RESEARCH ARTICLE

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Greenhouse gases induced climate change in Turkey and Bodrum district (Mugla province)

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Abstract

Since the industrial revolution, the modes of production and consumption that were incompatible with the environment has led to several environmental problems due to global population growth and welfare demands. In this process, the composition of the atmosphere has changed due to the gradual increase in greenhouse gas emissions by human activities, leading to global climate change due to the greenhouse effect and global warming. Greenhouse gases induced by human activities (transportation, power generation, water consumption, heating, fuel consumption, etc.) are generally measured in CO_2 emissions and carbon footprint. Global climate change, a significant global problem, entails the changes in climate due to the greenhouse effect induced by the gases released into the atmosphere by human activities, and this impact is expressed as carbon footprint (CO_2 equivalent). The present study aims to investigate the current status of greenhouse gases in terms of carbon footprint and the climate change due to global warming in Turkey, and monthly precipitation, soil temperature, sea water temperature and changes in air temperature were investigated in Muğla province, Bodrum district in Turkey, which is a significant tourist destination. The results showed that global climate change has started to occur in Bodrum district.

Keywords: Greenhouse gases, Global warming, Climate change, Bodrum, Muğla

INTRODUCTION

Although the earth is inhabitable due to the natural greenhouse effect of the atmosphere, human race faces global warming due to the increase in greenhouse gas volume induced by anthropogenic activities that increased with population growth as a result of the industrial revolution and subsequent developments in science and technology. The climate change due to global warming is associated with the increase in average surface temperature and climatic changes as a result of the rapid increase in the greenhouse gas accumulation in the atmosphere due to human activities such as burning fossil fuels, changes in land use, deforestation and industrialization. Significant variations in extreme mean surface temperatures, ice and snow cover, precipitation, ocean temperature and salinity, wind types, drought, heavy precipitation and heat waves have been considered as the causes of climate change (Binboğa and Unal 2018; İkizoğlu 2019).

Certain greenhouse gases could be released naturally (forest fires, volcanic activities and some biological activities etc.), atmospheric emissions and concentrations could increase due to human activities (agriculture, consumption of fossil fuels, etc.). Greenhouse gases include carbon dioxide, water vapor, ozone, nitrous oxides and methane. The main source of water vapor is the evaporation in the oceans. Ozone is another greenhouse gas formed by atmospheric reactions. The greenhouse gases released only by human activities include chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) (Argun et al., 2019; İkizoğlu, 2020).

Ecological footprint is the size of the biologically productive land or water resources in global hectares (kha) required to reproduce the resources consumed by an individual, community or activity with current technologies and the resources required dispose of the waste generated by these activities and management of these resources (Erden-Özsoy 2015; Mızık and Yiğit 2020). Ecological footprint includes six categories of productive surface areas: carbon demand on land, forest area, cropland, built-up land, grazing land, and fishing grounds (Apaydın, 2020). Among the components of ecological footprint of Turkey in 2007, the largest share was that of the carbon footprint with 46% Carbon footprint is a measure of the environmental damage induced by human activities based on greenhouse gas production, measured in units of carbon dioxide. Carbon footprint includes of two main categories, primary carbon footprint and secondary carbon footprint. Primary carbon footprint is associated with the direct CO_2 emissions due to the combustion of fossil fuels, domestic energy consumption and transportation. Secondary carbon footprint is the CO_2 emissions during the life cycle of commodities from production to degradation. The secondary carbon footprint includes the primary footprint. Imported foods or products should be transported by land, air, sea and rail until they reach the consumer. Since the waste generated during the deterioration or consumption of these products are stored and disposed of using the same transportation routes, the secondary carbon footprint is quite important. It is known that an individual's secondary carbon footprint is equal to 54% of the total carbon footprint of that individual. However, it is not possible to exactly calculate the secondary carbon footprint. (Argun et al., 2019; Şahin and Onurbaş 2016; Gökçek et al., 2019; Mutlu, 2021).

The aim of this study is to concretize the increasing greenhouse gas emission data in Turkey on the basis of existing data in order to observe and determine the situation in Muğla Bodrum district.

MATERIALS AND METHODS

The determination and analysis of the current status in Turkey was based on TUIK data and the graphs plotted based on these data.

Daily data were obtained from the Meteorology Directorate in Muğla province Bodrum district, a significant tourist destination in the Aegean Region, and monthly precipitation, monthly average soil temperature at 5 cm, monthly average air temperature, monthly average sea water temperature figures were calculated for 5 years, and the possible effects of global warming were analyzed based on the resulting graphs.

Figure 1. Muğla province and Bodrum district on the map of Turkey

RESULTS AND DISCUSSION

The distribution of greenhouse gas emissions in Turkey

In Turkey, the total greenhouse gas emission was 220 (Mt) CO_2 equivalent in 1990, and it increased to 508 million tons (Mt) CO_2 equivalent in 2019. It was 523.9 million tons (Mt) CO_2 eq. in 2020, an increase of 3.1%. The increase was 238.14% during the 30 years between 1990 and 2020. The total greenhouse gas emission per capita was 4 tons CO_2 eq. in 1990, 6.2 tons CO_2 eq. in 2019. and 6.3 tons CO_2 eq. Thus, the increase was 1.575 fold in the 30 years between 1990 and 2020 (Figure 2). Figure 3 demonstrates total greenhouse gas emissions by industry in 2020. The energy industry led the emission ranking with 70.2%, followed by agriculture (14%), industrial manufacturing and consumption (12.7%), and waste industry (3.1%). Energy industry emissions increased by 163.1% in 2020 when compared to 1990 and by 0.6% when compared to the previous year, reaching 367.6 Mt CO_2 eq. Industrial manufacturing and consumption emissions increased by 190.5% when compared to 1990 and by 14% when compared to the previous year, reaching 66.8 Mt CO_2 eq. (TUIK, 2020).

The Kyoto Protocol was based on 6 greenhouse gases. These greenhouse gases and their CO_2 equivalents are presented in Table 1 (GWP Global Warming Potential). CO_2 equivalent reveals the heat-trapping coefficient of the greenhouse gas when compared to the same volume of CO_2. Thus, the impact of all greenhouse gases could be standardized, facilitating the comprehension of emission calculations. Based on this chart, the most dangerous greenhouse gas is sulfur hexafluoride (SF6), and the least dangerous greenhouse gas is CO_2. However, the reality is the opposite since CO_2 emissions are quite higher when compared to other greenhouse gases (TUIK, 2020).

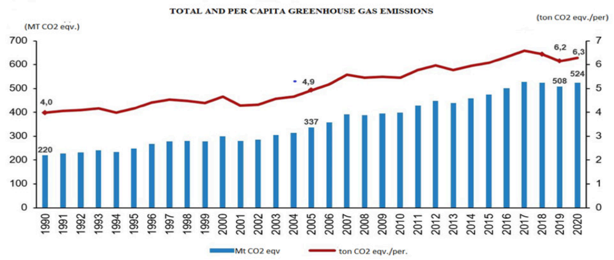


Figure 2. Total and per capita greenhouse gas emissions between 1990 and 2020 in Turkey (CO_2 eq.) (TUIK, 2020)

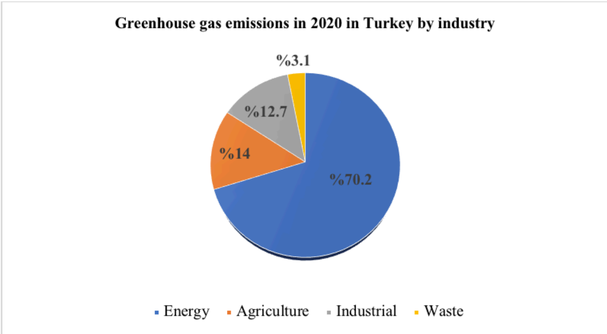


Figure 3. Greenhouse gas emissions in 2020 in Turkey by industry (TUIK, 2020)

Conversion of million tons of greenhouse gas (GHG) emission into million tons CO_2 equivalent;

Million tons (GHG) * GWP = Million tons CO_2 equivalent

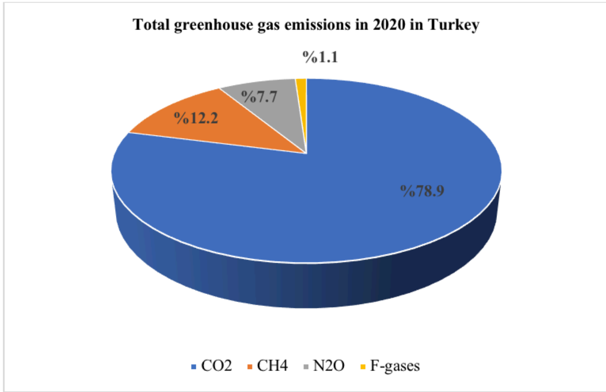
Table 1. The principal greenhouse gases in the Kyoto Protocol and CO^2 equivalents

Gases	Global Warming Potential (GWP)
CO_2	1
CH_4	25
N_2O	298
HFC	124 -14800
PFC	7390-17700
SF6	22800

In Figure 4, the total greenhouse gas emissions in 2020 in Turkey are presented based on the Kyoto protocol. It could be observed that 78.9% of total emissions (523.9 million tons (Mt) CO_2 equivalent) was CO_2, 12.2% was CH_4, and 1.1% was fluoride gases (HFCs, PFCs, SF6).

In Turkey, forestation activities should be improved to reduce greenhouse gas emissions that increase every year. Furthermore, carbon footprint should be calculated for each province [Tier 1, Tier 2, Tier 3 Approaches (from simple to specialized approach)], the current status should be determined and further measures should be investigated based on population growth predictions.

Figure 4. Greenhouse gas emissions in 2020 in Turkey by gas type (TUIK, 2020)



Interpretation of the current status of climate change based on Bodrum meteorological data

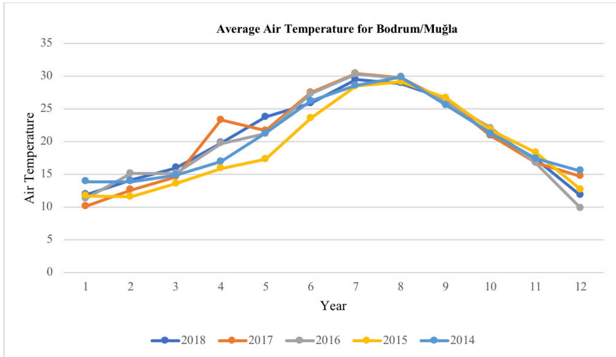


Figure 5. The monthly average temperatures in Bodrum in the 5-year period

The analysis of the Bodrum meteorological data revealed that the temperature differences between the seasons gradually decreased during the 5-year period as seen in the monthly average air temperature graph presented in Figure 5. Especially during the summer and winter, the decrease in the temperature differences is accepted as a result of climate change.

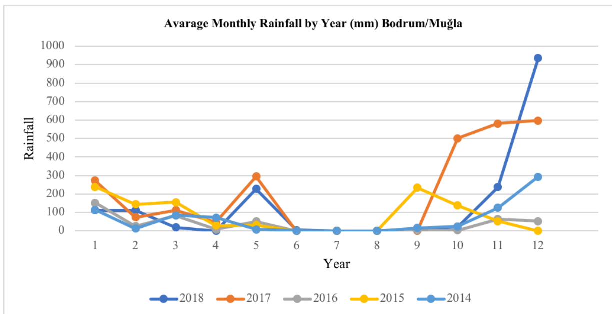


Figure 6. Mean monthly precipitation in Bodrum in the 5-year period

Bodrum meteorological data revealed that monthly precipitation varied during these 5 years. The precipitation regime was more irregular when compared to previous years. The summers were drier, and precipitation was irregular in the winters. In recent years, precipitation increased significantly in spring and autumn, demonstrating that Bodrum district was directly affected by global warming or climate change (Figure 6).

Global model simulations based on multiple scenarios predicted that global mean water vapor accumulation and precipitation will increase during the 21st century. In the areas where this increase was predicted, precipitation variations could be higher across the years. Models demonstrated that in warmer climates, evaporation will increase due to the increase in global average precipitation and the frequency of heavy rainfall events. On the other hand, it was predicted that precipitation will increase in certain areas, while decreasing in others, and there could be decreases in ground flow and soil moisture due to increased evaporation in areas where precipitation would increase. Seasonal and latitudinal shifts are predicted in precipitation after certain arid and semi-arid areas will get more arid. In general, precipitation may increase in summers and winters at high latitudes. Precipitation in winter may increase in mid-latitudes, tropical Africa and Antarctica, while it may increase in south and east Asia during summer. A sustained reduction in winter precipitation is expected in Australia, Central America and southern Africa. According to Hadley Center climate models and others, significant reductions in precipitation, water resources and flows are expected during the century, especially in the Eastern Mediterranean basin and the Middle East (Turkes, 2008, Atreya and Kaphle, 2020).

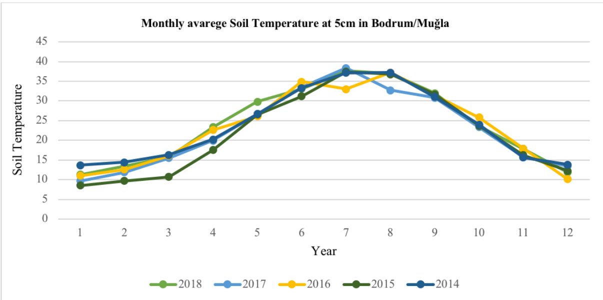


Figure 7. Monthly mean soil temperature at 5 cm in Bodrum by year

The average monthly soil temperature at 5 cm increased in the spring of 2018 (in April-May) when compared to the same period in the previous years in Bodrum district in Muğla. Soil temperature depends on the capture and reflection of solar energy. A portion of solar radiation is captured by the earth's surface and the remaining is reflected back to the atmosphere. As the air temperature increases, the soil temperature increases as well. The impact of global warming on the increase in soil temperature is significant (Figure 7).

The fluctuation in soil temperature is associated with changes in minimum and maximum air temperatures and solar radiation (Rathore et al., 1998). Nakadai et al., 2002 reported that soil CO_2 emissions are significantly associated with the temperature at 5 cm above the surface and at 0 cm, but not with the temperature below 10 cm. On the other hand, Coşkan et al. 2017 stated that there was a temperature change in the lower layers of the soil, albeit a quite slow one. Furthermore, Nakadai et al. 2002 reported that environmental CO_2 levels generally increase after sunset and gradually decrease after sunrise. Kim et al. (2015) reported that higher temperatures (12 and 22 °C) significantly increased CO_2 production in peat soil (Akbolat and Coşkan, 2020).

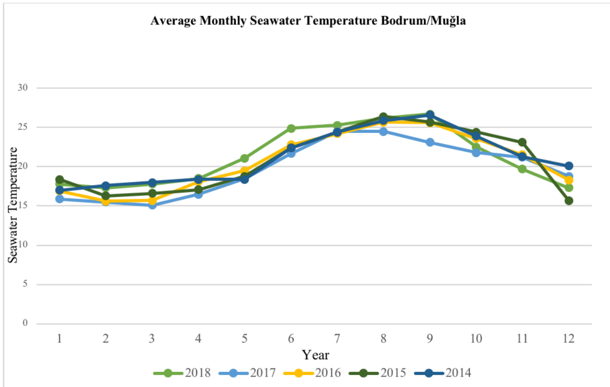


Figure 8. Monthly mean seawater temperatures by year in Bodrum district

The average monthly seawater temperature data for Bodrum district in Muğla province are presented for the 5-year period in Figure 8. In April-September 2018, an increase was observed in seawater temperatures when compared to previous years, which continued until October (around 27°C). This could be a direct reflection of seasonal climate change. If the increase in seawater temperatures continue, species in the habitat could change, certain species could become extinct and harmful new species could develop in the marine flora and fauna.

The rise in air and seawater temperatures is estimated to continue in the new millennium. Furthermore, the rise in seawater temperatures due to the melting of glaciers will lead to floods, erosion and increased transportation of sediment. Also, as the glaciers melt, houses, roads, airports, pipelines will be destroyed by landslides in these regions (Erdoğan et al., 2008). In addition, optimum temperature, light, air humidity and air movements, nutrients, water, air and microorganisms in the soil positively affect life and forest growth. Extreme severity in these parameters could lead to damages due to frost, fire, drought, topple, and those caused by plants and animals (fungus and insects). However, as long as there is no human intervention, all ecological factors are balanced within "natural cycles" (Muğla Province Environmental Status Report, (2021).

CONCLUSION

The annual increase in greenhouse gas emissions leads to the depletion of the ozone layer, global warming and climate change. Without preventive measures, events such as droughts, desertification and erosion could accelerate, agricultural production could decrease in the following years, and the existing water resource problems could exacerbate in Turkey, leading to scarcity of drinking and utility water, flooding in coastal areas, deterioration of the flora and fauna diversity, harmful species (viruses and bacteria) and epidemics may increase. Therefore, today, smart homes, sustainable waste management, forestation, production of some chemicals reduction and/or prohibition etc. has become a priority worldwide.To prevent these problems, greenhouse gas emissions should be investigated, and measures should be adopted for a more liveable and self-sufficient world by countries, regions, and provinces. For this purpose, future greenhouse gas emissions should be predicted.

In the current study, the increasing greenhouse gas emissions in Turkey were investigated based on Bodrum district in Muğla province, and the increases in air, seawater, and soil temperatures at 5 cm, and the precipitation irregularities were identified.

Dissemination of renewable energy sources for heating and power generation, employment of electrical energy, expansion of green buildings and new generation hybrid motor vehicles, and reduction of unnecessary energy consumption are quite important for the sustainability of the world. Further researches should be continued to have clear data about climate change.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The author declare that they have no conflict of interest.

Author contribution

The author read and approved the final manuscript. The author verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

There are no ethical issues with the publication of this manuscript.

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Data availability

All graphs and data obtained or generated during the investigation appear in the published article.

Consent for publication

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REFERENCES

Akbolat, D., Çoşkan, A. (2020). Effects of Different Soil Temperature and Reducing Soil Moisture Content on CO_2 Production. Journal of the Faculty of Agriculture, 15 (2), 192-198. (in Turkish). [Google Scholar]

Apaydın, Ş. (2020). Effects of Globalization on Ecological Footprint: The Case of Turkey. Journal of Research in Economics, Politics & Finance, 5(1), 23-42. (in Turkish). [Google Scholar]

Argun, M.E., Ergüç, R., Sarı, Y. (2019). Carbon Footprint Investigation of Konya/Selçuklu District. Selcuk Univ. J. Eng. Sci. Tech., 7 (2):287-297. (in Turkish) [Google Scholar]

Atreya, P. N., Kaphle, M. (2020). Visible evidence of climate change and its impact on fruit production in Nepal. International Journal of Agriculture, Environment and Food Sciences. 4 (2): 200-208. [Google Scholar]

Binboga, G., Unal, A. (2018). A Research on the Calculation of Carbon Footprint of Manisa Celal Bayar University at Sustainability Axis. International Journal of Economic and Administrative Studies, 21, 187-202. (in Turkish) [Google Scholar]

Coşkan, A., Erdal, İ., Öz, H. (2017). The Potential of Heat Source of Deeper Soil Layers on Earliness. Academia Journal of Engineering and Applied Sciences, 1, 318-324. (in Turkish) [Google Scholar]

Erden Özsoy C. (2015). Low-Carbon Economy and Carbon Footprint of Turkey. Hak İş International Journal of Labor and Society, 4 (7), 198-215. (in Turkish).

Erdoğan, N., Düzgüneş, E., Balık İ. (2008). Global Warming and Climate Change. Journal of Fisheries & Aquatic Sciences, 1, 89-94. (in Turkish). [Google Scholar]

Gökçek, Ö. B., Bozdağ, A., Demirbağ, H. (2019). Determination of the Carbon Footprint of Nigde Omer Halisdemir University Example. Omer Halis Demir University Journal of Engineering Sciences, Volume 8 (2), 721-730. [Google Scholar]

İkizoğlu, B. (2019). Renewable Energy: An Essential Resource due to the Environmental Effects of Fossil Fuels. Proceedings of the International Conference on Technology and Science, 2(4), 156-163.

İkizoğlu, B. (2020). Climate Change in Turkey. Proceedings of II. International Agricultural, Biological & Life Science Conference, 2(4), 212-216.

Kim, Y., Ullah, S., Roulet, N.T., Moore, T.R. (2015). Effect of inundation, oxygen and temperature on carbon mineralization in boreal ecosystems. Science of the Total Environment, 511, 381-392. [Google Scholar]

Mızık, E.T., Yiğit-Avdan, Z. (2020). The Cornerstone of Sustainability: Ecological Footprint. Journal of Natural Hazards and Environment, 6 (2), 451-457.

Muğla Province Environmental Status Report, (2021). Web Page, Retrieved May 2020. (in Turkish). [Google Scholar]

Mutlu, N. (2021). A research on the determination of energy consumption and carbon dioxide emissions in corn production in Harran plain. International Journal of Agriculture, Environment and Food Sciences. 5(1):23-32. [Google Scholar]

Nakadai, T., Yokozawa, M., Ikeda, H., Koizumi, H. (2002). Diurnal changes of carbon dioxide flux from bare soil in agricultural field in Japan. Applied Soil Ecology, 19 (2), 161-171. [Google Scholar]

Rathore, A.L., Pal, A.R., Sahu, K.K. (1998). Tillage and mulching effects on water use, root growth and yield of rainfed mus-

tard and chickpea grown after lowland rice. Journal of the Science of Food and Agriculture, 78, 149-161. [Google Scholar]
TUIK. (2020). Web page, Greenhouse Gas Emission Statistics 1990-2020. Retrieved July 2022 (in Turkish). [Google Scholar]
Türkeş, M. (2008). What is Climate Change? Basic Definition, Causes, Observed and Predicted Results of Climate Change. Climate Change and Environment, 1,26-37. (in Turkish).