances occur in the natural environment of various depths. They depend on the geochemical features of the field under development, the technology used and the level of technical equipment of the enterprise. Main researches and experimental studies of revegetation disturbed landscapes were conducting in Gold mine Kubaka, located in basin of Kolyma river in zone of larch forest. Earlier our experiments development of reclamation technology in restoration disturbed landscapes were conducting in tundra zone of Chukotka (Figure 1). Review of agrophysical and agrochemical parameters of soils of Gold ore deposit Kubaka are show in Table 1. Research conducted in the Chukotka peninsula let us possibility to evaluate a range of physical and chemical properties of technogenous formations on the Arctic coast. In particular, composition of fine soil varies from 0.0 to 16.8 %, and physical clay from 0.5 to 33.4 %. Agrochemical indicators also vary widely. The environment varies from strongly acidic to almost neutral, The presence of bases is from 28 to 95 %, the presence of mobile forms of phosphorus – from 0.0 to 30.0 mg/100 g of fine soil. There is considerable variability in the ratio of C:N and fractional humus group (Table 2).

For comprehensive understanding of direction of successive processes on the disturbed sites the comparative analysis of feature of pollination ecology of species in natural communities and technogenic formations have been hold. It was determined earlier, that majority of the species under investigation had self-pollination ability in case of obstructed xenogamy (Tikhmenev, 1999). Such peculiarity of reproduction system functioning at boreal and tundra plants allows them completing of ontogenenous cycles with relative regularity despite the harsh environmental conditions. At early stages of successive processes under climatic conditions of sparse vegetation cover of the disturbed sites anemophily easily occurs.

Figure 1. Reclamation of disturbed lands of the tundra zone with seeds of perennial grasses (Chukotka).

Table 1. Physicochemical properties of soils in the valley of the basin of Omolon River (basin of Kolyma}.

Horizon	Depth, cm	pH KCl	Humus, %	Nitrogen, %	Hydrolitic acidity*	Exchange Forms		V, %	Available Forms		Particle size, mm	
						Ca^{2+}	Mg^{2+}		P_2O_5	K_2O	<0,01	<0,001
					mEq/100g of soil				mg/100g of soil			
Tundra gley soil												
01_v	0-5	3,4	-	-	-	-	-	-	25	41	-	-
02	5-8	3,5	-	0,57	127,9	6,0	29,0	21	13	64	-	-
A1Bg	8-13	3,7	2,76	0,07	38,4	7,7	8,7	30	8	23	41	19
Bg	13-25	4,6	1,75	0,07	2,0	10,3	7,0	90	11	12	36	20
BG_1	40-50	5,0	1,16	-	1,6	10,6	9,0	92	-	-	40	21
BG_2	65-75	4,8	2,13	0,08	1,2	9,2	10,3	94	-	-	36	22
CG	82-92	4,2	3,21	-	-	9,8	6,7	-	-	-	38	22
Tundra underbur												
01	0-2	3,9	97,30*	-	-	22,0	6,2	-	-	-	-	-
AO2	2-6	3,9	52,02*	1,21	80,2	25,0	6,5	28	105	220	-	-
AB	6-15	4,0	2,85	0,06	7,2	13,3	6,3	73	18	4	21	6
BC_r	15-25	5,0	1,70	-	1,8	15,6	5,2	92	-	3	14	10
C	70-80	5,0	0,33	-	0,7	18,0	9,7	98	-	6	11	5
Floodplain shallow turf soil												
AO	0-2	5,2	50,95*	-	-	43,8	3,9	-	-	-	-	-
A1	2-7	4,8	3,40	3,40	32,6	14,1	2,6	34	40	14	26	12
BC	10-20	4,8	0,78	0,26	1,0	2,5	0,4	75	38	4	2	2

Note: -Not defined; * - loss on ignition;* - hydrolytic acidity; V,% is the degree of saturation with bases.

Table 2. Physicochemical properties of the overburden dump of the valley of Kolyma River.

Specimen depth, cm	pH KCl	Humus, %	Hydrolitic acidity	Exchange forms		V, %	Available forms			Particle size, mm	
				Ca^{2+}	Mg^{2+}		$N-NO_3$	$N-NO_4$	P_2O_5	<0,01	<0,001
5- 15	5,3	-	4,5	7,2	6,0	75	5,8	2,4	14,0	13	7
25- 35	4,2	4,9	7,0	6,4	5,2	62	1,1	0,8	3,0	33	17
150-160	4,2	-	36,1	8,6	5,4	28	1,3	10,2	30,0	-	-
350-360	6,1	-	1,0	3,4	2,2	85	0,3	0,6	12,0	1	0

Therefore, the disturbed sites are actively reseeded with grasses, sages and other wind pollinating species (Pugachev et al., 2004, 2005, 2011). Anthecological researches showed that regular and thick seeding is typical for species, referred to the Poaceae family: *Alopecurus alpinus, Hierochloë alpina, H. pauciflora, Poa abbreviata, xborealis, Elymus interior, E. sibiricus, E. mutabilis, E. confusus, Festuca rubra, Calamagrostis holmii, C. langsdorffii.* Many of these species are highly valuable for revegetation of the disturbed sites in permafrost condition (Tikhmenev, 2008). Regular and thick seeding on the disturbed sites is characteristic for some arboreal and shrub species of the disturbed plant communities.

Figure 2. Using of soils reserve from native communities for formation root layer on rock dumps (Gold mine Kubaka in Kolyma river basin).

Figure 3. Reclamation of gold ore deposit Kubaka.

Table 3. The biomass on overburden dumps of different ages, t/ha of dry weight.

Components of biomass	Age of dumps, years			
	2	8	14	20
Phytomass	0,04	0,54	2,67	3,59
incl. aboveground	0,03	0,23	0,31	2,53
Underground	0,01	0,31	2,36	1,06
Mortmass	-	0,05	0,06	1,23
Biomass	0,04	0,59	2,73	4,82

Overburden dumps with an age of vegetation more than 20 years are dominated by the tree and shrub layer, which already has a depressing effect on the grass cover and causes the appearance of mosses. The stock of phytomass reaches 3.59 t/ha. *Populus suaveolens* has high productivity - 1.32 t/ha, *Salix schwerinii* - 1.04 t/ha, the share of forbs does not exceed 0.01 t/ha. On 25-year-old overburden dumps, a stable vegetation cover is formed with a significant participation of a number of tree species. The layer of poplar (2.0 t/ha) and *Schwerin willow* (1.5 t/ha) is especially pronounced (Table 3).

Salicaceae family species (*Chosenia arbutifolia, Populus suaveolens, Salix shweriny;* Betulaceae family: *B. exilis, B. middendorffii, B. platyphilla, Duschekia fruticosa),* which are consist of typical anemophilous group of disturbed sites. Plenty of free-flowing pollen enriching ground-level air for 24 hours, close growing of trees and shrubs and long-lasting fertility of generative system contribute greatly to successful pollination and seeding at different succession stages. Among typical species of revegetating floral communities there is rather extensive group of species, mostly from the Fabaceae, Scrophulariaceae and Salicaceae families, which are characterized as obligatory entomophilous plants. For successful seed reproduction of this group species visitation of anthophilous insects is obligatory. Due to this fact occurrence of the majority of enthomophilous species, which are obligatory xenogamous ones, is rather rare in the rehabilitate plant communities and their use for revegetation purposes has relatively small efficiency (Tikhmenev, 1999). In the blooming phase of plants pollen of these species is usually mature and characterized by high fertility level lasting up to 2-3 days and more, thus, microsporogenesis of the most studied species at the disturbed sites is successful. These species can use self-pollination easily in case of obstructed xenogamy. This provides relatively regular seeding during possible lack of pollinating insects (Tikhmenev, 2001). Typical growing in clumps and dense groups also supports "efficiency" of pollination activity of anthophilous insects on the disturbed landscapes.

Among typical species of recovering floral communities there is rather extensive group of species, mostly from the Fabaceae, Scrophulariaceae and Salicaceae families, which are characterized as obligatory entomophilous plants (Tikhmenev and others, 2020). For seed reproduction of this group species visitation of anthophilous insects is obligatory. Due to this fact occurrence of the majority of enthomogamy species, which are obligatory xenogamous ones, is rather rare in the rehabilitate plant communities and their use for revegetation purposes has relatively small efficiency.

Determination of seed viability of some pioneer species showed that intensity of germination of species most common for floodplain forests and pioneer species of recoverable sites are rather comparable, and in some cases this parameter can be even higher at plants of pioneer species. Thus, *Salix pulchra, S. schwereni, Populus suaveolens* and *Saxifraga funstonii* on the disturbed sites showed high productivity and seed vitality comparing to the plants of natural communities. Due to higher level of warmth supply on the disturbed landscapes more species complete ontogenesis successfully including seeds maturation and dissemination. Quality

Wide spectrum of conditions for settling and development of introduced plants on the disturbed sites are reflected in structure and productivity of the vegetation cover of such habitats (Pugachev, Tikhmenev, 2011; Kapelkina and others, 2014).

Figure 4. Revegetation stone dump with seeds of local flora species (*Larix cajanderi*, *Pinus pumila*) and grasses.

Figure 5. Revegetation site (waste) with seeds of local flora species.

Quantity of the thin soil material, wetting regime of substratum and distance to the natural floral societies (as source for seeds) play the determinative role for successfulness comparing to natural communities, which have more severe conditions for seasonal development (Tikhmenev, 2008). Effectiveness seed transportation of anemochorous species, which contribute the main portion of "seed rain" to the disturbed sites, rarely exceeds 100-120 meters from the adjacent natural plant communities. The animals' activity determines success of zoohores species seed distribution, including Siberian dwarf pine (Khomentovsky, 1995). Observation have shown that artificial reclamation by native species more effective and in short time to increase of an erosion process (Tikhmenev, 1999)

Experimental studies on plants introduction in the region showed that the seeds range for cultivation of artificial meadows and recovering of the disturbed landscapes should be drawn up using resources of local flora under estimation of its ecological peculiarities, level high seed reproduction. On the bases of field experiments, an effective technology of the reclamation of disturbed sites in Arctic and Subarctic has been developed (Patent #2711926, date of Russian Federation registration 23.01.2020). Some species of native flora are being used: *Arctagrostis latifolia* and *A. arundinaceae*, *Elymus* *sibiricus, E. mutabilis, Calamagrostis purpurea, Trisetum spicatum, Beckmania syzigachne* and others grasses. Seed material of Larix *cajanderi* and *Pinus pumila* are very perspective to be introduce to the disturbed landscapes.

Thus, research of reproductive biology of phanerogams and principles of revegetation of disturbed permafrost landscapes let us determine rather large group of anemophilous and entomophilous species perspective for introduction to the disturbed sites. In number of cases performance of the assisted land reclamation measures is necessary; therefore, the data obtained on reproductive potential of species, which are dominants of the forming vegetative complexes, are valuable for development of efficient anti-erosien restoration of vegetation cover and creation of artificial meadows on the disturbed landscapes.

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Determining of Carbon Storage Using Remote Sensing

Mehmet Mısır*✉, *Nuray Mısır, Abdullah Yıldız

Karadeniz Technical University, Faculty of Forestry, Department of Forest Engineering, Trabzon/TÜRKİYE

✉***Correspondence****:* mmisir@ktu.edu.tr

Abstract: Forest ecosystems, which have an important role in the global carbon cycle by storing large amounts of carbon in the above-ground, below-ground and soil, make up about 30 % of all terrestrial ecosystems. Two different methods are used to determine the amount of carbon stored in forests. In both methods, different parameters should be determined by stand measurements. However, new methods are needed because it is time -consuming and costly to do these studies. In this context, the determination of the carbon storage capacity of forest areas by using the data obtained by remote sensing methods has come to the agenda. For this purpose, the stands selected as a study area were determined with the help of measurement data of terrestrial carbon storage levels in the Gazipaşa Central State Forest Enterprise of Antalya Regional Directorate of Forestry in Mediterranean region. In the satellite image (Sentinel), the relationship obtained from the brightness values of various bands and the amount of carbon stored to be determined by various vegetation indices have been established.

Keywords: Carbon storage, Remote sensing, Sentinel.

1. INTRODUCTION

It is not known exactly when the human being in the world begins. However, it is a well -known fact that man is more and more distorting the natural structure of the earth with the activities of the earth. Now human beings are concerned that this increasing deterioration, natural life, and thus the existence of it on earth. The changes observed in the climate since the beginning of the 20th century stem from human activities that increase the greenhouse gas levels in the atmosphere by raising the world's average temperature (Mısır & Mısır, 2018; Yıldız, 2021). The most important of these activities is the burning of fossil fuels that provide carbon dioxide to the atmosphere. According to the data of the National Oceanic and Atmospheric Administration, the amount of carbon dioxide in the atmosphere continued to increase and reached 419.68 ppm as of August 2023 (NOAA, 2023). If the ratio of carbon dioxide and other greenhouse gases in the atmosphere is not reduced rapidly, climate change will have destructive and irreversible effects on the world. In this context, it is important to determine the amount of carbon stored by forest ecosystems, one of the carbon pools in the world. 67 % of the carbon held in terrestrial ecosystems except sedimental rocks and 75 % of the carbon held by vegetation around the world are kept in forests (Mısır & Mısır, 2017). According to the Intergovernmental Panel on Climate Change (IPCC, 2006), the main carbon pools or reservoirs that can be included in the forest carbon sampling program are five:

1. Above-ground
2. Below-ground (roots)
3. Deadwood
4. Litter
5. Soil organic carbon

The most challenging stage of the carbon storage of forests is undoubtedly the most challenging stage. The time consuming and highly cost effectiveness of field studies has directed researchers to methods that do not require field studies. In this study, it is aimed to develop the regression model by taking independent variables of the sample areas determined in the study area, the reflection values of the satellite image of these areas and the vegetation indexes obtained from these bands.

2. MATERIALS AND METHODS

2.1. Study Area

In this study, Gazipaşa Planning Unit was selected as the research area within the boundaries of Gazipaşa Forest Management Directorate of Antalya Forestry Regional Directorate in the south of Türkiye (Figure 1). There are Çamlıca to the north of this planning unit, Demirtaş to the west, Gürçam in the south, Doğanca to the east and Çığlık planning units.

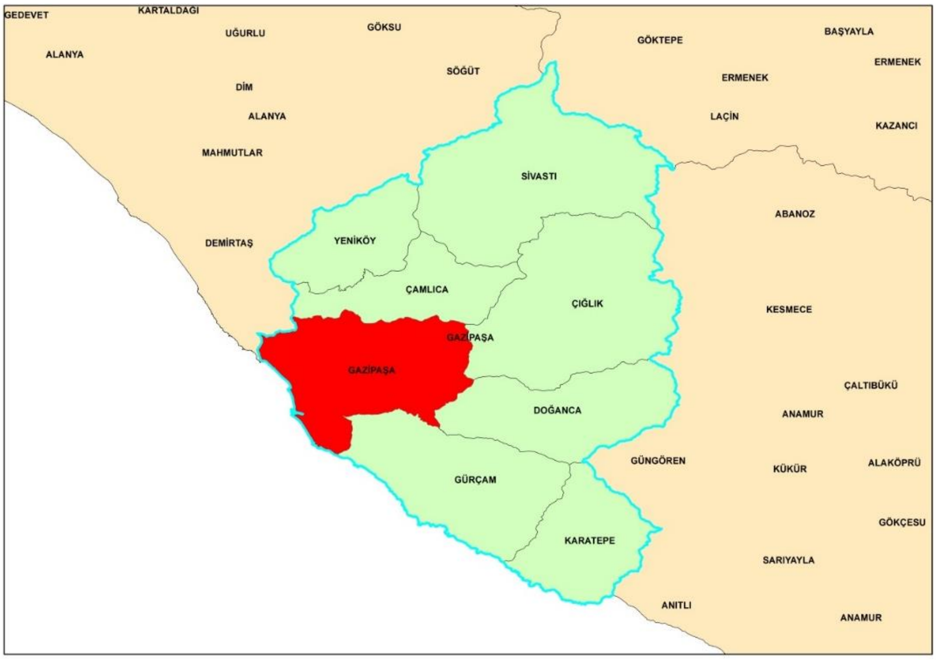

Figure 1. Study area.

Typical Mediterranean climate is seen in Gazipaşa region subject to the study. In this region, summer is dry and hot, and the winter season is warm and rainy. According to the data of the Regional Directorate of Meteorology, the highest temperature of the last 90 years was 45.6 c˚ in August 1958 and the lowest temperature was measured in January 1964 - 8.1 c˚ (MGM, 2023). The vegetation of the region is the typical vegetation of the Mediterranean region. In this region, it is seen on the steep slopes of the areas up to the sea up to 800-1000 meters high. After 800-1200 meters, it is possible to see the pine forests mixed with the *Erica arborea*. Forest vegetation is typical and the dominant tree species include Turkish pine (*Pinus brutia* Ten.), Oak (*Quercus* sp.), Stone pine (*Pinus pinea* L.), Juniper (*Juniperus*), Lebanon cedar (*Cedrus libani* A. Rich.).

2.2. Field Sampling

The paper incorporates sample plots and sample trees data. The results of sample plots include stand type, stand diameter (two type: mean diameter and quadratic mean diameter), stand height, basal area, number of trees, herbaceous biomass, shrub biomass, litter biomass, lying dead wood biomass, herbaceous carbon amount, shrub carbon amount, litter carbon amount and lying dead wood carbon amount. The sample trees' results include diameter at breast height, tree height, stem biomass, branch biomass, foliage biomass, stem carbon amount, branch carbon amount and foliage carbon amount.

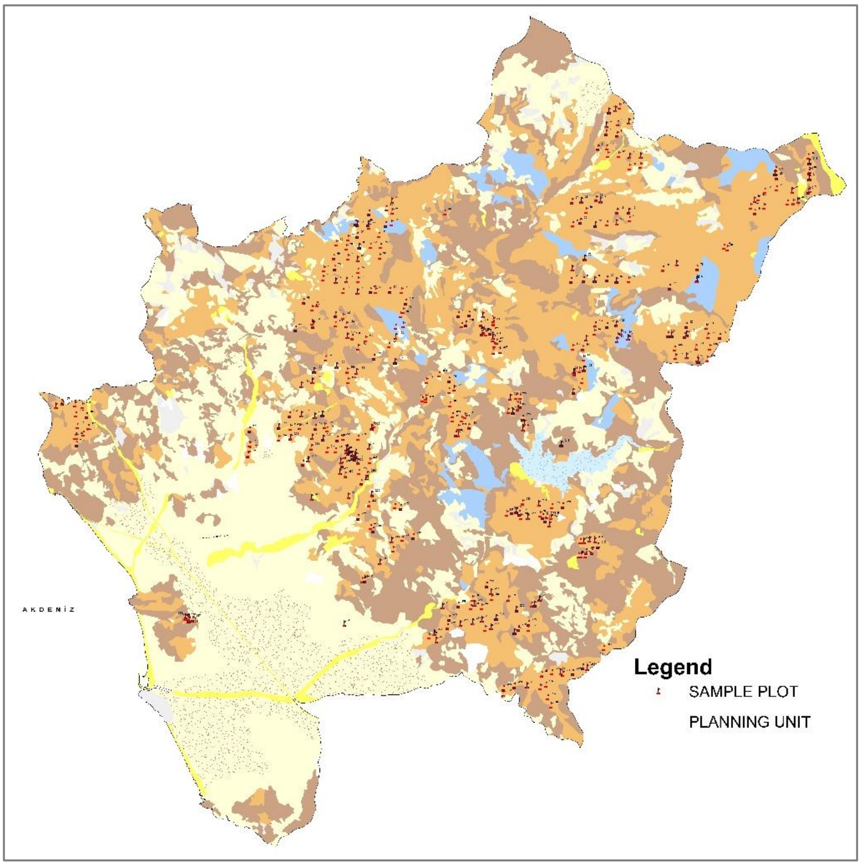

Figure 2. Sample Plots.

2.3. Obtaining of Reflection Values

To obtain the reflection values of all sampling plots, Sentinel 2 satellite images of the research area dated 28.07.2018 were obtained. In the field feature layers, separate reflection values are created for each band. By combining these layers with sample plots, the reflection values of the bands corresponding to the sample plots were found (Figure 3). If there is more than one reflection value falling into the sample plot, the weighted average of the reflection values in the sample plot is determined and a single reflection value is obtained for each sample plot. Various models have been developed by taking independent variables of 14 different vegetation index values as the amount of carbon taken as dependent variables, reflection values of the bands and independent variables. The statistically developed models were decided to be the most appropriate.

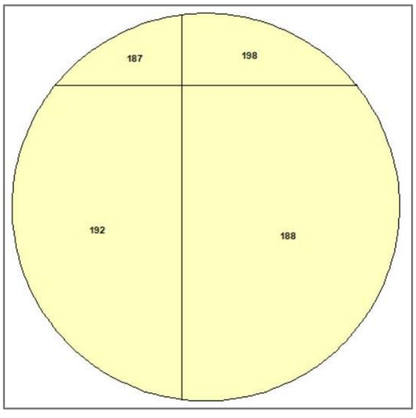

Figure 3. Satellite image reflectance values for the 212th sample plot.

2.4. Relationship Amount of Carbon Storage with Remote Sensing Data

Remote sensing data can provide detailed information about the composition of the stand structures and the species forming the stand. Different stand structures have different spectral reflectance values in different wave lengths (Mısır et al., 2011; Çakır et al., 2017). Therefore, the relationship between stand parameters and remote sensing data also varies. In this study, dependent variable of carbon storage amount; reflectance values for satellite image bands, vegetation indices obtained from different band combinations were using as independent variables, the relationship between the amount of carbon storage in the stands and the remote sensing data was investigated.

3. RESULTS

The statistical values of certain characteristics of the sample plots taken in the research area are given in Table 1.

Table1. Statistical values of all bands and vegetation indexes.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
BAND1	369	100,99	42424,17	874,15	3255,06
BAND2	369	67,99	39865,15	924,59	3020,67
BAND3	369	171,98	37763,27	1349,43	2817,26
BAND4	369	111,99	35735,58	1212,83	2682,75
BAND5	369	279,97	35016,68	2010,12	2699,40
BAND6	369	569,95	34275,25	3117,22	2745,22
BAND7	369	634,94	33756,67	3371,60	2756,68
BAND8	369	701,93	33061,50	3667,36	2799,69
BAND9	369	323,97	43601,00	3787,32	3684,73
BAND10	369	10,94	9619,25	294,40	1127,65
BAND11	369	418,96	20062,45	2501,02	1964,17
BAND12	369	283,97	16643,05	1601,02	1533,14
NDVI	369	-0,02	0,58	0,34	0,11
SR	369	0,97	3,77	2,12	0,50
DVI	369	-718,90	6591,53	797,29	543,51
TVI	369	0,48	1,08	0,84	0,11
NLI	369	0,59	0,88	0,78	0,05
SAVI	369	-0,03	0,87	0,51	0,17
ND53	369	-0,04	0,84	0,54	0,16
ND54	369	-0,03	0,58	0,26	0,09
ND57	369	-0,37	0,25	-0,04	0,03
ND32	369	-0,43	0,22	-0,08	0,09
ND73	369	-0,08	0,86	0,57	0,16
NDWI	369	-0,58	0,03	-0,26	0,09
EVI	369	-1,55	1,53	0,67	0,25
IPVI	369	0,49	0,79	0,67	0,06

The relationship between carbon storage amounts, reflection values of satellite image bands and vegetation index values have been tried to be obtained. As described above, the amount of carbon storage, which is dependent variable, is estimated based on the reflection values of the bands and the vegetation index values. The obtained regression model is given in Table 2.

Table 2. Parameters Estimations of the Carbon Model.

	Parameter Estimate (β)	R Square	Std. Error of the Estimate (ton/ha)
Constant	151,396		
Band10	0,009		
DVI	-0,016	0.52	18.2
ND54	-113,082		
EVI	15,223		
ND32	-55,619		

4. DISCUSSION AND CONCLUSION

In this study, to model the amount of carbon stored in the forest areas of the Mediterranean Region, Gazipaşa Planning Unit with a remote sensing method; Carbon storage values obtained from the measurements made in sample plots, the reflection values of satellite image bands and the relationships between 14 different vegetation indexes were examined. As a result of the statistical evaluations, a model was developed to determine the amount of carbon stored in the study area by using satellite images.

Türkiye has a complex climatic structure, especially due to global warming, is one of the countries that will be most affected by climate change. Naturally surrounded by sea on three sides, it has a flawed structure and orographic properties, and different regions of Türkiye will be affected by climate change in different formats and different sizes. The determination of the carbon storage capacity of the forests in Türkiye is therefore of great importance. In addition to the determination of carbon storage capacity, it is important that our country periodically update this data (Mısır et al., 2019).

Satellite images, one of the remote sensing methods, can determine the carbon storage capacity of forest areas at a rapid, easy and minimum cost. In such a study, the difference between the year in which the satellite images were taken and the year in which the data to be received as checkpoints is obtained is important. To see how the year difference affects performance, more accurate information will be obtained by doing similar studies with the latest and long -term data (Mısır et al., 2013).

The results obtained from such studies can be transferred to other working areas with similar conditions and can be used as a guide for the selection of the best spectral band combinations in the work on the work of the bushes. In addition, these results are important for selecting possible bands in classification of the forest cover. It is estimated that these new relationships can be applied to studies using Sentinel, Landsat ETT +, SPOT, MODIS or AVHRR data on a regional or global scale.

Since forests are one of the most important factors affecting global climate change, it becomes increasingly more important to determine the carbon storage capacity of forests. It is of great importance to perform these and similar studies using different satellite images, so that we need to have more information about the carbon storage capacity of our forests.

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Determining of Carbon Storage in Anatolian Black Pine Stands

Nuray Mısır*, Mehmet Mısır, Abdullah Yıldız

Karadeniz Technical University, Faculty of Forestry, Department of Forest Engineering, Trabzon/TÜRKİYE

***Correspondence**:* nuray@ktu.edu.tr

Abstract: One of the most important problems of today is global warming that occurs due to climate change that affects human life. Especially with the industrial revolution, the destruction of forests, the increase in the use of fossil fuel, the increase in the world's population, the increase in energy consumption and the increasing levels of greenhouse gas released into the atmosphere because of human activities such as distorted urbanization has increased more than normal. As a result of this increase, local, regional, international conferences and efforts to raise awareness have been initiated to prevent global warming threatening the future of the world. As a result, it was decided to limit the release of carbon dioxide, which is one of the most important measures that can be taken against global warming, has a high rate of presence between greenhouse gases and has a high rate of presence between greenhouse gases. In this context, the United Nations Framework Convention on Climate Change (UNFCCC), countries that are parties to the various sectors of greenhouse gas emissions, National Greenhouse Gas Inventory Report (NIR) has entered the obligation to report. In the NIR reports that need to be arranged every year, the amount of carbon stored by forests with an important carbon pool should be determined. Carbon in the forest areas, trees; it is stored in lifeless biomass consisting of litter, dead wood, soil organic matter and other substances with live biomass consisting of branches, foliage, stem and roots. In this study, the amount of carbon storage in the black pine stands of Balıkesir Forestry Regional Directorate, Dursunbey Forest Enterprise, Çamlık Forest Planning Unit was calculated based on ecosystem.

Keywords: Global warming, Carbon storage, Forest, Black pine.

1. INTRODUCTION

Forest ecosystems have an important potential in preventing global warming due to the excess of the carbon they connect in the unit area and their ability to keep this carbon within many years. Carbon pools in forest ecosystems are divided into 5 categories according to the 2006 guide of the International Climate Change Panel (IPCC, 2006). These are above-ground biomass, below-ground biomass, deadwood, Litter and soil organic matter. Countries on the Kyoto Protocol are obliged to inform the United Nations Climate Change on Framework (UNIDCS) by preparing a national greenhouse gas inventory report in various sectors. In this context, it is necessary to determine the amount of carbon stored by forests with an important amount of carbon. Within the scope of the National Greenhouse Gas Inventory Report, the carbon storage amounts of forests are determined while the agricultural, forestry and other land use (AFOLU) guide prepared by International Climate Change Panel (IPCC) is used. In this guide, 3 methods are recommended for calculating carbon emissions or carbon storage amounts caused by various sectors. These methods require calculation according to the data source; It is called tier1, tier2 and tier3. The simplest and basic method that requires minimum data is the tier1 method. In this method, carbon emissions are found by multiplying the amount of consumption with the emission factor calculated on a global scale. In the tier2, which is a high -level calculation method, carbon emissions are calculated by the approach in the tier1. The difference of the tier2 method from the tier1 method is to obtain the emission factor from the calculated values specific to the country. The most complex and precise predictions method is the tier3 method. In this method, emission factor is determined by inventory data or using previously developed models (Ravindranath & Ostwald, 2007). As the level used in these calculation methods recommended by IPCC, the reliability and accuracy of the estimation made increases. In this context, tier3 methods were used in this study. In this study, the amount of carbon storage of the Anatolian black pine, which naturally spread in the area corresponding to 18.3 % of the Turkish forested area, was calculated based on ecosystem.

2. MATERIALS AND METHODS

2.1. Study Area

In this study, Çamlık Planning Unit was selected as the research area within the boundaries of Dursunbey Forest Management Directorate of Balıkesir Forestry Regional Directorate in the west of Türkiye. There are Akdağ to the north of this planning unit, Gediktepe to the west, Kınık in the south, Musalar planning units to the east (Figure 1).

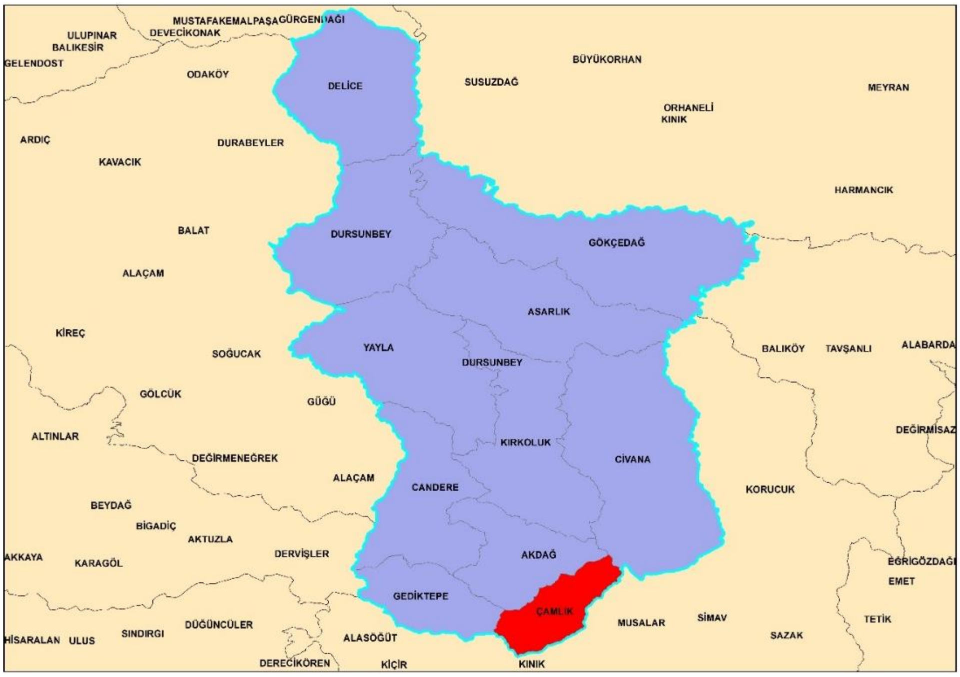

Figure 1. Study area.

Although the study area is located in the Aegean Climate Zone, the summers are cooler and the winters are harder. Vegetation time is quite short. Forest vegetation is typical and the dominant tree species include Anatolian black pine (*Pinus nigra* subsp.), Oak (*Quercus* sp.), Oriental beech (*Fagus orientalis* Lipsky.) and Lebanon cedar (*Cedrus libani* A. Rich.).

2.2. Determination of the Carbon Stored in the Tree

In the sample plots selected, a tree that can represent a sample plot is selected as a sample tree. The sample tree is cut from a height of 0.3 m and divided into sections and diameter measurement is made every two meters. The age and height of the sample tree are determined. All branches are separated from the body to measure diameter and height. A branch representing all branches is selected as an example branch and separated from the foliage. All sample foliage and branch weights are determined. 5-7 cm thick cross-section is taken from a portion of the sample tree. All samples taken are transported to the laboratory (Mısır et al., 2012).

2.3. Determining the Amount of Litter, Living Cover and Dead Wood Carbon

In the sample plots, there are trees as well as different herbaceous and woody species. To determine the carbon stored by these herbaceous and woody species; In each sample plot, 2 pieces of sampling plots are formed at the points determined by random method. The covering degrees of the living cover entering the area are determined and the living covers in the area are cut from the soil surface and weighed. To determine the amount of litter accumulated on the soil surface, the litter is collected in the sampling areas of 25 x 25 cm at 4 points determined by random method. In addition, for the sample deed wood sampling in the sample plots, 1x1 m samples are collected from 2 points where it is randomly determined (Mısır et al., 2011).

2.4. Determination of Carbon Stored Below-Ground

To determine the amount of below-ground carbon storage; The root sample is determined, and the root pit is opened around 80x120 cm. A corner of the root pit is close to the tree and the corners of the root pit are determined and removed by digging litter on it. The soil pit is started to be opened by paying attention not to overflow beyond the specified boundaries. Excavation depth is up to the depth of the roots. Roots removed from the root pit are classified as fine (0-2 mm), small (2–5 mm) and coarse root (5–10 mm) (Yavuz et al., 2010).

2.5. Determining the Amount of Carbon Stored in Soil

Soil samples are taken by using the pit excavated for the root. 0-10, 10-30, 30-50, 50-80 and more than 80 cm, including different depth levels, using the soil cylinder.

2.6. Laboratory Work

The samples taken during the field studies are transported to the laboratory for the necessary measurements and analysis. The stem and branch wood samples brought to the laboratory are measured. With the aid of sections made in sample trees, each sample tree has a total stem volume. Then, to determine the dry weights of the stem, branches, foliage and bark, to reach the unchanging weight of 105 ± 3 ºC in the drying oven, the stem and branch samples are dried by waiting for 72 hours and the samples of the samples are dried by waiting for 24 hours and the dry weight values of the samples are recorded by weighing. The shell weight of the stem sections, which have become oven dried, is measured and volume is made, then the shell is peeled, and the shell is measured again, and the dry weight is measured. Litter, living cover and dead wood samples are also made of oven and their weights are measured. After the root samples are kept in water for 24 hours, they are washed and removed from the soil and litter, the washed roots are divided into three classes as fine (0–2 mm), small (2–5 mm) and coarse root (5–10 mm), 65 ºC in the drying oven. It dries for 24 hours. After the necessary measurements are completed, the body, branch, shell, exile, alive cover, dead cover, dead wood and root samples are broken down and grinded. Following the completion of the grinding process, the process of determining the amount of carbon amounts found in the tree, litter, living cover and dead wood and root components that form the ecosystem biomass is started. Carbon quantities of all samples are determined using the elemental analysis machine.

3. RESULTS

The amount of carbon stored in the stem of the Anatolian black pine trees in the study area is 13.07 tons/ha and 54.29 tons/ha, the amount of carbon stored in its branches is 3.3 tons/ha and 10.72 tons/ha, the amount of carbon stored in its foliage is 1.74 tons/ha and 7.04 tons/ha. The total amount of carbon stored in the trees varies between 20.26 tons/ha and 72.18 tons/ha. In some sample plots, there is no living cover, while the maximum amount of carbon was determined as 0.8 tons/ha. Likewise, dead wood was not found in some sample plots, while the amount of 2.7 tons/ha dead cover carbon was determined. The amount of dead wood carbon varies between 2.76 tons/ha and 4.22 tons/ha. Forest ecosystems are in the soil with the highest carbon accumulation in carbon pools. In this study, it was observed that the amount of carbon stored by the soil to a depth of 1 meter varies between 104,18 tons/ha and 139.06 tons/ha. The amount of carbon stored in under soil biomass was evaluated in 3 classes and was found to be between 56 kg/ha and 61 kg/ha in the fine root, 10 kg/ha in small root and 80 kg/ha in coarse root and 10 kg/ha to 100 kg/ha. Descriptive statistics regarding the amounts of carbon stored by carbon pools in forest ecosystems are given in Table 1.

Table 1. Descriptive statistics on carbon amounts in carbon pools.

<table>
<tr><th rowspan="2">Carbon pool</th><th rowspan="2" colspan="2">Components</th><th colspan="4">Carbon Stock (ton/ha)</th></tr>
<tr><th>min</th><th>max</th><th>mean</th><th>std. Deviation</th></tr>
<tr><td rowspan="6">Above-ground biomass</td><td rowspan="5">Living trees</td><td>Stem</td><td>13,07</td><td>54,29</td><td>33,55</td><td>20,61</td></tr>
<tr><td>Branch</td><td>3,30</td><td>10,72</td><td>7,65</td><td>3,87</td></tr>
<tr><td>Foliage</td><td>1,74</td><td>7,04</td><td>4,15</td><td>2,68</td></tr>
<tr><td>Bark</td><td>1,84</td><td>7,96</td><td>5,19</td><td>3,10</td></tr>
<tr><td>Tree</td><td>20,26</td><td>72,18</td><td>50,89</td><td>27,19</td></tr>
<tr><td>Living cover</td><td></td><td>0</td><td>0,80</td><td>0,42</td><td>0,54</td></tr>
<tr><td rowspan="3">Below-ground biomass</td><td rowspan="3">Roots</td><td>Fine</td><td>0,056</td><td>0,061</td><td>0,059</td><td>0,004</td></tr>
<tr><td>Small</td><td>0,01</td><td>0,08</td><td>0,05</td><td>0,04</td></tr>
<tr><td>Coarse</td><td>0,01</td><td>0,10</td><td>0,05</td><td>0,06</td></tr>
<tr><td>Deadwood</td><td></td><td></td><td>0</td><td>2,70</td><td>1,69</td><td>0,95</td></tr>
<tr><td>Litter</td><td></td><td></td><td>2,76</td><td>4,22</td><td>3,32</td><td>0,79</td></tr>
<tr><td>Soil organic matter</td><td></td><td></td><td>104,18</td><td>139,06</td><td>121,62</td><td>24,66</td></tr>
</table>

4. DISCUSSION AND CONCLUSION

In this study, it was determined that the total amount of carbon stored in the pure Anatolian black pine stands within the boundaries of Balıkesir Forestry Regional Directorate, Dursunbey Forest Management Chief, Çamlık Forest Management Directorate was 137.8 tons/ha. Forests, which constitute the majority of the amount of carbon stored in terrestrial ecosystems, have undertaken important tasks against climate change. One of the most important of these tasks is to store carbon dioxide (CO_2) by connecting. The studies show that the increase in global warming and the change in the climate will affect the whole world and our country with the increase in CO_2 density released into the atmosphere. For this reason, the studies carried out to determine carbon storage amounts on tree species are very important. In particular, the carbon storage capacity of the forests should be determined according to the Tier 3 method, which is one of the methods specified in the IPCC guides. By using the coefficients obtained from studies in different countries, the determination of the carbon storage capacity of forests will lead to some deficiencies. Türkiye is one of the countries that will be most affected by a climate change that can be seen, especially in the complex climatic structure, especially due to global warming. Naturally, it is surrounded by seas on the three side, it has a defective topography and its orographic characteristics, due to its orographic characteristics, different regions of Türkiye will be affected differently and in different sizes from climate change (Öztürk, 2002; Erkut, 2013). For these reasons, determining the carbon storage capacity of our forests, how the changes in carbon storage capacity over time, how carbon storage capacity changes according to planning units, and how the interventions affect the carbon storage capacity in the fastest and practical way to determine.

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Protected Areas for Biodiversity Conservation in Morocco

Assmaa Alaoui✉
Ibn Zohr University, Laboratory of Biotechnology & Valorization of Natural Resources, Agadir/MOROCCO
✉***Correspondence**:* a.alaoui@uiz.ac.ma

Abstract: On a global scale, human activities and unsustainable consumption and production patterns have, over the last century, led to an erosion of biodiversity, manifested by a major wave of ecosystem degradation and species extinction. Faced with this alarming situation, and in recognition of the importance of biodiversity for humanity, governments have adopted several conventions aimed essentially at conserving biodiversity. Aware of the threats of degradation to biodiversity, and in order to honor its international commitments by ratifying several conventions, Morocco has drawn up a Master Plan for Protected Areas (1996), which aims to evaluate the main natural environments over a surface area of 2.5 million hectares, and to identify 154 Sites of Biological and Ecological Interest (SIBE). The aim of this work is to present a diagnosis of the current situation, the importance and evolution of the diversity of natural ecosystems and the role of protected areas in biodiversity conservation, through case studies in Morocco.

Keywords: Protected areas, Biodiversity, Conservation, Degradation, Morocco.

1. INTRODUCTION

The earth is home to some 8.7 million plant and animal species, of which 86% of terrestrial species and 91% of marine species have yet to be discovered (Leroux et al., 2010). These biological resources are largely a potential source of income for the world's rapidly growing population.

Faced with a combination of complex natural factors, such as recurrent droughts, and man-made factors, such as the over-exploitation of natural resources, the misuse of chemical products and the introduction of exotic species to feed production systems that have remained extensive, the world's biodiversity is at risk (Vivien, 2002).

The extent of the biodiversity extinction crisis was measured by the Millennium Ecosystem Assessment. This assessment showed that, over the last fifty years, human activities have caused more rapid and extensive changes to ecosystems than at any other time in human history, resulting in a substantial loss of biological diversity on earth, often irreversible (Frankham, 2022).

Aware then, of the importance of preserving species and natural habitats, the United Nations Organization (UNO) in collaboration with the International Union for Conservation of Nature (IUCN), affiliated, over 50 years ago, the inventory of all protected areas in the world; A list of national parks and equivalent reserves was established (Deguignet et al., 2014).

This list of United Nations (UN) protected areas has since been maintained by IUCN and the United Nations Environment Programme's World Conservation Union. Other terrestrial and marine protected areas are designated, and the list is updated regularly. The aim is to have at least 17% of terrestrial and inland water areas and 10% of marine and coastal areas designated as protected areas by 2020 (Pollock et al., 2020).

2. BIODIVERSITY IN MOROCCO

In the Mediterranean Basin, Moroccan biodiversity is second only to that of the Anatolian region (Türkiye), with an overall endemism rate of 20% (Pollock et al., 2020). Thus, the variety of bioclimates and natural environments favors the development of very rich and diverse ecosystems of great ecological and socio-economic value.

The forty or so terrestrial ecosystems identified across the country are home to over 4,000 vascular plants, nearly 550 vertebrate species and thousands of invertebrates (Laaribya et al., 2021a). Two-thirds of these plants and one-third of the animal species live in forest environments. As a result, Moroccan forests are the foundation of the country's ecological biological wealth.

Moroccan forests cover some 9,631,896 hectares (including over 3 million hectares of alfalfa cover), or 13.5% of the national territory (IFN, 2005), and occupy different bioclimatic stages, from semi-arid to humid. They are made up of very heterogeneous, often open species with very diverse structures, divided into natural deciduous forests (Holm oak, Cork oak, Tauzin oak, Argan, Carob, Acacia, etc.) and coniferous forests (Atlas cedar, Berber cedar, Aleppo pine, Maritime pine, Black pine, Thuriferous juniper, Red juniper, etc).

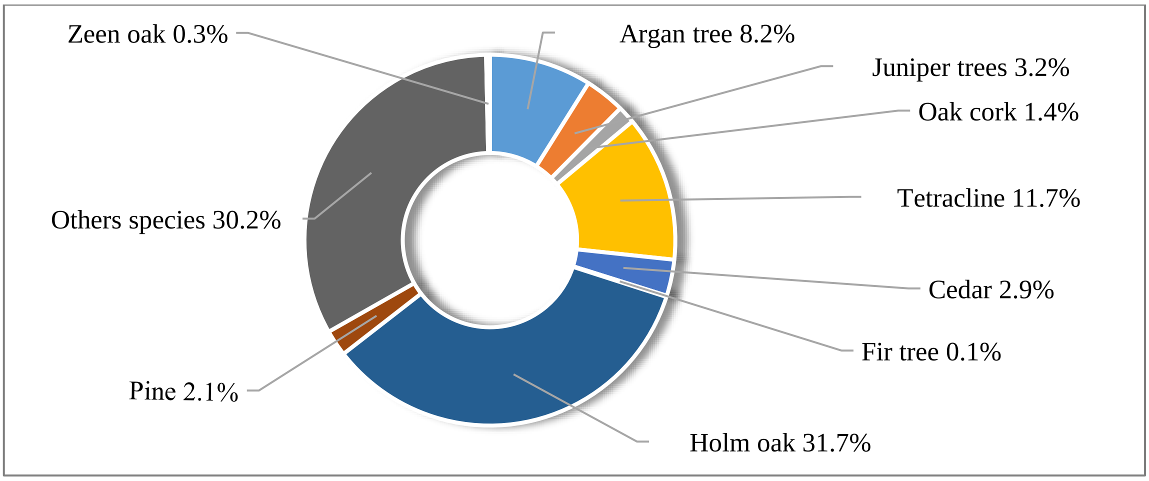

Figure 1. Main forest ecosystems in Morocco.

The forests are also home to a wide variety of fauna, including the cuffed moufflon, the magot monkey, the golden jackal, the wild boar, the panther and the striped hyena, the gazelle, the addax, the otter, the lynx and the African ostrich. Without mentioning all the animal species, the list is surely incomplete. They are also home to several bird species, including some rare birds of prey (Golden Eagle and Bearded Vulture), reptiles, lepidopterans and amphibians, which are represented by around a hundred species (Dobson, 1998).

In addition, the cultural resources, many of which are centuries old, combined with the natural potential, forest ecosystems offer very significant ecotourism potential and constitute a major resource for the people who live there, and a sector of economic activity in its own right.

Although Morocco's natural resources are of a high quality, they are insufficiently protected and increasingly under threat from climate change and anthropogenic pressure (Laaribya et al., 2021b). So, like all other countries, the conservation of natural environments in Morocco has become a decisive challenge.

3. PROTECTED AREAS AND MAINTAINING BIODIVERSITY IN MOROCCO

Aware of the threats to biodiversity and in order to meet its international commitments, Morocco has committed itself to a policy of sustainable development, which aims both to safeguard biological diversity and to develop several socio-economic axes, through the designation of sites of biological and ecological interest which, depending on their characteristics, vocation and socio-economic scope, will be assigned to one of the protected area categories (national park, nature park, biological reserve, nature reserve and natural site) defined by the law on the creation of protected areas (Mghili et al., 2023).

Following the example of other countries around the world, 154 sites of biological and ecological interest have been designated, ten national parks have been created to date and several wetlands are classified as protected areas, including 38 nature or biological reserves listed as Ramsar sites (Dakki et al., 2015).

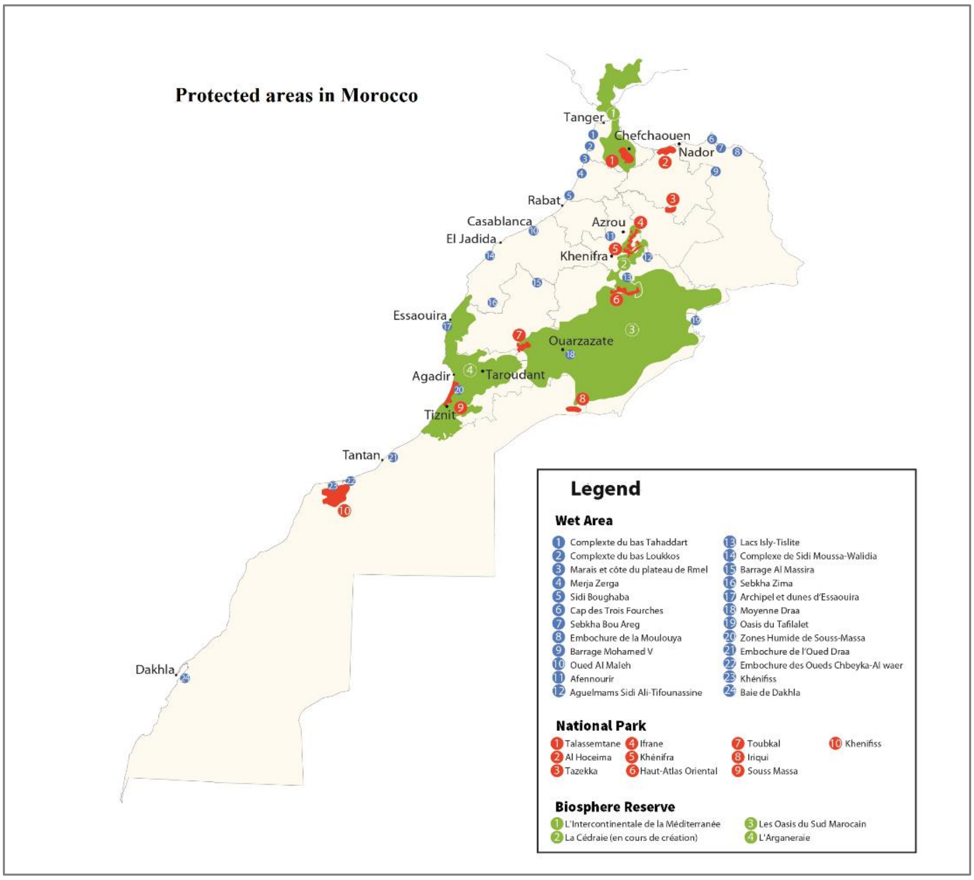

Figure 2. Protected areas in Morocco.

These protected areas, with their unique and highly diversified flora, contain locally endemic plant taxa, some of which are rare or threatened (Ayan et al., 2023), such as argan tree, Atlas cypress, Atlas cedar, Moroccan fir, black pine, etc. Some of these are part of the four Biosphere Reserves declared and recognized by UNESCO as world heritage sites for humanity. The aim of these reserves is to contribute to the conservation of natural resources and promote a model of sustainable development by fostering the social and economic development of rural populations through the preservation of their natural and cultural heritage (Vasseur & Siron, 2019). These include the Arganeraie Biosphere Reserve (1998), in the South-West region, covering an area of 2.5 million hectares, the Oasis Biosphere Reserve of Southern Morocco (2000), covering an area of around 7 200 000 ha, the Mediterranean Intercontinental Biosphere Reserve (2006), covering almost 1 000 000 ha, divided between the Moroccan and Spanish shores, and the Atlas Cedar Biosphere Reserve (2016), covering around 1 400 000 ha.

4. RESTORATION OPTIONS FOR DEGRADED ECOSYSTEMS

We have carried out research on ecosystems dominated by protected plant species with endemic and threatened characteristics. We have shown that these ecosystems can still be restored under current bioclimatic conditions by regenerating them on the scale of their projected potential areas. These include:

1. Cork oak (*Quercus suber* L.), which covers an area of almost 384 200 ha. It is a remarkable species in our forests, given its ecological and socio-economic roles. Unfortunately, the area covered by cork oak continues to decline under the influence of anthropozoogenic degradation, as well as damage caused by a number of insect pests, including Lepidoptera, and climate change. All these factors essentially threaten the world's most extensive lowland Cork oak forest (Maamora forest, 133 000 ha) with certain disappearance in the near future (Laaribya et al., 2021a).

In this study we applied the maximum entropy algorithm (MaxEnt) to estimate the current and potential distributions of cork oak (*Quercus suber* L.) in the Maarmora Forest, Morocco, in order to provide a basis for its conservation under conditions of climate change in the Mediterranean basin. A total of 1 428 spatial field records of cork oak locations were used (altitude and 19 bioclimatic environmental variables) to model the distribution potential of cork oak. We found that precipitation in the wettest quarter of the year, precipitation seasonality, altitude and seasonal temperature variations are the key factors determining cork oak distribution in Maamora forest. Most of the areas currently presenting favorable conditions for cork oak are located in the western and central Maamora forest; regions benefiting from a humid bioclimate and receiving significant sea spray from the Atlantic Ocean. Away from the ocean, humidity decreases and temperature rises, so that cork oak encounters adaptation and regeneration difficulties. The results can be used to identify high-priority areas for cork oak restoration and conservation against the expected impact of climate change.

2. The Atlas cedar (*Cedrus atlantica* Manetti) is an emblematic species of Morocco, classified by the International Union for Conservation of Nature (IUCN) in the red list of endangered species. Determining its potential range under current climatic conditions is an essential step in planning and ensuring its conservation. We modelled the distribution of the potential range in Morocco using the "MaxEnt" maximum entropy approach. The most significant variables conditioning the distribution of Atlas cedar, under current climatic conditions, are rainfall in the driest quarter, rainfall in the driest month, mean annual temperature and relative humidity. The model developed has enabled us to draw up the first map of the potential area of suitable zones for Atlas cedar in Morocco. The current mapped area of the Atlas cedar in Morocco is 138 691 hectares, while the modelled potential distribution area represents 770 605 ha, i.e. a surplus of 631,914 ha (+455%) compared with its current habitat. This result shows, on the one hand, the regression of the area occupied by Atlas cedar in the past, as a result of human and pastoral pressures, and reveals, on the other hand, the possibility of reconstituting its habitat under current climatic conditions by restoring it to the scale of its predicted potential range (Laaribya & Alaoui, 2021).

3. Moroccan fir (*Abies marocana* Trabut) located in Talassemtane National Park, is endemic species of the Moroccan Rif, classified as “endangered” in the IUCN Red List of Threatened Species. Since the beginning of the last century, this species has suffered 70% habitat loss. However, despite its bioecological, economic and social importance, Moroccan fir has received little attention from researchers. Determining the potential area under current topographic and climatic conditions is a very important step to develop conservation and sustainable management strategies for this endangered endemic species. For this purpose, the potential distribution of Moroccan fir using the maximum entropy approach (MaxEnt software 3.4.1) is presented in this work.

Our results showed that the main variables conditioning the presence of A. marocana were the average temperature of the warmest quarter and the maximum temperature of the warmest month. The potential area represents a gain of 227% compared to the current distribution of the Moroccan fir forest. Suitable areas are provided allowing management for afforestation programs and carbon sequestration in Talassemtane National Park, Morocco (Alaoui et al., 2021).

5. CONCLUSION

Biodiversity, as a common heritage, is of exceptional interest and remains at the heart of major global concerns. However, its decline is putting all the services provided by nature at risk.

Although they are not the only mechanism, protected areas are essential for the maintenance and sustainable use of biodiversity. They have been set up to conserve and restore habitats and species, and to enhance the value of natural and cultural assets.

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King of the Desert

Nurtore Omirzak*✉, *Zhumagul Boranbay

S. Seifullin Kazakh Agro Technical Research University, Astana/KAZAKHSTAN

✉***Correspondence**:* mr.n_01@mail.ru

Abstract: The saxaul plant, which is considered an integral part of nature, is considered, its morphology, and economic importance. Saxaul, which became the “King of the desert”, did not lose its value and holiness, no matter how much time passed. Only the generation of each era, not understanding its value, creates the danger of saxaul disappearing from the face of the earth. This, of course, is a great abuse, first of nature, and then of humanity. Saxaul is used when planting field-protective forests, planting in sand, especially in sand with saline soil. Saxaul is a fortress of the sandy desert. That is, it holds the sand tightly. Saxaul is the living depths of the desert.

Keywords: Saxaul, Kazakhstan, Desert, Sand, Soil, Nature.

1. INTRODUCTION

Saxaul is a Turkic word that means “HorseTail” in Kazakh. In fact, when the leaves are down and the branches are bent, the horsetail will not budge. The Greeks call it “Salt Tree” (Anonymous, 2013). Saxaul also entered science under the name “Haloxylon”, “a perennial plant belonging to the Amaranthaceae family *(Chenopodiaceae)*, not very tall, the trunk is tuberous, the leaves are small, scaly, opposite, the flower are also small, bisexual, grows and reproduces by shoots and seeds. It is written in the domestic encyclopedia and educational literature that this tree lives about 30 -60 years. There are 10 species of saxaul growing in Asian deserts and steppes, of which only 3 species are found in Kazakhstan: black saxaul *(Haloxylon aphyllum)*, Zaisan saxaul *(Haloxylon ammodéndron)* and white saxaul *(Haloxylon persicum)*. The roots of the black plane tree go up to 12 meters in length, the height sometimes reaches 10 meters, the trunk diameter is 50-70 cm. It blooms in April-June, bears fruit in October-November. It mainly grows between Ustyurt and Lake Balkhash (Mukanov et al., 2009).

"King of the Desert", this is what the Kazakh called saxaul, which protects the soil from erosion in the desert, stops landslides of sand dunes and heats up more than coal. Unfortunately, the number of this valuable plant is declining in the country. That is why experts are sounding the alarm, claiming that saxaul needs special protection. And the government is trying to save the precious plant by banning pruning of saxaul.

11.2 % of the lands of Kazakhstan are forested, 48 % of them belong to saxaul groves (Anonymous, 2022). There are about ten species of hardy woody plant native to sandy areas and tolerant of desert conditions in Central Asia and the Arab countries. Three of them grow in Kazakhstan: white saxaul, black saxaul and Zaisan saxaul. Saxaul in Kazakhstan occupies 48 % of the forest fund. Half of the 30.552 hectares of the republic’s forest fund belongs to saxaul. It is well known that the main reason for this is the growing number of people wishing to illegally cut down a valuable plant. In addition, today the regrowth of saxaul is also a problem for foresters. Every year, although saxaul seeds are sown in many places, it is not easy for them to take root. The natural vegetation of the field has become sparse and cannot serve as protection from the wind. That is why the seed sown in the ground is carried away by the wind. In turn, the actions of merciless cutting of Saxaul prevent the plant from re-growing. In the past, people used saxaul as a fire starter. And now the shortage of coal and the increase in its price, in addition to the lack of natural gas, have affected people living in the villages, and they began to use saxaul as clean fuel (Khabdulkhabar, 2019).

Valuable firewood is prepared from saxaul; its trunk is difficult to cut and split with an axe, but if you hit each other with one of them, they will quickly break. Kazakh people warmed up and having absorbed the heat of saxaul, will not yield to an external enemy; he can only be defeated by driving him closer to each other. They listen to other people's gossip, cut themselves off, judge good and evil, shake their heads, saying that "the Kazakh has no enemy but the Kazakh", finish what they ruined, and return to their old life.

Saxaul ash contains potassium carbonate, which was previously used to make soap. Kazakh Saxaul Ash is added to the tobacco leaf, "Nasway", hitting the heel of his boot with his fist, glancing into the space around him, he admits that his only owner is himself, grateful to the ancestors who inherited this vast steppe from their descendants. When saxaul completely withers, a very large amount of salt is released into the soil. It can be seen that the Saxaul region has brackish soil, and there is little vegetation around (Anonymous, n.d.).

Forestry officials are responding to increased plant supplies. In the early 1990s, planting of saxaul began on an area of 54 thousand hectares. Due to lack of finance, it remained idle and was resumed only in 2002. In the period from 2008 to 2014, a project was launched for the conservation of forests and the reproduction of plant reserves in Kazakhstan. With the support of the World Development Bank, saxaul was sown on an area of 57 thousand hectares. Today, Almaty, Kyzylorda and Turkestan regions occupy leading positions in the use of saxaul in everyday life. In these territories, saxaul has a high risk of complete extinction as a biological species. In this regard, within the framework of the project, research work, activities to involve the local population in small business and environmental education of children, measures to counter illegal saxaul logging, improvement of the material and technical condition of nature reserves and reserves located in these territories, training in them are carried out personnel (Anonymous, 2019). The UN Development Program and the country's government have jointly initiated special projects to preserve biological diversity. For the same projects, special attention is paid to the protection of saxaul in Kazakhstan.

In desert areas, saxaul is used to stop landslides because it has a very strong root system that takes deep roots. In honor of the tenth anniversary of our independence, at the command of the First President, who at one time traveled through the southwestern regions, members of the special train "My Kazakhstan", which included representatives of art and a service group, were amazed by this country, calling it "Unbending Oaks". Yesterday's ancestor bowed indiscriminately for centuries, preserving the offspring. Today we have taken sovereignty and formed the ruler of the country and the land.

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Characteristics of Carbon Deposition of *Salix alba* L. Forest Plantations in Irtysh-Karagada Channel Tract in Pavlodar State Institution

Zhassulan Kadyrbekov*✉, *Zhumagul Boranbay

S. Seifullin Kazakh Agro Technical Research University, Astana/KAZAKHSTAN

✉***Correspondence***: kadyrbekov.zhassulan@mail.ru

Abstract: Since forests contain more than 70% of the Earth's total phytomass, any significant changes in its reserves can affect the global carbon cycle, CO_2 content in the atmosphere and climate. Currently, the likelihood of environmental crises and the danger of a further increase in CO_2 content in the atmosphere has increased significantly. Forests plantations along the Irtysh-Karaganda Channel of Pavlodar and Karaganda regions have great socio-economic and cultural-ecological significance. However, their research has still been carried out mainly from the point of view of the raw material properties of wood and almost did not affect the ability of regional forests to absorb carbon, which increases the practical value of the research.

Keywords: Carbon, Carbon deposition, biomass, forest plantation.

1. INTRODUCTION

The main reservoir where carbon accumulates is the phytomass of forest plantations (the trees themselves), as well as undergrowth, forest litter, dry wood and soil cover. When plants respire, up to 40% of the carbon absorbed from the atmosphere returns back to the atmosphere, but while the forest is young and continues to grow, it accumulates this carbon within itself every year, thereby ensuring climate balance on the planet. As soon as the planting has reached the age of maturity, the accumulation (collection) of carbon almost stops, the reservoir is full - it cannot accommodate more, therefore it is vitally necessary to make every effort to create favorable conditions for the emergence of the young generation of the forest, both naturally and by creating forest crops (Isaev et al., 2001).

The processes taking place in the world after the signing of the Kyoto Protocol are recognized by many countries and are acquiring specific numerical characteristics and economic outlines. For example, after setting the limit values for carbon dioxide emissions into the atmosphere at the level of its actual volumes in 1990, countries around the world came to the need to trade its surplus. There is a practice of selling and buying carbon dioxide, which indicates the presence of demand for it and internationally recognized prices (Baranov & Boranbai, 2012). Therefore, if it is necessary to compensate for anthropogenic CO_2 emissions, in principle, each ton of carbon deposited by forest vegetation can receive a cost estimate.

Since 2012, specialists of State Institution KazNIILHA have been working on assessing the carbon deposition potential of Kazakhstan's forests. For this purpose, the calculated phytomass data were analyzed in connection with the age and stand volume of tree stands as the main determining indicators included in the forest background, and a database was compiled that characterizes the stock and deposition of organic carbon in forest plantations of Northern, Central, Eastern and Southern Kazakhstan (Baranov & Boranbai, 2013; Boranbai & Baranov, 2015).

2. MATERIALS AND METHODS

According to the State accounting of the forest fund on 01.01.2013, forest plantations of the total area of the "Irtysh-Karaganda Channel tract" is 1755 hectares, of which tree willow (*Salix alba* L.) occupies 23.7% or 415.94 hectares. The distribution of areas and reserves of forested land by age classes in plantations of tree species is heterogeneous. They were used to determine carbon stocks and their annual deposition models describing the dependence of phytomass on age (A, years) and stock (M, m^3/ha) plantations by species, set forth in methodological provisions (Usoltsev & Zalesov, 2005).

In general, the data model calculates the stock phytomass in absolutely dry conditions states for all forest-forming species are as follows:

lnPi or ln(Pi/M) = f [lnA, (lnA)2, lnM, ln(PB/M), ln(PF/M)] (1)

Path of tabulation of models for storage of stem wood (M, m^3/ha) in growth of plantations (A, years) is determined by the total forest stands of phytomass stems, and ot phytomass stem using a series of constants and independent variables (Usoltsev, 2007). The calculated phytomass of branches, needles (leaves), roots and the lower layer (understory, undergrowth, ground cover).

Further, the reserve phytomass of each fraction is calculated according to the translation coefficient phytomass: carbon (K = 0.5 for woody part and K = 0.45 for leaves and lower tier).

3. RESULTS AND DISCUSSION

Calculations made based on the data of the distribution of areas and reserves by predominant species established that the total reserves of organic carbon of forests amount to 10.319 thousand tons. Carbon pool for young stands - 20.519 thousand t, middle-aged - 11.359 thousand t, ripening - 19.631 thousand and ripe stand and overmature - 27.926 thousand tons. The average carbon stock in phytomass plantations of 1 ha of forest cover is 14.932 tons (Table 1).

Table 1. Sequestration of organic carbon in the tract, thousand tons.

***Salix alba* L.**	**Age classes of forest stands**					
	Saplings					
	1 age class (0-10 years)	**2 age class (10-20 years)**	**Middle-aged (20-30 years)**	**Ripening (30-50 years)**	**Ripe and overmature (50-70 years)**	**Total, tons**
Organic carbon stocks	0.055	1.025	3.771	4.378	1.09	10.319
Average carbon reserve in phytomass t/ha	9.262	11.257	11.359	19.631	27.926	14.932
Annual deposition of carbon (thousand tones)	0.007	0.079	0.549	0.296	0.051	0.982
Average carbon reserve in phytomass t/ha	1.162	0.872	1.654	1.326	1.317	1.422

It was calculated that the total annual flow of atmospheric carbon in the phytomass plantations of the nature reserve is 22,638 thousand t or 1,299 t/ha and distributed according to the size of the forested area and stocks of stem wood

As can be seen from the data, young trees (i.e., plantations of the 1st and 2nd age classes) are inferior to mature and dormant plantations in terms of annual carbon deposition.

And as it was said above, in order to strengthen the carbon-depositing properties of plantations, it is necessary to increase the area of young trees by gradually replacing dormant plantations (reconstruction of plantations) and creating artificial plantations on uncovered forest lands (reforestation and reforestation).

Forests plantations along the Irtysh-Karaganda Channel of Pavlodar and Karaganda regions have great socio-economic and cultural-ecological significance. However, their research has still been carried out mainly from the point of view of the raw material properties of wood and almost did not affect the ability of regional forests to absorb carbon, which increases the practical value of the research.

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Paulownia in Kazakhstan

Khamit Liza✉, Yesmurzayeva Aida
S. Seifullin Kazakh Agro Technical Research University, Astana/KAZAKHSTAN
✉***Correspondence***: lxamit@list.ru

Abstract: Every year in Kazakhstan, the number of industries is growing, respectively, and environmental pollution, and especially air pollution. The government cannot refuse and close the industry, as well as the citizens themselves in economic terms, so let's look at one of the best trees that can help us cope with this difficult task. Paulownia is a genus of trees in the Paulownia family. It grows in Southeast Asia (especially in China), where it has been grown for decorative, cultural and medicinal purposes for more than 2000 years. It is also known as the princess tree, the royal tree, the Kiri tree, the Empress tree and the phoenix tree, and its Chinese name is 泡桐 (pāotóng). It is believed that the genus Paulownia includes from 6 to 17 species, depending on the taxonomic classification. Of these, P.tomentosa, P.elongata, P. Fortune and P. catalpifoliaare considered the most popular.

Keywords: Paulownia, *P. tomentosa*, Shan-Tong, Pao Tong Z07, Carbon dioxide, Oxygen, Seeds, Polluted air, Saplings, Seedlings.

1. INTRODUCTION

Currently, paulownia trees are planted in Asia, Europe, North America and Australia for commercial, medical and decorative purposes. Due to their rapid growth rate and adaptability, they are considered invasive species in some countries. However, most of the risks can be reduced by planting hybrids that produce infertile seeds (for example, an in vitro 112 clone). Paulownia can adapt to various environmental conditions, has a fast growth rate and exceptional regenerative abilities; a cut tree trunk can grow up to 2-4 m per year. In fact, it is one of the fastest growing trees in the world, capable of producing several times more biomass per year than some slow-growing species. These properties have led to increased interest in creating a paulownia plantation for the purpose of biomass production (Sławińska et al., 2023).

Recently, the growing interest in paulownia has led to the development of various hybrids, the most famous of which are Clone in vitro 112, Shan Tong, Sundsu 11 and Cotevisa 2. Paulownia Clone in vitro 112 is an artificially created hybrid of two species of paulownia.

In which regions of Kazakhstan does Paulownia grow: in Turkestan and South Kazakhstan regions. Most often it can be found in Almaty and Shymkent. According to the latest data from 2018-2019, Entrepreneurs: Baltabai Kurbanbayev planted 50 thousand seedlings on two hectares of land in the Turkestan region, and Dauren Baltabayuly – 37 thousand seedlings on a similar plot of land in the South Kazakhstan region. Currently, it is very easy to find Paulownia seedlings in the Internet sites of Kazakhstan and they are even used for landscaping the city in Southern Kazakhstan (Anonymous, 2023a). This shows that Paulownia has a good future in Kazakhstan

Why do some consider Paulownia the "tree of the future" and openly believe that there are no other alternatives to it?! Let's stop at its uniqueness and features, which have earned good fame in many areas, such as landscape design, medicine, forestry, cattle breeding, economics and of course ecology:

- Large paulownia leaves absorb 32 times more CO_2 and emit 10 times more oxygen than ordinary trees. Absorbs 22 kg of carbon dioxide and gives out 6 kg of oxygen (Anonymous, 2018).

- Bloom for 2 months

- The increase per year is 3-5 meters, which is why they give a thick shadow.

- Flower nectar is a source of high-quality honey

- The leaves have a high protein content (about 20%) and can be used to make high-quality and cheap animal feed (Boyarshinova, 2018)

- Paulownia wood is also used in construction, paper pulp production, furniture and musical instruments.

- Has the ability to withstand high concentrations of heavy metals (for example, Mn, Pb or Zn) can be used for rejuvenation of polluted soil and reforestation

- The possibility of using paulownia as a bioenergy crop, i.e. for the production of biofuels and CO2 capture, is also being considered

- Fast and good adaptation

- Paulownia after cutting down does not require re-planting, as it has a high regenerative capacity and can be restored during cultivation for 70 years

In Kazakhstan, you can find frost-resistant varieties of technical paulownia (these are hybrids): 9501, 9502, 9503, Shan-Tong, Pao Tong Z07 (Imanberdieva & Sanzharbekova, 2023). The last variety was grown in a greenhouse by entrepreneurs in the city of Almaty, their activity in this city lasted 4-5 years, later they moved to Shymkent, as Paulownia began to grow poorly from seeds. In the south, experts believe that Paulownia will make their region the greenest in Kazakhstan. We recommend planting paulownia en masse in cities with polluted air to improve the ecology. Based on the results of monitoring conducted in 2022, experts identified eight Kazakhstani cities with high levels of air pollution. These included Astana, Almaty, Karaganda, Temirtau, Atyrau, Aktobe, Balkhash and Ust-Kamenogorsk (Anonymous, 2023b).

Firstly, as the experience with the greenhouse in Almaty shows, it is rather necessary to plant adult saplings, not seedlings, so that they are strong enough to adapt and fight the polluted atmosphere. Secondly, there are cities in the list of cities that are covered not with soil, but with sand. This is a serious problem for paulownia, even if it is not whimsical. Thirdly, since interest in paulownia is increasing to this day, hybrids and new varieties are being created, we hope that a variety for arid areas will also be released soon.

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Chitosan; A Novel Adsorbent for CO_2 Capture

Ali Eslem Kadak

Kastamonu University, Devrekani TOBB Vocational School, Kastamonu/TÜRKİYE

***Correspondence**: alieslem@hotmail.com*

Abstract: Carbon dioxide is a chief greenhouse gas found as the main combustion product of fossil fuel, which is responsible for environmental changes such as the increase in atmospheric temperatures, melting of glaciers, rising sea levels, and increasing acidity of the oceans. A comprehensive technology was developed for the absorption of CO_2 based on chemical absorption. But to mitigate climate change, developing new efficient strategies and technologies must receive considerable attention. CO_2 adsorption using biopolymer natural and abundant materials is considered as an alternative technology in commercial and industrial applications due to its generally low energy requirements, ease of operation, and low maintenance. Chitosan within natural biopolymers has been intensively studied recently for CO_2 adsorption. Chitosan may be used in CO_2 adsorption having low energy necessity, ease of processability, and low maintenance and, thus, may be deliberate as a substitute technology in commercial and industrial applications. Chitosan (poly-β-1.4-2-amino-2-deoksi-β–D-glucopyranose) is derived by deacetylation of chitin. Chitin (β-1,4-poly-N-acetyl-D-glucosamine) is a natural biopolymer, and its production in biomass of up to 10^{12} tons/year makes it one of the most abundant polysaccharides on Earth. It is the main component of the cell walls of fungi, exoskeletons of arthropods such as crustaceans (crabs, lobsters, shrimps, etc.) and insects. Due to its biodegradability, renewability, biocompatibility, non-toxic, and non-antigenicity, chitosan is a green material. In this research, studies on CO_2 adsorption of chitosan biopolymer were investigated.

Keywords: Chitosan, Shellfish waste, CO_2 adsorption, Green material.

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Factors Affecting Land Use Change Around the Anzali Wetland and the Challenges Ahead

Seyede Mohadese Hatami Shahkhali*✉, *Shahram Sharifi Hashjin, Farzane Nasiri Jan Agha, Habib Mahmoodi Chenari

Academic Center for Education, Culture and Research, Tahran/IRAN

✉***Correspondence**:* mahdishatami1359@gmail.com

Abstract: Changes in land use and destruction of natural covers lead to disturbances in the ecosystem and a decrease in biodiversity. In recent years, climate change, agricultural, industrial, and tourism activities, land use changes around the wetland, and the occurrence of eutrophication phenomena have brought this valuable ecosystem to the brink of destruction. The Anzali wetland complex is located near the city of Bandar Anzali in Guilan province in northern Iran, along the southern coast of the Caspian Sea. The aim of this study is to identify and monitor changes in land use over the past two decades, as well as to determine and analyze the influential factors on land use changes around the Anzali wetland in order to develop management plans to reduce the negative effects of land use changes by providing logical solutions to prevent economic, social, environmental, and livelihood damages in this area. In this study, by preparing a land use map of a 20-year period of the study area and modeling land use and cover changes in the Anzali wetland basin, effective parameters in land use changes were identified, analyzed, and introduced. This study has depicted land use changes from 2000 to 2020. The images are classified into agricultural lands, wetlands, forests, water bodies, residential areas, and barren lands. Landsat images from 2000, 2008, and 2020 were used. The outputs of the processing are LULC images, which show the extent of land use changes based on the information obtained from these images. The results of the spatial image comparison show that in the period of 2000-2020, wetland areas have changed by -29.3%, grasslands by 37.4%, agricultural lands by 15%, residential lands by 183%, forests by 40.1%, water bodies by -28.4%, and barren lands by 15.1%. Finally, the villages around the wetland, which have undergone the most changes, were identified.

Keywords: Land use changes, Spatial images, Anzali wetland, Guilan province.

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Investigating the Amount of Carbon Sequestration of Oak Seedling (*Quercus castaneifolia* C. A. Mey.)

Javad Torkaman[1]✉, Tooba Abedi[2]

[1]*University of Guilan, Faculty of Natural Resource, Somehsara/IRAN*

[2]*Academic Center for Education, Culture and Research, Environmental Research Institute, Rasht/IRAN*

✉***Correspondence***: torkaman@guilan.ac.ir

Abstract: One of the most important ways to reduce Atmospheric carbon is the carbon sequestration by trees. In this study, by using some morphological characteristics of the root and stem of Oak seedling the carbon sequestration evaluated. For this purpose, one hundred seedlings were sampled by method of Systematic-Random from the planting bed on March 2022 in the Pylambra nursery at Guilan province. Seedlings are divided to three grades small, medium and large according to Root Collar Diameter (RCD). The biomass and carbon sequestration of Oak seedling calculated according to the basic density of its root and stem. the Pearson's correlation coefficient used for correlation detection between variables. The one-way analysis variance test at the 95% confidence level used to recognize difference between biomass and carbon sequestration of three group of the Oak seedlings. The results of correlation analysis showed that the root collar diameter (RCD) had the strongest correlation with other morphological characteristics. the amount of the basic density for the root and shoot of the Oak seedling obtained about 0.57 gr/cm^3 which is the same for both of them. the amount of the biomass and carbon sequestration of the root obtained more than shoot at the small and medium seedlings, whereas in large seedling was the same. In general, by increasing the size of seedling the biomass and carbon sequestration increased.

Keywords: Oak seedling, Biomass, Carbon sequestration, Basic density, Root collar diameter.

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Carbon Capture Potential Across Northern Forest of Iran, Case Study: Asalem Forests

Maryam Kazempour Larsary*, *Hassan Pourbabaei

University of Guilan, Faculty of Natural Resources, Department of Forestry, Somehsara/IRAN

***Correspondence**:* kazempourmaryam@yahoo.com

Abstract: In the context of global climate change, carbon sequestration has become a highly valued function of forest ecosystems. Forests harbor approximately 44% of the global carbon pool, storing carbon dioxide (CO_2) in their woody biomass, and playing an irreplaceable role in regulating global carbon balance. So, the main purpose of this research is to discover the importance of Iran's northern forests in carbon capture potential through scientific approaches. To evaluate CO_2 absorption, 164 400 m^2 (20 × 20 m) temperate forest plots were stablished along altitudinal gradients (400-1800 m) within Asalem forests located in northwest Iran. We applied the allometric equations relate individual aboveground biomass (AGB) with diameter at breast height (DBH), height and wood density to calculate AGB and multiply each value by organic carbon content (%) derived from combustion method to quantify aboveground carbon (AGC) sequestration potential. The CO_2 absorption amounts were further estimated by multiplying total AGC sequestration by 3.67 as a conversion factor. The regression and correlation analyses were used to model carbon capture potential along altitudinal gradients. We found 3837 individuals belong to 21 species, 15 genera, and 11 families. The total value of annual AGC sequestration and CO_2 absorption was about 31.23 and 114.61 gigatons per hectare (Gt ha^{-1}), respectively that showed negligible correlations with elevation. The one-way analysis of variance (ANOVA) and Tukey's post hoc test indicated the significant differences in carbon capture potential among 21 species. The highest AGC sequestration (17.21 Gt ha^{-1}) and CO_2 absorption (63.17 Gt ha^{-1}) were recorded for beech trees (*Fagus orientalis* Lipsky). The results revealed an important basis role of our northern forests (beech trees) in mitigating climate change consequences that have to improve by applying appropriate conservation management strategies.

Keywords: Climate regulation, Carbon sequestration, Tree species, Natural forests.

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Study on Vegetation Composition in Broadleaved and Coniferous Plantations, Bibiyanlou's Forest Park, Astara, Iran

Towhid Salahi[1]✉, Hassan Pourbabaei[1], Mehrdad Ghodskhah[1], Maziar Salahi[2], Sarkhosh Karamzadeh[3]

[1]*University of Guilan, Faculty of Natural Resources, Department of Forestry, Somehsara/IRAN*
[2]*University of Guilan, Faculty of Mathematical Sciences, Department of Applied Mathematics, Rasht/IRAN*
[3]*Guilan Province, Director of the General Directorate of Natural Resources and Watershed Management, Rasht/IRAN*

✉***Correspondence***: tohidsalahi@yahoo.com

Abstract: The aim of this study was to investigate vegetation composition in hardwood and conifers Plantation in 220 ha of *Pinus taeda* and alder and poplar hardwood plantation and its comparison with natural forests in Bibiyanlu protected forest park at Astara. A total of 60 sampling plots of 1000 m^2 by randomly-systematic method using 150 × 150 m grid in plantation and 200 × 200 m in natural forest was implemented. Rosaceae and Aspidiaceae family had the highest species richness in the study area, respectively. The results of the classification of life forms based on Rankayer method showed that Hemicryptophytes and Phanerophytes with total of 67% were the important in the area. Studying the geographical distribution of plants showed that the most species belongs to Europe - Siberian in the study area. To study the biodiversity, Shannon - Wiener diversity index, Simpson's index, Hill evenness index and richness indices were used. The results of this research showed that there are significant difference for diversity and richness indices between natural forest and plantation. Diversity and richness indices in natural forest were more than Taeda pine, Poplar and Alnus plantation.

Keywords: Plantation, Species composition, Coniferous, Broadleaved, Astara.

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Carbon Emission and Urban Climate in Georgia

Roza Lortkipanidze[1]✉, Giorgi Iakobashvili[2], Nunu Chachkhiani-Anasashvili[1], Rusudan Tskipurishvili[1]

[1]*Akaki Tsereteli State University, Agrarian Faculty, Department of Agronomic Sciences, Kutaisi/GEORGIA*
[2]*National Food Agency of Ministry of Environmental Protection and Agriculture of Georgia, Tbilisi/ GEORGIA*
✉***Correspondence**:* roza.lortkipanidze@atsu.edu.ge

Abstract: The GHG indicator based on the data collected in Georgia in 2015 was 17.6 mt. CO2 eq. GHG emissions are generated in 7 sectors: energy generation, transportation, construction, industry, agriculture, waste management and Forestry. Increase of CO_2 in Georgia is greatly affected by urban activities- namely exhaust fumes and poor quality of fuel. 10% of carbon dioxide in atmosphere is combustion product. All atmosphere protection operations in Georgia are regulated in the frameworks of official state program, which groups all the emissions connected with energetics, climate strategy and transport through sectors. In 2015 total GHG emission in the sector of transportation was up to 24% (Ministry of Environmental Protection and Agriculture of Georgia, 2019). In previous years (2015) transportation GHG emission was up to 68% in total. Various types of transportation data: car emission-88%, bus emission 5% and minibus emission-6%. 32% of emission falls on railway and agricultural technology. 29% falls on trucks. Characteristics of transportation GHG emissions data in Georgia up to 2023 remains the following: electricity is mostly consumed by the railway, which includes Tbilisi underground train service. Expense is only 1% of electricity. Considering basic data collected in the sector of agriculture, by 2030 increase in Agricultural emission will probably be about 40% more compared to the initial data. That is 4.63 mt. CO_2 eq. Within livestock, ruminant livestock remains main source of emissions, that is in 2015 92% of Enteric fermentation emission and 82% of emission was due to dung waste emission. These forms still remain as main sources of emission till 2030. Agricultural development is of high priority in Georgia. Strategically, main focus will be made on forming and launching the climate-oriented agricultural practices. In the future sustainable business will be the chief foundation determining a reasonable growth and development of the field of agriculture. Considering the climate change, drastic measures should be taken in order to prevent or avoid natural disasters. Vivid example of the climate change is a tragic disaster that happened in one of the regions of Georgia, Ratcha, Shovi on the 3rd of August, 2023. As a result of landslide several tons of mass almost completely covered resort Shovi. 220 people were rescued, 30 died and rescuers are searching for more victims. As survivors claim, landslide covered the surrounding area of so-called "Cottage district" in just 3-4 seconds, ruining all the infrastructure, bridges and caused death of several people. The natural disaster was a result of melting glaciers both locally and in the oceans worldwide. Global warming is responsible for such devastating disasters.

Keywords: Emission, Urban, Gases, Climate, Carbon dioxide.

1. INTRODUCTION

According to a 2020 study in Georgia conducted by the Caucasus Environmental Center (REC Caucasus) for the Environmental Development Program (UNDP), more than 91% of Georgians believe that climate change is a well-defined process that poses serious threats to life on earth. Based on the survey, 96,11% of respondents said they were most concerned about droughts and global warming brought on by climate change (Lortkipanidze, 2010; Lortkipanidze & Kheladze, 2015).

Additionally, the Shovi resort was completely devastated as a result of the tragedy that took place on August 3 of this year in the Georgian region of Ratcha. This disaster resulted the removal of 2 million tons of earth in the form of a landslide. 220 people were evacuated by helicopter, 32 people died, 30 of them were found, the search party is currently seeking for two juveniles. According to the survivors, the deadly landslide developed in 3-4 minutes, which wiped out the bridges, buried the "district of cottages" and caused casualties. The rapidly developing landslide thoroughly destroyed the Shovi resort. The work was carried out using environmental and agro-ecological monitoring research methods (Lortkipanidze & Kheladze, 2015; Walker et al., 2007; Lortkipanidze, 2015).

Along with such unpredictable events, it is crucial to have a well-thought-out long-term plan for low-emission development on earth, which is significant in Georgia. The government and scientists collaborated to create a program called the "2021 updated document (NDC)-2030" that serves as the country's main road map for the action plan that was created in response to climate-related occurrences. Georgia's 2030 Climate Change Strategy and Action Plan ("Climate Strategy and Action Plan-CSAP", "Climate Action Plan-CAP") outlines what should be done to mitigate climate change and includes a mechanism for organizing and carrying out coordinated efforts to meet the national goals. As a result, it establishes the methods to fulfill the aim of reducing greenhouse gas (GHG5) emissions in our nation by 2030. In accordance with the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), the objectives are stated in "Georgia's updated Nationally Determined Contribution" document (NDC).A long-term aim for lowering greenhouse gas emissions by 2030 is laid out in the Climate Strategy and Action Plan, for which particular initiatives are planned. Our involvement in the preparation and planning of the action plan for the Ministry of Environment Protection and Agriculture of Georgia's structures was based on scientific research data for the year 2030 compared to the data for the year 2020 using contemporary technology. This method is going to reduce carbon dioxide emissions from 1,091 mg CO_2 eq to 840 mg CO_2 eq by 2030 via today's technologies, and the aforementioned landfills must be closed by 2024. In Georgia, transportation emissions account for a sizable portion of emissions: studies show that only the metro and railways consume electricity in the country, which according to data from 2015 accounted for only 1% of the electricity consumed. CO_2 emissions in the country, according to the preliminary forecast for 2030, according to road transport, strict environmental measures are required. There will be 13 billion vehicle kilometers of traffic in 2020. 3900 vehicle kilometres per capita is less than half of what the International Council for Environmentally Clean Transport (ICCT) expected for EU countries in 2020. According to data from 2020, private vehicles made up 70% of passenger kilometers traveled in Georgia, while 30% of those kilometers were taken by public transportation, which included railways (4%), buses (12%), minibuses (14%) and buses (12%) (Lortkipanidze, 2010; Lortkipanidze & Kheladze, 2015; Landmeyer, 2011; Walker et al., 2007).

Georgian carbon dioxide emissions are predicted to be 189 g CO_2 eq/vehicle kilometer, especially for light automobiles. According to the EU emissions recommendations, new cars must emit no more than 96 g of carbon dioxide per kilometer by the year 2020 (European Commission Report, 2018). According to data from 2019, Georgia's high emissions are primarily brought on by its fleet of secondhand automobiles and out-of-date models, with more than 87% of all vehicles registered there being more than ten years old. The majority of light trucks and buses utilize diesel fuel, whereas 68% of internal combustion engine cars run on gasoline. Less than 1% of all vehicles sold are electric, which is a very modest percentage (Walker et al., 2007; Horst et al., 2020).

In terms of low-emission vehicles, hybrid vehicles make up the majority of this growth. 78% of Georgia's railway transportation is electrified. The deployment of electric buses has been criticized over the past two years in the capital city and other regional cities. It is anticipated that the transportation sector's greenhouse gas emissions will be reduced by 15% from their baseline levels by 2030 in order to achieve the objective outlined in the document of contributions outlined by the state program at the national level. According to the state's strategy, the solution to this problem is to increase the percentage of technically maintained private vehicles with low and zero emissions in the fleet which will be implemented thanks to Normative acts on technical inspection, as well as effective enforcement of stipulated fines and control of vehicles on the roads using modern technology. On this basis, emission intensity should be decreased and technically flawed and environmentally inefficient automobiles should be taken off the road (Lortkipanidze & Kheladze, 2015; Walker et al., 2007; Mardaleishvili et al., 2006; Margvelashvili, 2010).

In addition to decreasing the usage of diesel vehicles and importing outdated, ecologically unfriendly automobiles, the state's plan for minimizing transportation emissions calls for the promotion of electric vehicles. The government promises to find additional, ideal tax incentive options in order to promote the use of electric vehicles. Tbilisi will explore raising the import tariff on used light vehicles based on an economic feasibility study and improving the infrastructure for electric vehicles based on a cost-benefit analysis. A big portion of drivers are going to switch to using public transportation as a result of the "emission standard" being implemented at the same time for imported vehicles based on cost-effectiveness analysis (engine EUR4/EUR5), which will lower transportation emissions. Since fossil fuels have a detrimental impact on greenhouse gas emissions when used in transportation, the use of environmentally friendly fuel is also recommended here. To achieve this, the proportion of energy from renewable sources—including biofuel—in the gasoline used for transportation should rise by at least 10% by 2030. To achieve this, it has been suggested that the potential of raising the gasoline tax be addressed, and that biodiesel production be supported and promoted in order to lower carbon dioxide emissions based on the development of the Tbilisi Sustainable Urban Plan (SVMP) which involves improving the parking lot and establishing a new bus network in Tbilisi, modernizing the metro and expanding its capacity, building a cable car, and instituting zonal hourly parking. 15% of baseline emissions from transportation should be eliminated. Georgia's state action plan in this regard for commercial and public buildings addresses both direct emissions, such as the direct burning of fuel for energy supply in buildings, and indirect emissions, such as the consumption of electricity in buildings and other related issues. Since Georgia has never done the building inventory and lacks engineering-related data in this area, the information is based on the data found in various research projects and papers published by the government (Lortkipanidze, 2010; Lortkipanidze & Kheladze, 2015; Chernikov et al., 2000; Ran & Sobti, 2020).

According to regional electrical efficiency standards, the state should use the developed certification methods. The required bylaw normative actions should be created and approved, and construction projects for thermal insulation of the buildings' surrounding structures should be prepared. The Georgia Law "On Energy Efficiency of Buildings" mandates that by 2030 any newly constructed structure that is subject to certification will have achieved 100% energy efficiency. 100% of (incandescent) lights will be replaced by energy-efficient lamps in residential and commercial buildings starting in 2023 as a consequence of a very significant step taken in the tax regulation that the government presented alongside the information campaign regarding these types of lights. The use of solar energy and energy-efficient stoves being promoted, which will lower greenhouse gas emissions, along with the replacement of inefficient light bulbs in public buildings. This gives people and legal entities an incentive to put into place a mechanism that rewards them for buying solar water heating systems for their own homes, businesses, and other facilities. It is crucial to educate staff members regarding energy efficiency issues to the highest professional standards (Lortkipanidze & Kheladze, 2015; Lortkipanidze, 2010; Zhorzholiani & Gordadze, 2010).

In recent years, the growing demand for tourism in Georgia needs to be promoted. One of the Georgian government's priority focuses is the expansion of the tourism industry. By developing and promoting energy-efficient practices and sustainable development, the area should be promoted. In this direction, carbon dioxide-free buildings are of the utmost importance. By supplying alternative energy sources, this is intended to increase the energy efficiency of residential buildings, hence fostering the growth of ecotourism in Georgia. This course of action is consistent with the country's program submitted to the Green Climate Fund of Georgia. Environmental industry is a sector that reflects the emissions produced in the industrial sector as a result of processes developed from the use of industrial energy, such as emissions produced by direct fuel combustion, directly at the sites of industrial activity, and also indirect emissions produced as a result of the consumption of electricity, the generation of which took place outside the implementation of industrial activity. In comparison to the predicted amount of baseline emissions, the industry reform seeks to reduce emissions by 5% on a national scale. The main goal is to reduce the level of greenhouse gas emissions caused by energy consumption - by replacing industrial facilities with an energy-saving dry method of cement production and equipping the nitric acid production enterprise with modern technology to guarantee elimination of 95% of N2O emissions. By 2030, the amount of reduced emissions from the production of cement and nitric acid is 571 kt CO2-eq, with cement 352 kt CO2-eq and nitric acid 416 kt CO2-eq, a system for studying emission factors and data management in the industry sector should be developed (Oniani et al., 2006; Mardaleishvili et al., 2006; Walker et al., 2007).

Our field of interest for inclusion in the research was represented by the sectoral priority of agriculture. It should be mentioned that according to the accumulation of emissions from agriculture in the direction of climate change, we should first consider the directions of animal husbandry and farming - from energy consumption in manure management, intestinal fermentation, agricultural soils, fisheries and forestry. Emissions from agricultural soils include direct emissions from: use of synthetic and organic nitrogen fertilizers, decomposition of agricultural residues, pastures and fenced pastures. Indirect emissions come from atmospheric deposition, nitrogen leaching, and the power use of high-speed vehicles such as agricultural machinery (Margvelashvili, 2010; Mardaleishvili et al., 2006; Odum & Barrett, 2005; Lortkipanidze, 2015).

The state will promote climate-smart agricultural technology and services in order to achieve our goal of developing low-carbon agriculture on a national level. In order to accomplish this, it is required to: 1) reduce greenhouse gas emissions from agriculture, and for this, the nutritional quality of 20% of cattle should be improved as much as possible. The resulting greenhouse gas emissions will be reduced by enteric fermentation. 2) provide sustainable management of soil and pastures and promote the introduction of sustainable practices in the feeding regime of domestic animals. The state should take into account that the objective will be implemented for farmers in order to conserve the biodiversity of pastures and lower the cost of care for cattle for all farmers working in the field: The expense of veterinary care for the owner of small livestock should be provided free of charge. Farmers that raise animals are given the opportunity to switch their equipment for intensive grass production. A sustainable windbreak system is a crucial step in creating a climate change-resistant ecosystem. It is crucial to develop a multifunctional windbreak and agroforestry system (mWAE) that would improve agricultural production in areas like horticulture and prevent soil erosion. This process will reduce carbon emissions (Shetekauri et al., 2007; Lortkipanidze, 2010).

In the field of agriculture, it is crucial to do scientific research on the soil's bioclimatic conditions. The state plans to conduct research in this area and to promote the introduction of climate-adapted agricultural crop practices for the determination of climate-smart agricultural activities (CSA) through promotion and awareness-raising campaigns. Under the circumstances of global warming, developing appropriate agro-cartograms in accordance with agro-climatic conditions, where the reduction of carbon emissions will be a significant problem. According to cost-benefit analyses and other data, this will enhance the proportion of climate-smart technologies and/or initiatives in government and donor agricultural programs (Lortkipanidze, 2010; Margvelashvili, 2010).

As a result, future predictions call for an increase in production and the growth of large-scale commercial agriculture, from which it is expedient to incorporate sustainable business practices that will have an impact on emissions levels. Current and future plans for our nation's agriculture to be more productive and fertile will result in an increase in greenhouse gas emissions on the one hand, but will also result in a reduction in emissions over time by raising livestock that is incredibly productive (CAP), in accordance with ongoing research and the climate action plan (Lortkipanidze, 2010; Lortkipanidze & Kheladze, 2015; Walker et al., 2007).

2. CONCLUSION

1. As part of the nation's climate action strategy, cost-benefit research on emissions reduction in pet feeding and manure management will be designed and put into practice as the most popular form of climate-wise agricultural practices.

2. According to a survey by the Caucasus Environmental Center, 96.11% of Georgians think that climate change endangers life on earth, which was proved by the "Shovi flood disaster" that occurred there on August 3. Human casualties and the destruction of "Resort Shovi" were results of the unfolding events. It is crucial that ecologists from Georgia and other countries participate in the "Shovi" resort's rehabilitation operation.

3. Representatives of the local population, environmental non-governmental organizations, local governments, and agro-ecologists who will attend the work process of developing waste processing techniques based on new technologies should collaborate with local municipalities in order to fulfill the statement presented by the state program in Georgia by 2030, which envisages the reduction of carbon dioxide emissions in the suburbs surrounding large cities over landfills.

4. In order to reduce CO2 emissions in Georgia, the possibility of processing paper recycling and composting of green plant residues of biodegradable waste should be created.

5. Georgia's natural resources, including its water sources, are contaminated by domestic and other agricultural mineral and organic waste, making it important to keep animal farms, beekeeping operations, and flood fisheries separate from irrigation systems. The Law of Georgia "On Environmental Protection" and the Law on "Plant Protection and Pesticides" both regulate the establishment of a waste management system that will reduce CO2 emissions in this direction.

6. In accordance with the environmental protection legislation of Georgia, there are opportunities to reduce carbon emissions, which, along with the strengthening of the scientific research base of the sector, need to be upgraded with modern equipment of scientific research laboratories with the support of international organizations.

7. The goal is only achievable with the proper selection of woody and bushy kinds, suitable distribution, and proper growth and development. Long-living and quickly expanding forest plantations are required to achieve a certain goal. The row rule states that plants such as trees and bushes should be spaced apart in parallel rows. More than two kinds should not be planted consecutively. Linear planting of trees and shrubs provide a windbreak, one main variety is planted in the forest strips, and several other species are planted in the watershed. Bushy kinds are typically placed in the bank row, if necessary.

8. In 2020, more than 91% of Georgians, according to a survey by the Caucasus Environmental Center (RECCAUCASUS) in collaboration with the European Union and the Environmental Development Program (UNDP), believe that climate change is a well-defined process and poses a threat to life on earth. This belief is supported by the Shovi disaster, which occurred on August 3 with landslide events. By granting funding from the United Nations and other donor organizations, it is significant to support the collaborative work of scientists, researchers, geologists researching the earth, soil scientists, etc. from the Black Sea countries. It is crucial to hold the "Forum of Scientists and Researchers of the Black Sea Countries," which will convene every two years to discuss the effects of global warming in the participating nations (alternatingly serving as the host nation).

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Impact of Petroleum Products on Water Resources, the Example of the Bartskhanistskali River

Nana Zarnadze*✉, *Nargiz Alasania, Eteri Jakeli, Tsiala Bolkvadze, Sophiko Manjgaladze

Batumi Shota Rustaveli State University, Batum/GEORGIA

✉***Correspondence***: zarnadze.nana@bsu.edu.ge

Abstract: The negative impact of oil and oil products on the environment is well known and represents the most important ecological problem. Although manufacturers and logistics services work in compliance with environmental legislation, oil, and its products still occur in the environment. As a result, oil transformation products enter the biosphere, and change the composition of soils, surface and underground waters, and the atmosphere. The research aimed to study the content of petroleum products in the waters of the Bartskhanistskali River and evaluate its ecological condition. The river Bartskhanistststskali flows into the territory of the city of Batumi and is attached to the Black Sea. Most of the entire catchment area of the river is crossed by roads close to the Batumi oil terminal and the main oil highway. It studied the quantitative and qualitative conditions of the Bartskhanistskali River in two observation areas: one at the mouth of the sea, and the other 5 km from the head of the river. The experiment was conducted in 2022–2023, and water samples were taken in different seasons. The results of the study showed the change in the oil content in the Bartskhanitskali River in different research areas and in different seasons of the year. The concentration of the pollutant in the water is variable and dependent on climatic conditions (temperature) and weather. The highest level of oil content was recorded in the river area, where highways, oil reservoirs, and transfer pipes are adjacent. Its content is also especially high in summer.

Keywords: River, Bartskhanistskali, Oil products, Pollution.

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Evaluation of the Tea Accessions in the Lankaran-Astara Region of Azerbaijan Republic Based on Morphological Traits

Afsana Abdullayeva[1]✉, Agil Hasanov[2], Farman Abdullayev[2], Chinara Rzayeva[2], Javid Ojaghi[1]

[1]*Khazar University, Department of Life Sciences, Baku/AZERBAIJAN*

[2]*Azerbaijan Republic Ministry of Agriculture Scientific Research Institute of Fruit-Growing and Tea Planting Lankaran Tea Branch, Lankaran/AZERBAIJAN*

✉***Correspondence**:* afsana.abdullayeva@khazar.org

Abstract: Based on diversity of available plant genetic resource, plant breeders can create new and improved cultivars with desirable qualities, including those favored by both farmers and breeders. However, to address upcoming global concerns relating to food and nutritional security, preserved plant genetic resources must be applied to crop enhancement. Therefore, the identification of untapped sources of genetic diversity that may be crucial for adaptation to various biotic and abiotic stresses would be made possible by the genetic and morpho-phenological characterization of landraces. In this study we evaluated 10 tea accessions by some morphological traits like number and weight of tender shoots, number and weight of normal buds, number of total leaf buds, leaf length, bush height, bush diameter, intermodal length, number of total leaves in bush and yield per bush. Analysis of variance (ANOVA) revealed a significant differentiation among the 10 tea genotypes in all morphological traits assessed. There was a positive and significant correlation between bush yield with number and weight of tender shoots, number and weight of normal buds, number of total leaf buds, leaf length and bush height. Dendrogram formed through cluster analysis based on agro-morphological traits divided the 10 tea accessions into four main clusters. All studied tea accessions evaluated through principal component analysis were grouped into different clusters with more morphological similarities among accessions within cluster. The distribution plant genotypes into different groups revealed that the genetic diversity existed among these accessions. These findings might be a valuable resource for efforts involving breeding, preservation, and further characterization in Azerbaijan tea accessions.

Keywords: Tea accessions, Morphological traits, Genetic diversity, Cluster analysis.

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The Importance of Linden (*Tilia sp.*) in terms of Carbon Sequestration: Perspective in the World and in Türkiye

Özlem Ağırman Han*✉, *Ali Ömer Üçler

Karadeniz Technical University Faculty of Forestry, Trabzon/TÜRKİYE

✉***Correspondence***: ozlemm.a@hotmail.com.tr

Abstract: Carbon emission is increasing in the world due to exponential growing of population, excessive usage of natural resources which resulted with environmental pollution and decline in biodiversity. Carbon emission as a result of greenhouse gases and carbon dioxide rising is the main reason of climate change and global warming. Reducing the amount of CO_2 and greenhouse gases released into the atmosphere; is possible by increasing the use of vegetative mass, limit emissions, and increasing the amount of carbon in carbon pools (ocean, soil, vegetation, etc.). In forest ecosystem the soil, biomass and water have essential roles in carbon deposition that is the basic element of carbon dioxide. Since trees have the capacity of storing CO_2 via photosynthesis, they execute important functions for the formation of important sinks by deposition of carbon in plant biomass and under the soil. To reduce the amount of carbon emissions in cities, afforestation is made on the roadsides from tree species that deposit exhaust gases and are resistant to difficult conditions. Lindens are trees that have resistance against, winds air pollution and poor quality soils, also tolerant for variable climate conditions, and sensitive for frost and drought. In literature there exists not enough studies that examines carbon sequestration and storage capacity of lindens while there exist some other papers regarding other species such as scotch pine, larch, red pine, cedar, and poplar. In this study we aimed to investigate the possible role of lindens used for arborization of cities for carbon sequestration and storage. This review, in which various articles were discussed, will be informative for those who are interested in the subject.

Keywords: Linden, *Tilia sp.*, Carbon, Global climate change, Urban trees.

1. INTRODUCTION

Forests are a union containing woody and herbaceous plants, moss, ferns, fungi, microorganisms and fauna, which can create a unique microclimate and exist in a composition and proportion (Aytuğ, 1976).

The increase in the population of countries and the world increases the stress on forest areas, and as a result, forests are disappearing. The world's forest assets, which were reported to be 8 billion hectares in 2000 B.C. have begun to decrease rapidly. According to the latest data, world forest assets have decreased to 3.2 billion hectares (URL-1, 2021). 29% of Türkiye's surface area is covered with forest areas (OGM, 2020). While the productivity area rate of our country's forests is around 44% the productivity rate of the world's forests is over 70% (Tuncer & Kaya, 2010).

FAO defines deforestation as the opening of forests to long-term land uses such as pasture, agriculture and settlement, or their closure falling below 10% (FAO, 2005). Large areas of forest are lost every year due to changes in climate and meteorological conditions brought about by deforestation, poor air quality and decrease in biodiversity (Ayoo, 2022). When deforestation and climate change are examined together, a global environmental problem emerges (Ak et al., 2021). For this reason, important research is being carried out on the protection and development of forests in our country (Karakaya & Sofuoğlu, 2015).

Global climate change emerged as a result of the increase in greenhouse gas emissions after the industrial revolution (Lal, 2008; IPCC, 2014). Destruction of terrestrial sink areas as a result of incorrect and excessive land use is another cause of climate change. Forests are considered as the most important terrestrial carbon sink areas worldwide (FAO, 2016). Forests, which hold 76-78% of the organic carbon in the terrestrial ecosystem (Borucu, 2014), store large amounts of carbon and play an important role in combating climate change (IPCC, 2007; Miles & Kapos, 2008; Güner & Makineci, 2017). Although our country has a low share in the total CO_2 emissions in the world (Karakaya & Sofuoğlu, 2015), many studies are carried out on the protection and development of sink areas, adaptation and reduction in accordance with its international agreements (Türkeş, 2008).

Approaches to the management of urban green areas in planning and design processes in terms of exposure and sensitivity to the negative effects of global climate change in urban areas are clearly expressed within the Intergovernmental Panel on Climate Change (IPCC) and UN 2030 Agenda Sustainable Development Goals reports (Sturiale & Scuderi, 2019). Urban green areas support biodiversity and have positive effects such as improving air quality, water and soil, reducing noise, and improving microclimate conditions (Angold et al., 2006; Barbosa et al., 2007; Jorgensen et al., 2002). With all these positive aspects, urban green areas are useful for strategies to be developed to combat the negative effects of global climate change and to increase the resilience of urban areas in different aspects (Scarlett & Boyd, 2015).

Today, the places where carbon emissions are highest are cities and, accordingly, areas that have a negative impact on the climate. Therefore, urban forestry is one of the important green infrastructure systems that can be used to reduce the negative effects on the climate (Yılmaz et al., 2006).

Urban forests, which have an important place in improving the air quality of the city, absorb aerosols and particles from pollutant sources around the city by holding them on their leaf surfaces and prevent urban air pollution (Keller, 1979). Research on the transport of airborne pollutants through vegetation has shown that plants are very effective in eliminating air pollution. For this reason, vegetation acts as a natural filter in improving air quality (Öner et al., 2007).

One of the most important action strategies regarding global warming and climate change in developed countries is the storage of CO_2 within the forest ecosystem (soil, plants and litter). This strategy is defined as carbon sequestration. Urban trees and urban forests have an important role in reducing CO_2 emissions and storing carbon in cities. Therefore, as in developed countries, it is aimed to establish an urban forest in every city or to increase the number of trees in urban areas in our country. Urban afforestation aims to prevent air and noise pollution and improve the urban climate.

Linden species are species that are resistant to wind and air pollution and poor soils within the Fagetum zone (Rajendra, 2009; Pigott, 2012). With these features, they are forest trees that can be tolerant to changing climatic conditions. This study aimed to evaluate the importance and usability of linden used in urban afforestation in terms of carbon storage.

2. GENERAL INFORMATION ABOUT LIDEN (*TILIA sp.*) AND ITS ROLE IN TERMS OF CARBON STORAGE

Linden (*Tilia sp.*), which has 4 species in our country, has around 30 species in the northern hemisphere, including Northeastern America, Europe and Asia (Radoglou et al., 2009). The general distribution of some species of linden tree is as follows: *Tilia platyphyllos* and *Tilia cordata* are common in Europe, *Tilia tomentosa* in the Balkans, *Tilia sibirica* in Siberia and Asia, and *Tilia rubra* in Anatolia, the Caucasus and Northern Iran (Boratynska & Dalatowski, 1991). Linden species growing in Türkiye are *Tilia tomentosa* Moench., *T. plathyphyllos* Scope., *T. rubra* DC. and *Tilia cordata* Mill (Oral, 2013). They are narrow-topped trees that can grow up to 30-40 m and shed their leaves in summer (Oral, 2014). Linden species are not found as pure stands in the forests where they naturally spread, but rather as individual trees or in clusters (Alan et al., 2018).

The flowers of Tilia species (*Tilia cordata* Mill. and *Tilia platyphyllos* Scop.) used for medicinal purposes contain sugar, gum, fixed oil, mucilage and tannin. The ashes of Linden (Tilia) contain manganese, the oil compound in its flowers contains parnesol, and its leaves contain a glycoside called Tiliacin. In addition to being good for diseases such as colds and flu, intestinal diseases, ulcers and constipation, linden also prevents vascular occlusion and hypertension (Tuttu et al., 2017). Its flowers are boiled and consumed as tea (Mamıkoğlu, 2015). It is known that non-wood products are not only leaves and flowers, but also linden tree bark and linden flower water are considered non-wood products. However, it is known that linden flower oil (Parlak et al., 2019) is used for production, and the leaves are also pruned and used as cow feed (Turna, 2001). It is also used in various areas in the furniture industry (URL-2, 2019). Even though it is rarely found in forests, it is preferred as an ornamental tree in parks and gardens.

Urban green spaces have ecosystem characteristics that are fundamental to the provision of ecosystem services, as they retain carbon and nutrients and act as reservoirs for organic matter. While it is known that urban vegetation affects the physico-chemical properties of the soil, it is not known whether ecosystem properties depend on the type of plant used.

Setälä et al. (2016) in the cities of Helsinki and Lahti, they included young parks of different ages (7-15 years), medium parks (about 50 ± 10 years) and old parks (>100 years old, the oldest of which were established more than two centuries ago), 41 city parks and control forests. Three common functional plant groups in parks in terms of their ability to amend soil (evergreen trees; Norway spruce (*Picea abies*), deciduous trees; Linden [*Tilia × vulgaris*] and grass species mostly Poa and Festuca species, with scattered plants such as *Trifolium pratence* and *Plantago major*) and included control forests. In addition, Norway maple (*Acer platanoides* L) was chosen instead of linden in two parks in Lahti and one park in Helsinki, and spruce was chosen instead of Scots pine (*Pinus sylvestris* L) in three parks in Helsinki. The sizes of the parks vary between 0.1 ha and 1 ha. In the city of Lahti, parks of three age groups are randomly distributed throughout the city, while in Helsinki the oldest parks were chosen closer to the urban core than parks of the other two age groups. Five non-grass mature (>60 years old) mixed control forests, several hectares in size, dominated by Norway spruce and small-leaved lime (*Tilia cordata*) near the city of Lahti, were also included in the study. As a result of their study, they showed that the soil has a significant capacity to store N and C even without frequent fertilization and irrigation, that Norway spruce (*Picea abies*) is particularly important in terms of soil properties compared to Linden [*Tilia × vulgaris*] and that Norway spruce (*Picea abies*). They found that old parks which are effective in changing park soil.

In a study examining the inter- and intra-specific variations of carbon in biomass tissues for 10 temperate tree species in Northeast China, it was found that the average amount of carbon for the species varied from 47.1% in the fine roots to 51.4% in the leaves. While the average root carbon amount of 10 species was found to be 49 ± 1.3% (mean ± sd), the average carbon concentration for the species was; Amur cork tree (55.1%) > Amur linden (53.9%) > Korean pine (53.2%) > Manchurian ash (52.9%) > Manchurian walnut (52.4%) > Mongolian oak (47.6%) > Dahurian larch (46.9%) > Mono maple (46.4%) > white birch (46.1%) > aspen (43.7%). Carbon concentration for *Tilia amurensis* Rupr. (Amur linden) species was found to be 55.7% in the leaf, 53.1% in young branches, 53.7% in old branches, 54.3% in stem, 52.7% in thick root, and 50% in thin root. Species weighted average carbon concentration was negatively correlated with average annual biomass increase; found that planting fast-growing tree species for C sequestration in these afforestation and reforestation practices sacrificed some C gain from the increased annual biomass increase due to decreasing C (Zhang et al., 2009).

In their study, Moser et al. (2015) characterized the sizes of two urban tree species (small-leafed lime, *Tilia cordata* Mill. and black carob, *Robinia pseudoacacia* L.) and predicted their future structural sizes based on trunk height diameter and tree age. The data obtained revealed strong relationships for both tree species between crown dimensions (diameter, volume, projection area, height), tree pit and tree height of *T. cordata*. 3 ecosystem properties (cooling, shading, carbon storage) were estimated based on the leaf area index and tree dimensions. As a result of this estimation it was revealed that urban trees significantly improved the city climate. And also a significant relationship was found between carbon storage, shading and cooling of single trees and leaf area index and age of these trees. In the same study, for the *Tilia cordata* Mill. it has been observed that the amount of carbon storage increases in direct proportion to age.

In a study investigating the carbon storage potential of two tree species (*Tilia × vulgaris*, *Alnus glutinosa*) growing in three different growth environments considering urban conditions in Helsinki, measurements were made using an urban land surface model SUEWS (Surface Urban Energy and Water Balance Scheme) and soil to simulate carbon sequestration. The carbon model was evaluated with Yasso15. Yasso 15 measured at temporal scales (daily, monthly and yearly). While SUEWS provides information about the urban microclimate and photosynthesis and respiration of street trees, the amount of soil carbon storage was measured with Yasso 15. Models were used to examine the urban carbon cycle over the expected lifespan of the species (2002-2031). The annual amount of carbon taken per tree for the Tilia region varied between 3.55 and 13.44 kg C, while for the Alnus region it was measured between 2.68 and 10.73 kg C. During the 30-year period, 1.0 and 4.3 kg C per square meter were stored in the leaves of Tilia and Alnus trees, respectively. Cumulatively over a 30-year period, species sequestered 172 and 156 kg C per tree in the Tilia and Alnus regions, respectively (Havu et al., 2022).

Table 1. Amount of carbon in studies conducted.

Researcher	Tree Type	Branch (%)	Leaf (%)	Trunk (%)	Shell (%)
Güner and Makineci (2017)	Quercus L.	49	49	49	48
Ritson and Sochacki (2003)	*Pinus pinaster*	56.6	-	49.7	-
Zhang et al. (2009)	*Tilia amurensis* Rupr.	53.7	55.7	-	-
Kanlı (2022)	Fraxinus L.	52.79	53.28	58.25	63.51

In their study with *Pinus sylvestris* Laiho and Laine (1997) measured the amount of carbon storage as 53.1% in the branch, 53.8% in the leaf, 51.8% in the trunk and 53.2% in the shell.

In their study Güner and Makineci (2017) determined the carbon storage amounts of Quercus L. species as 49% in the branch, 49% in the leaf, 49% in the trunk and 48% in the shell.

Ritson and Sochacki (2003) found carbon storage amounts in *Pinus pinaster* species to be 50.6% live branches and leaves and 48.1% in the roots.

In his study Kanlı (2022) measured the carbon storage amounts of Fraxinus L. species as 52.79% in the branch, 53.28% in the leaf, 58.25% in the trunk and 63.5% in the shell.

3. USE OF LIDEN (*TILIA sp.*) IN URBAN AFFORESTATION

The species to be brought to cities from forests, which are their main habitat, should be resistant to air pollution and pests, have a deep root system, are long-lived and able to grow quickly, and have an aesthetic appearance that do not produce roots and stumps (Alptekin, 1997).

In arid and semi-arid cities, tree species that have developed a mechanism to reduce transpiration, are resistant to drought conditions, are evergreen, contented, have a tap root system, and have visual and functional effects should be preferred. The tree species to be chosen for the afforestation of these cities, in addition to their aesthetic appearance, must have developed a mechanism to absorb water and to minimize the loss of water through transpiration. For example, ash-leaved maple (*Acer negundo* L.) and other maple species, white-flowered false acacia (*Robinia pseudoacacia* L.), linden (*Tilia argentea* Desf.), common ash (*Fraxinus excelsior* L.) provided that it is suitable for the urban habitat conditions, etc. The species are suitable for use in road afforestation (Gezer & Gül, 2009).

It has been determined through research that large and small-leaved linden (*Tilia platyphyllos* Scop., *T. tomentosa*) species provide biological success in many cities with semi-arid climate conditions, especially in the Central and Southeastern Anatolia regions, the Mediterranean and Black Sea regions, where periodic droughts occur (Gezer & Gül, 2009).

Tilia tomentosa Moench is resistant to air pollution, drought, cold and frost and is one of the species used in urban area afforestation such as residential gardens, parks, industrial facilities, squares, hospitals, road afforestation, median pavement (median), urban forest, urban grove and cemeteries (Gezer & Gül, 2009).

The most appropriate size for road trees to reach is; It should be considered according to the width, class and quality of pedestrian and vehicle roads, the density of traffic, and the condition of the structures in the immediate vicinity, and appropriate types should be selected. Medium-crowned broad-leaved silvery linden (*Tilia tomentosa* Moench.) should be preferred for normal-width streets, while large-leaved linden (*Tilia platyphilla* Scop.) should be preferred for very wide streets (Gezer & Gül, 2009).

4. CONCLUSION

Studies on carbon storage due to the development and growth of linden used in urban afforestation over time are limited in Türkiye. As seen in the research, *Tilia sp.* is found in the same population with other species of studies have been conducted on the amount of carbon storage in species. *Tilia sp.* Within the scope of using the species in urban areas in urban forestry studies, it would be appropriate to make sustainable plans in line with the scientific and technical principles and to carry out studies in forests and urban green areas where the linden population is dominant, in order to measure the amount of carbon storage in a healthy way. In urban afforestation areas, species that tend to grow slower in terms of carbon sequestration should be preferred rather than species that grow rapidly. Species that tend to overwinter show lower performance in terms of carbon sequestration. Sustainable management of afforestation areas should be considered and planned from a perspective that supports the tendency of trees in urban living areas to become carbon sinks rather than their overgrowth tendency and their impact on visual quality. In this context, when choosing species, species with a low tendency to overgrowth should be selected or afforestation areas should be arranged at a frequency that eliminates the tendency towards overgrowth.

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Sustainable Use of Biomass to Assist the Development of Türkiye's Economy Towards Green Growth

Melek Akay

Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policy (TAGEM), Ankara/TÜRKİYE

***Correspondence**:* melek.akay@tarimorman.gov.tr

Abstract: Biomass, being derived from organic materials, is considered a carbon-neutral energy source. Biomass energy is a more environmentally friendly alternative to fossil fuels in a manner of the natural carbon cycle. In this concept, there are some investigations and projects going on with respect to biomass potential and energy production in many countries. Sustainable Use of Biomass to Assist the Development of Türkiye's Economy Towards Green Growth project started in 2018 to evaluate the agricultural biomass potential in Türkiye in cooperation with the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policy (TAGEM) and the United Nations Industrial Development Organization (UNIDO) and financed by the Global Environment Fund (GEF). The project aims to reduce greenhouse gas emissions while increasing energy performance and competitiveness by triggering sectoral transformation with the applications of modern bioenergy technologies in the agricultural industry. Shaped within the framework of combating climate change, the project aims to increase the biomass potential of agricultural residues with sustainable and repeatable strategies; and supports the transformation into domestic and clean energy at a high level of efficiency. The project serves through four main components: "support to supply chains and energy facilities", "legislation regulations", "capacity building and awareness raising" and "monitoring and evaluation" in Türkiye.

Keywords: Biomass, Sustainability, Green growth, Bioenergy, Project, Türkiye.

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