



Carbon footprint changing with Covid-19 in Turkey

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Abstract

The COVID-19 virus first appeared in Wuhan, China, and has affected the whole world. Due to COVID-19, which spreads rapidly and causes death, countries have taken their own pandemic measures. The first case of COVID-19 was seen in Turkey on March 11, 2020, and on the same day, the COVID-19 outbreak was declared a pandemic by the World Health Organization. Turkey has implemented measures such as full closure and partial closure throughout the country in certain periods during the pandemic process. These measures have increased the time people spend at home and have led to differences in their general lifestyles. These differences have caused various effects, especially on ecological carrying capacity, as well as the changes in the world's economic and social consumption habits (electricity, heating, transportation, etc.). It is observed that the changing human habits due to the pandemic are effective in ecological developments, in cities having cleaner air and environment, and in the positive renewal of natural life. One of the most important components of the ecological footprint, which is used to make ecological differences measurable and comparable, is the carbon footprint. In this study, the individual change in the carbon footprint is discussed and the positive environmental changes in Turkey are questioned in relation to individual human activities. The study comparatively examines pre-COVID-19 (before 1 March 2020) and post-COVID-19 (after 1 March 2020) in terms of individual carbon footprint.

Keywords Ecological footprint · Carbon footprint · Carbon footprint calculation · Turkey · COVID-19

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1 Introduction

1.1 Carbon footprint

Since the transition to settled life, human beings have preferred to live in places where they can easily meet their basic needs. Especially with the development of construction techniques, these regions, which they preferred, became increasingly crowded and cities emerged.

The opportunities provided by the cities compared to the rural living areas accelerated the migration from the village to the city. With migration, the existing carrying capacities of cities have been filled, and the horizontal and vertical spread of urban areas has increased (Sakal, 2007; Steel, 2015). The need for employment and production arose as people migrated to city centers in order to benefit from their living opportunities. Production facilities and factories were established to meet this need. Urban vehicle traffic and the use of various fuels have increased. These uses have increased the emission of CO₂ and other harmful gases, greatly affecting the city's air quality, temperature, and all biological life in the city (Dascher, 2014; Kahveci & Acar, 2021; Martínez-Zarzoso, 2008).

The 1972 United Nations Environment Conference held in Stockholm stated that people's right to natural life and the environment should be evaluated within the framework of human rights. With this first initiative, these concepts started to take place in international documents after the 1992 Rio Conference (Abdulahakimoğulları et al., 2011).

The right of people to live in a healthier environment for present and future generations can be achieved through sustainability. In addition, with the awareness of people, concepts such as Ecological Footprint and Carbon Footprint have begun to enter our lives.

Increasing resource consumption with the rapid development of the world with the industrial revolution, the desire for a comfortable life, global warming and a sustainable world order has caused us to move away. The world has begun to alarm by the amount of greenhouse gases such as carbon dioxide, nitrous oxide, and methane, which are released by the fossil fuels used, reaching levels that will poison the world. Increasing global temperature and changing climatic conditions have led the governments to come together and make some decisions. First of all, certain regulations have been made to reduce the greenhouse gases emitted, and then carbon emissions have been tried to be determined primarily on the basis of country and city, and then personally (Kaypak, 2013; Tosunoğlu, 2014).

Studies show that most of the greenhouse gas emissions in countries and cities are caused by human consumption. The active use of cities by people (public transportation, individual transportation, CO₂ emissions, cultural and social activities, etc.) causes personal consumption to be faster. This increases the CO₂ level.

The concept of the ecological footprint was first introduced by Mathis Wackernagel and William Rees in 1990. This concept has emerged as a result of the process in which individuals are engaged in production and consumption. Biocapacity should be compared with the self-renewal process of a region after production and consumption. In this way, it is aimed to ensure that both today's people and the next generation live in a better world with sustainable resource use, which is tried to be created in line with production, consumption, and renewal (Ozsoy, 2015; WWF, 2012).

The Ecological Footprint is the area of biologically productive land and water required to produce the resources an individual, community or activity consumes and to

dispose of the waste it creates, with current technology and resource management. The Ecological Footprint is expressed in “global hectares” (kha). This includes infrastructure and areas for vegetation that will absorb waste carbon dioxide (WWF, 2012).

National Footprint Accounts (NFA) analyze resources in nature and their consumption in six different categories: agricultural areas, forest areas, grasslands, fishing areas, carbon capture areas, and built-up areas (WWF, 2012).

Carbon Footprint, which stands out on a global scale, is one of the most important Footprint components. The largest denominator of Turkey’s total Ecological Footprint, with 46–49% (1.24–1.36 kha per capita), comes from the demand required to trap CO₂ emissions. Between 1961 and 2007, there was growth in the Footprint for all land categories, but the largest increase occurred in the Carbon Footprint (WWF, 2012). Table 1 contains the definitions of carbon footprint found in the literature.

The planet’s capacity to meet humanity’s demand was first exceeded in the mid-1970s. By 2007, the Ecological Footprint has exceeded the current biological capacity by approximately 50%. In other words, as of 2007, humans have used the equivalent of 1.5 planets to sustain their activities. This means that 1.5 years are needed to reproduce the natural resources that people consume in 1 year and to capture the CO₂ they release into the atmosphere. When the biological capacity of the world is compared with the Footprint of humanity, it is seen that the global ecological deficit has increased rapidly over the years (WWF, 2012).

As seen in Table 2, carbon emissions in the USA, which accelerated in the 1960s and reached their peak in the 1980s, are 5 times the world average in these years. In Europe, it was about 2.5 times the world average in the 1980s. In these years, industrial development lagged behind and the developing countries of the Arab world, East Asia, Pacific, Middle East, and North Africa remained below the world’s carbon emissions. As the years progressed, developed countries made efforts to reduce carbon emissions, such as the Kyoto Protocol, and while complying with these rules, they greatly reduced carbon emissions, while developing countries completed their industrial development, greatly

Table 1 Carbon footprint definitions

Global Footprint Network (2007)	The carbon footprint measures the biocapacity demand from burning fossil fuels in terms of the amount of forest area required to capture these CO ₂ emissions
Wiedmann and Minx, (2008)	A carbon footprint is a measure of the specific total amount of carbon dioxide emissions that are directly or indirectly caused by an activity or accumulated throughout a product’s life stages
MCI (2008)	The carbon footprint is the total amount of CO ₂ and other greenhouse gases emitted over the entire life cycle of a product or service
Tatar (2012)	The Carbon Footprint is a measure of the damage caused by human activities to the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide. In other words, it is a measure of one’s personal share in global warming
Kaypak (2013)	The carbon footprint is the measure of human damage to nature in terms of the amount of greenhouse gases, measured in units of carbon dioxide (CO ₂). Transportation, heating, electricity consumption, etc. of institutions or individuals. It is the total amount of greenhouse gas emissions resulting from its activities

Table 2 Regional carbon emissions change

Region/Year	1960	1980	2000	2014	Peak year and quantity
Earth	3.99	4.35	4.03	4.97	2012/4.99
North America	15.52	20.51	19.9	16.35	1973/21.98
Arab World	0.64	3.06	3.68	4.86	2014/4.86
Central Europe and the Baltics	5.10	11.26	6.60	6.14	1980/11.26
East Asia and the Pacific	1.16	2.05	3.19	6.29	2013/6.33
Middle East and North Africa	0.96	3.47	4.64	6.15	2014/6.15
Turkey	0.61	1.72	3.41	4.49	2014/4.49

increasing their carbon emissions. Table 2, prepared with the data of the World Bank, shows the carbon emissions of important regions of the world (URL1, 2018).

While the carbon emission value per capita in Turkey was 0.612 tons in 1960, it became 4.491 tons in 2014 (URL1, 2018). Since Turkey is a developing country and increases its industrial production every year, this proportional increase is parallel to the average increase of the world.

The Carbon Footprint, unlike other Footprint components, is a measure of the space requirement for carbon absorption. Direct resource use, consisting of agricultural lands, forest areas, grasslands, fishing grounds, and built-up areas increases the demand for natural resources on the lands from which the resources are obtained. Carbon Footprint and Agricultural Land Footprint, which stand out on a global scale, also constitute the most important components of Turkey's total Footprint (Table 3). Since 1961, the Carbon Footprint per capita has increased, while the Agricultural Footprint per capita has decreased. In total, both types of Footprints have increased (WWF, 2012).

Due to Turkey's geopolitical position, having commercial ports, being on a transit route, and having productive raw material fields, carbon emissions have gradually increased. According to the measurements made in 2012, Turkey's total carbon emission and the distribution of this emission are shown in Table 4. The population distribution of Turkey is given in Table 5.

The most industrialized region of Turkey is known as the Marmara region. However, the regional distribution of carbon emissions in our country, which is affected not only by industry but also by all activities involving humans and other living things, is shown in Fig. 1. The density distribution of the population by regions is shown in Fig. 2.

Ecological footprint measurements made in recent years have begun to be concluded in terms of planets. The reason for this is to further attract the attention of all humanity. In Turkey, this approach has come to the fore in recent years and it has been calculated that

Table 3 Components of Turkey's ecological footprint

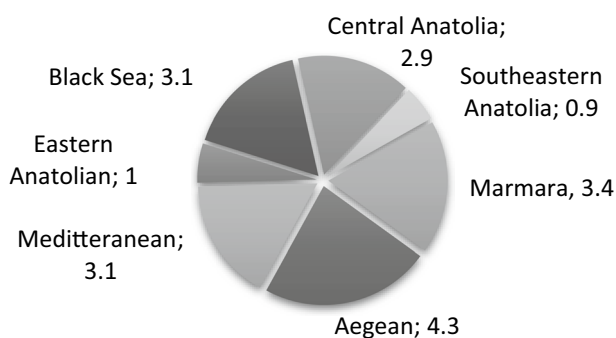
Carbon	46%
Farmland	35%
Forest	11%
Pasture	3%
Built Area	3%
Fishing Range	2%

Table 4 Turkey's sectoral carbon footprint (URL2, 2018)

	Electric	26%		International transportation	4%
	Manufacturing Industry and Construction	22%		Energy Consumption (Excluding Electricity)	2%
	Imported products	16%		Agriculture, Forestry, Fishing	2%
	Transportation	15%		Other	1%
	Housing and Services	12%		Turkey's Total Emissions	440 Million Tons of CO ₂

Table 5 Population distribution by regions

	Population	Percent (%)
TURKEY	81.642.669	100
Marmara	24.899.126	30
Eastern Anatolia	6.513.106	8
Mediterranean	10.584.506	13
Black Sea	7.696.132	9
Central Anatolia	12.896.255	16
Aegean	10.477.153	13
Southern Anatolia	8.576.391	11

Fig.1 Carbon emissions of geographical regions of Turkey (Tatar, 2012)

country lives as if there were 1.5 worlds according to its carbon footprint. Multiplying the planetary calculations by 1.8 will give the carbon footprint in hectares (URL3, 2018).

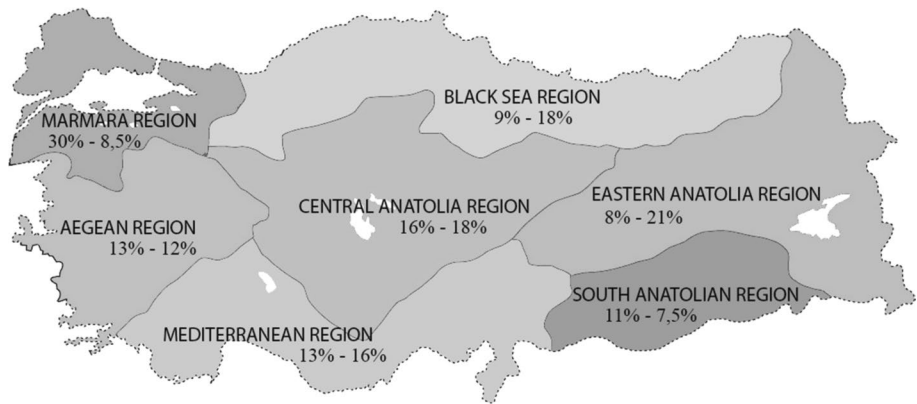


Fig. 2 Density distribution of Turkey's population by regions (Population of the Region—Area covered by the Region)

1.2 Covid- 19 and Its effect

COVID-19 is the disease caused by a new coronavirus called SARS-CoV-2. The World Health Organization (WHO) first learned of this new virus on 31 December 2019, following a report of a group of 'viral pandemic' cases in Wuhan, People's Republic of China (URL4, 2021).

COVID-19 caused symptoms such as fever, cough, and shortness of breath in infected people, and due to its rapid spread, the virus began to affect the world in January (URL5, 2022). Upon the occurrence of cases (URL6, 2020) in many different countries (USA, France, South Korea, Japan, Nepal, Thailand, Singapore, Vietnam, Taiwan, and Australia), the World Health Organization (WHO) announced that SARS-CoV-2 caused He declared Covid-19 a pandemic on March 11, 2021 (URL5, 2022). As of February 7, 2020, the number of cases worldwide is 396,343,205, the number of deaths is 5,759,927 and the number of people recovering is 315,181,677 (URL7, 2022).

As a result, little attention was paid to the Covid-19 disease when it first appeared. However, with the spread of the disease and cases resulting in death, measures such as curfew and mask ban have begun to be taken around the world. Despite all the measures taken, it was late to intervene in the disease and Covid-19 has become a pandemic that threatens all humanity.

While the number of cases is increasing worldwide, the first case of the COVID-19 outbreak in Turkey was announced by the Ministry of Health on 11 March. In addition, the first death due to COVID-19 in Turkey occurred on March 17, 2020 (URL8, 2022). Some restrictions in Turkey after the first death (URL9, 2021);

- March 17, 2020: Starting from midnight, theatre, cinema, performance center, concert hall, engagement-wedding hall, restaurant with instruments-music, cafe, casino, beer hall, tavern, coffee house, coffee house, cafeteria, country garden, hookah lounge, internet cafe, all kinds of game rooms, indoor children's playground, tea garden, association club, funfair, swimming pool, Turkish bath, sauna, spa, massage parlor, SPA, and sports centers have been stopped.

- March 21, 2020: The activities of barbershops, hairdressers, and beauty centers were stopped, it was decided not to allow mass farewell ceremonies for soldiers.
- March 22, 2020: As of midnight, citizens aged 65 and over, as well as chronically ill, were restricted from leaving their residence.
- March 23, 2020: Students started to continue their education from home via the internet and television channels.
- March 27, 2020: Intercity travels are subject to the permission of the governor, a flexible working system is introduced in the private sector, international flights are stopped.
- April 4, 2020: Entries and exits to 30 metropolitan cities and Zonguldak, where lung diseases are common, are prohibited as of midnight. The curfew for 65 years and older has been extended to include young people and children under the age of 20. Masks are required at the entrance to the marketplace, market, and collectively working places.
- 10–12 April 2020: The first curfew was implemented in 30 metropolitan cities and Zonguldak, where lung diseases are common.
- May 10, 2020: "Controlled social life" period started. Citizens aged 65 and over, whose curfews have been restricted since 22 March, went out with a time limit after a 50-day break. Children aged 14 and under were on the street for the first time on May 13, children and youth between the ages of 15–20 were on the streets for the first time on May 15.
- June 1, 2020: "New Normalization" period has started during the Covid-19 outbreak.
- July 21, 2020: Restrictions on working hours of businesses such as restaurants, cafes, coffee houses, and tea gardens have been removed.
- October 12, 2020: Face-to-face education was resumed in the 2nd, 3rd, 4th, 8th and 12th grades.
- November 17, 2020: With the increase in the number of new cases, restriction decisions were made again.
- November 20, 2020: It has been decided to continue official, private, formal, and non-formal education activities with distance education until Monday, January 4th.
- December 1, 2020: The country-wide curfew started between 21.00 and 05.00 on weekdays until a second decision.
- March 2, 2021: "Controlled Normalization" process started.
- April 14, 2021: Two-week partial closure to cover the whole country. (Curfew will be restricted to cover all Saturdays and Sundays, starting at 19.00–05.00 on weekdays, and starting at 19.00 on Fridays on weekends) (URL10, 2021).
- May 17, 2021: During the gradual normalization period; A curfew will be applied between 21.00 and 5.00 on weekdays, and starting from 21.00 on Fridays on weekends and covering all Saturdays and Sundays (URL11, 2021).
- July 1, 2021: The curfew and intercity travel restrictions applied accordingly, regardless of weekdays and weekends will end, and curfews and intercity travel restrictions will not be applied from the specified date (URL12, 2021).

Turkey has taken measures such as full closure and partial closure in certain periods during the pandemic process. These measures have increased the time people spend at home and have led to differences in general living conditions. This situation, which affects people from urban use to consumption habits, has started a different era in the environment.

Especially, Curfew Restriction Circular has been published in Turkey as of March 2020, the activities of many workplaces have been stopped (restaurants, factories, etc.) and people's home quarantine period has begun (URL13, 2020). Although these restrictions were relaxed from time to time in 2020, the restrictions continued at certain time intervals. This

situation has caused great changes in fields such as human–environment, human–nature, human–economy in Turkey as well as in the whole world. With the withdrawal of people to their homes, their living spaces have been left to nature and animals, and the positive reflections of this situation on the environment have come to the fore.

The positive effects of COVID-19 restrictions on the environment in the weather measurements made in Turkey and nature and animal news in the media revealed the assumption of this study. In the news with the withdrawal of people to their homes within the scope of COVID-19 restrictions in 2020, it was determined that air pollution in Istanbul, the most populated city of Turkey, decreased by 11 percent in the first year of the pandemic compared to the same period of the previous year (URL14, 2021). With the decrease in air pollution in Istanbul, Uludağ could be seen after many years (URL15, 2020). Again, in the news of the BBC, it is seen that the dolphins are approaching the coastline due to the interruption in the sea traffic on the Bosphorus and the fishermen staying at their homes (URL16, 2020).

This study based on Turkey is not to measure the carbon footprint value in Turkey, but to examine the effects of individual CO₂ emissions before and after COVID-19 (in 2019–2020).

1.3 Literature review

The concept of footprint is a quantitative measurement that describes how natural resources are used by humans. With this concept, the global effects of human activities can be revealed (Hoekstra, 2008; UNEP/SETAC, 2009; Cucek et al., 2012).

Ecological footprint is the support provided by the ecosystem to this cycle so that the life cycle can continue. It can be used as an indicator to measure human impacts on the ecosystem (Galli, 2014; Mancini, et al., 2016; Monfreda, 2004; Wackernagel, 1999).

Ecological footprint is a system of measuring the renewal capacity of the planet in order to balance production and consumption. One of the important parts of this balance is carbon emissions from fossil fuel use (Kitzes, 2009; Kitzes, et al., 2009; Mancini, et al., 2016).

The “Carbon Footprint” introduced by Wackernagel and Rees (1996) is a subset of the ecological footprint. Ecological footprint is specified as the number of resource layers needed for human activities. Carbon footprint, on the other hand, is the amount of CO₂ released by all individual or social activities. It is very difficult to calculate all activities and their effects (Pandey & Agrawal, 2014; Wackernagel & Rees, 1996).

The concept of carbon footprint gained importance and developed with the emergence of the effects of climate change. Carbon emissions resulting from human activities have been announced to the public since 2005. According to Wiedmann and Minx (2008), a carbon footprint is the total amount of emissions (GHG) caused by an organization, event, or product (Cucek et al., 2012; Ercin & Hoekstra, 2012; Pandey & Agrawal, 2014; Pandey et al., 2011; Radua et al., 2013; Wiedmann & Minx, 2008).

Carbon footprint can be thought of as a hybrid concept that takes its current form from the concept of ecological footprint and is conceptually directly related to global warming. Despite this link, the carbon footprint is often not calculated spatially. In addition to the diversity of the calculation tools, the difference in the results of the calculations causes the public to be misinformed. It is also seen as a field open to use by various countries, companies, and individuals for benefits (Kleiner, 2007; Wiedmann & Minx, 2008; East, 2008; Finkbeiner, 2009; Pandey et al., 2011).

According to the National Footprint Accounts (NFA) 2014 report, our consumption in 2010 was calculated as 1.5 times what our planet could provide. The largest component of this resource demand is the Carbon Footprint component, with approximately 54%. (Mancini et al., 2016).

Goldfinger et al. (2014), with their study, tried to measure how much the planet's carbon sequestration capacity could meet human activities. In this way, more effective uses can be determined with changeable activities (Goldfinger, 2014; Mancini, et al., 2016).

With the Carbon Footprint calculation models, the total emission can be calculated and it can facilitate the taking of measures to make the emission appropriate. When the calculations are detailed, the weaknesses of our activities and the items that can be reduced can be determined. Thus, the requirements for a sustainable world may emerge. (Radua et al., 2013).

Building on Maccini's 2012 study, Mancini et al. In 2016, it tried to make the parameters used to calculate the carbon component of the Ecological Footprint up-to-date and clearer. (Mancini, et al., 2016).

Even though the Carbon Footprint is considered one of the biggest factors affecting global warming, it was not known exactly what it was until a few years ago. The biggest reason for this is that there is no definitively accepted calculation method. Nielsen et al. (2009) stated that current computational methods and perspectives are still in the development stage. The parts where the calculation methods are missing need to be completed. It can be the use of more than one test at certain intervals or a jointly determined test in order to make healthy measurements and to determine the Carbon Footprint. In this way, it can be determined to what extent the damage has been reduced despite the margin of error of a calculator developed to make the correct determination. It is this awareness and work that gains momentum for a more sustainable world in the future (Nielsen et al., 2009; Pandey & Agrawal, 2014; Pandey et al., 2011; Radua et al., 2013; Wiedmann & Minx, 2008).

Individual Carbon Footprint calculations seem to be quite popular in recent years. This is due to increased internet usage and increased automatic calculators. There are calculators that give different results with many different sources and information. Even if these do not give the right results, they are very important in terms of raising awareness. On the other hand, various calculators are used to obtain certain results in line with scientifically collected data. Padgett et al. (2008) tested the differences between their study and 10 US-based Carbon Footprint calculators. It is seen that it is difficult to come up with a clear result in terms of the data taken by the calculation tools and the results they give (WRI/WBCSD, 2004; BSI, 2008; Kenny, 2008; Padgett, 2008; Murray, 2009; Pandey et al., 2011; Cucek et al., 2012; Radua et al., 2013).

Edgar and Paters (2009) conducted an extensive study using the GTAP database to calculate the per capita carbon footprint of 73 nations. As a result of the study, in 2001, approximately 1.1 tons of CO₂ emissions were calculated at the lowest level in undeveloped countries such as Bangladesh, Mozambique, and Uganda, and about 33.8 tons of CO₂ emissions for Luxembourg, which is the developed one (Edgar, 2009; Pandey et al., 2011).

The United Nations Development Program calculated carbon footprints per capita in 2007. However, not all carbon emission components were considered during the calculation. Therefore, the data found in this study are not similar to the data found in Edgar and Peters' (2009) study. This situation reveals the necessity of considering all components while calculating the Carbon Footprint. Otherwise, the results of concepts such as carbon emission and global warming, which will affect our world deeply, can easily be distorted (Edgar, 2009; Herrmann, 2009; Pandey et al. 2011).

2 Material and method

2.1 Material

Turkey is located in the northern hemisphere and is located between 36° and 42° north latitude and 26°–45° east longitude. It has 7 regions geographically (Marmara, Aegean, Mediterranean, Central Anatolia, Black Sea, Eastern Anatolia, and Southeastern Anatolia) and 81 provinces, connecting the continents of Asia and Europe, surrounded by seas on three sides. The population of Turkey as of 2022 is 84 million 680 thousand 273 people. (URL17, 2022). However, since the study was based on the years between 2019 and 2021, the population data of that period was used.

Among the geographical regions of Turkey, the Marmara region (24,899,126) has the highest population with 30%, while the Eastern Anatolia region (6,513,106) has the least population. The total surface area of Turkey is 783,562 km² (the area it covers is 814,578 km² including the lakes) and 6% of this area is structural (URL18, 2021; Yiğit & Benliay, 2022). In this area; Marmara Region 8.5%, Aegean Region 12%, Mediterranean Region 16%, Central Anatolia Region 18%, Black Sea Region 18%, Eastern Anatolia Region 21%, Southeastern Anatolia Region 7.5% (URL19, 2006). Considering these data, the required number for the survey was created by proportioning the population of 7 regions to the area measures of the regions. The number of people to participate in the survey was calculated according to the density calculations of each region, and in this way, it was aimed to make the distribution of the survey data more reliable.

This study aimed to determine the carbon footprint (carbon emission) change in Turkey between the year 2019 before COVID-19 and the year 2020 after COVID-19. For this purpose, a survey was conducted with a total of 650 people in 7 regions in Turkey.

2.2 Method

There are many web-based sites and calculation methods for carbon footprint measurement (URL 21; URL 21). In this study, Tatar's (2012) Carbon Footprint Calculation method was used. During the survey study, the surveys were conducted via Google Form in order not to put the participants at risk due to the ongoing COVID-19 epidemic. The surveys consist of 19 questions and these questions are divided into 2 groups within themselves. The questions in the first group include demographic information (gender, age, occupation, province of residence, etc.), while the questions in the second group include information about heating, electricity, transportation, and lifestyle in Tatar's (2012) Carbon Footprint Calculation table.

Personal carbon footprint is formed from the sum of four main components. These are heating, electricity, transportation, and lifestyle. The carbon footprint calculation using Tatar's, 2012 study is shown in Table 6 (Tatar, 2012).

According to Tatar's (2012) method, carbon footprint; It is found by the sum of heating, electricity, transportation, and lifestyle components. In this context, each item is calculated separately as follows.

1. When calculating the warming component, first of all, which type of heating is used is selected. m3 consumption is calculated for natural gas or liquid recording usage, and consumption is calculated in tons for coal usage.

Table 6 Carbon footprint calculation

HEATING	ELECTRIC	TRANSPORT	LIFESTYLE
Annual Natural Gas Consumption $\times 0.19$	Annual Electricity Consumption $\times 0.43$	Carbon Emissions per Km of Personal Car $\times$ Annual Mileage Made. (https://carfueldata.vehicle-certification-agency.gov.uk/)	I live a new and luxurious life, I consume packaged products, I keep up with fashion. Add 3000 kg
Annual Liquid Fuel Consumption $\times 2.975$		Airplane Journeys Show Big Changes in Carbon Emissions According to Distance. It can be calculated from the site below. http://www.chooseclimate.org/flying	I don't buy what I don't need, I shop at the big markets in the necessary amount, I am thrifty. Add 2000 kg
Annual Coal Consumption $\times 2.00$		Public transport Km by Train $\times 0.11$ Km by Bus $\times 0.09$ Km by Metro $\times 0.09$ Km by Ferry $\times 0.47$	I produce my own fruits and vegetables and / or buy things produced in this way, I do not consume packaged and out-of-season products. Add 600 kg

Natural Gas (Annual natural gas consumption (m³) $\times 0.19$).

Liquid fuel (Annual Liquid Fuel Consumption (m³) $\times 2.975$).

Coal (Annual Coal Consumption (tonnes) $\times 2.00$) is multiplied by the coefficients.

To determine the individual carbon footprint, the calculated figure should be divided by the number of adults in the household.

2. When calculating the electricity consumption; It is multiplied by the individual electricity consumption (kWh) $\times$ coefficient of 0.43.

As with the warming component, the calculated figure must be divided by the number of adults in the household to determine the individual carbon footprint.

3. The calculation of the transportation component requires a more complex calculation than heating and electricity. Multivariate transport types can be used. In this section, the types of personal cars, airplanes, and public transport should be calculated.
- 3.a The calculation of the transportation component requires a more complex calculation than heating and electricity. Multivariate transport types can be used. In this section, the types of personal cars, airplanes, and public transport should be calculated.

It is necessary to calculate how many kilometers you have traveled during the year. However, the brand of the car used and the type of fuel consumed are very important. In the calculation, changes occur according to the type of fuel. The make, model and type of fuel used are calculated from websites such as www.cacarfueldata.org.uk. E.g; This figure is 145 for Honda Civic, 160–200 for Renault Megan, 220 for Ford Focus, 285 for Cherokee Jeep (Divided by 1000 for kg) (Tatar, 2012).

- 3.b In order to calculate public transportation, the kilometer traveled by train is multiplied by 0.11, the kilometer made by bus is 0.09, the kilometer made by metro is 0.09, and the kilometer made by ferry is multiplied by 0.47.
- 3.c An internet engine (available at <http://www.chooseclimate.org/flying>) can be used to calculate the carbon footprint resulting from air travel.

The results from the types of transportation used in transportation are collected.

4. Tatar (2012) divided the lifestyle component of individuals into 3 parts. These;
 - 4.a 3000 kg for the option “I buy the newest model of everything, I love to shop, I consume packaged food”.
 - 4.b 2000 kg for the option “I am thrifty, I only buy new things when I need them, I buy my food mostly from supermarkets”.
 - 4.c For the option “I grow my own organic food, I shop at local markets, I never consume food that is out of season”, 600 kg is added to the carbon footprint.

The individual carbon footprint is found in kilograms (kg) by summing the results from heating, electricity, transportation, and lifestyle components.

The sum of all these data gives our carbon emissions. The amount of carbon emissions in total shows that you are an environmentalist between 1000 and 3000 kg, sensitive to the environment between 3000 and 6000 kg, causing an average damage between 6000 and 9000 kg, exceeding the limits between 9000 and 12000 kg and needing to be corrected, well above the limits of over 12000 kg (Tatar, 2012).

In the study, participants were asked questions about their consumption in 2019–2020 and their consumption in 2020–2021 in order to calculate the carbon footprint before and after COVID-19. Then, with the information given by the participants, each item of the carbon footprint was calculated according to the method. For people living as a family, their collective use is divided by the number of family members. Evaluation was made according to the resulting pre-COVID-19 and post-COVID-19 carbon footprint.

In order to make it easier to calculate the carbon footprint, the same data was collected for two different periods, taking into account fossil fuel use, transportation, electricity use, and lifestyles. In this way.

- Identifying pre- and post-Covid-19 use by categories,
- Determining the change in daily lifestyle with a global event,
- Abandonment of public transport with the risk of covid-19 contagion and determination of the differences in release,
- Measuring the effect of the increase in the number of people in the households due to the return of students and employees living outside the city to their homes,
- With the curfews, it is aimed to examine the connection between individual consumption and carbon emissions in the formation of a cleaner environment.

The questions are prepared in such a way that they can be answered simply in line with the method and the resulting data can be transferred to the method to be used. Even if this method, which will be used to calculate the Carbon Footprint, has shortcomings, it will provide the necessary information for this study, which is aimed to compare the values before and after Covid-19.

The questionnaires conducted with 650 participants were calculated using Tatar's (2012) Carbon Footprint Calculation method, and statistical information was obtained using the Statistical Package for Social Sciences (SPSS) program.

3 Results and discussion

3.1 Results

650 people across Turkey participated in the research. 52% (340 people) of the participants are female and 48% (310 people) are male. Based on the data obtained, it was observed that a gender-balanced survey was conducted with male and female participants (Table 7).

All data were checked in normality tests. It was determined that the data did not fit the normal distribution. It was determined that the carbon footprint variable did not fit the normal distribution according to the gender distributions ($p=0.000<0.05$). In addition, the Mann–Whitney U test was used because there were only two different categories for gender ($p=0.087>0.05$). The difference between the carbon footprint changes of female and male individuals is not significant.

In addition, while the number of participants who do not want to share the sector they work in was 11% (75 people), 36% (232 people) were working in the public sector, 33% (213 people) were working in the private sector, 2% (15 people) were retired, 18% (115) used the other option. When the Kruskal Wallis test was applied, it was determined that there was no significant relationship in the total change between public employees, retired, private sector, and other occupational groups ($p=0.001<0.05$).

In terms of demographic data, surveys were conducted among female participants, mostly in the 18–30 age range, with 46% (158 people), with at least 1% (2 people), and 60+. The majority of male users were surveyed between the ages of 18–30 with a rate of 48% (150) (Table 8). There is a significant difference in carbon footprint changes between age ranges, pre-COVID-19 and post-COVID-19 ($p=0.017<0.05$). Multiple comparisons were made to determine the difference between age groups. According to the research, it is observed that there is a difference between the 18–30 and 31–40 age groups ($p=0.019<0.05$).

The number of surveys was calculated in direct proportion to the population density of the regions and the area calculation, and surveys were made considering this situation. The region that participated most in the survey is the Marmara region with 24% (155 people) (Table 9). In addition, 15% (98 people) of the participants in the survey have changed cities due to the COVID-19 process. With the effect of city changes, the number of people living at home increased by 4%.

Within the scope of the study, the carbon footprint was found to be 5938 kg before COVID-19 and 5339 kg after COVID-19 in Turkey. There has been a 10% reduction in carbon footprint after COVID-19. According to Tatar's (2012) carbon footprint calculation method, participants in this study in Turkey are environmentally sensitive individuals since they have values between 3000 and 6000 kg.

There is a semantic difference between the pre-COVID-19 individual carbon footprint and the post-COVID-19 individual carbon footprint ($z=-8.198$ and $p=0.000<0.05$, Table 10). According to Table 10, there are 41 individuals with the same carbon footprint

Table 7 Distribution of the participants by gender

Gender	The number of participants	Percent (%)
Female	340	52
Male	310	48
$p=0,087$		

Table 8 Age distribution of the participants by gender

Gender	Age	18–30	31–40	41–50	51–60	60 +
Female	Number	158	96	48	36	2
	All Female (%)	46	28	14	11	1
Male	Number	150	98	40	17	5
	All Male (%)	48	32	13	5	2
Total	Number	308	194	88	53	7
	All users (%)	47	30	14	8	1

$p=0,017$

Table 9 Distribution of survey numbers by regions

	Marmara	Mediterranean	Black Sea	Central Anatolia	Eastern Anatolia	Aegean	South- eastern Anatolia	Total
Number	155	127	99	83	68	63	55	650
Percent(%)	24	20	15	13	10	10	8	100

before and after COVID-19. It was determined that the number of individuals with negative carbon footprints was 372, and the number of individuals with positive carbon footprints was 237. In other words, the carbon footprint of individuals has decreased after COVID-19.

Post-COVID-19 Carbon footprint increased in the Eastern Anatolia (18%) region. The region where the carbon footprint decreased the most after COVID-19 was the Black Sea region (15%). Considering the carbon footprint on the basis of regions, participants were found to be environmentally damaging individuals, although there was a 13.4% decrease in the Mediterranean region before and after COVID-19 (Table 11).

COVID-19 has been effective in reducing the carbon footprint (carbon emission) in Turkey (10,09% decrease). There is a semantic difference between transportation use before COVID-19 and transportation use after COVID-19 ($Z = -13,832$ and $p = 0.000 < 0.05$). In other words, the transportation usage values of the individuals in the experimental group decreased significantly after COVID-19. According to Table 12, there are 96 individuals with the same warming + fuel value after COVID-19 and before COVID-19. It has been determined that the number of individuals in which the difference between heating + fuel is negative is 92, and the number of individuals in which it is positive is 462. There is a semantic difference between transportation use before COVID-19 and transportation use after COVID-19 ($Z = -14,328$ and $p = 0.000 < 0.05$). Our lifestyle data consists of three categorical data: environmental (1), normal (2), and luxury (3) (Table 12).

According to the analysis, 53 people who were environmentalists, 458 people who were normal, and 29 people who were luxury before COVID-19, did not change their lifestyles after COVID-19. 6 pre-COVID-19 environmentalists changed their post-COVID-19 lifestyle to normal(5) and luxury(1). 60 people who had a luxury lifestyle before COVID-19 adopted a normal(53) and environmentalist(7) lifestyle after COVID-19. There is a semantic difference between pre-COVID-19 lifestyle and post-COVID-19 lifestyle ($p = 0.001 < 0.05$, Table 13).

The reason why this decrease is high is the amount of time people spend at home during the restrictions period. For this reason, lifestyle (8.42%), personal vehicle (3.59%) and transportation (34.72%) values used in carbon footprint calculations decreased after COVID-19, and heating + electricity (18.56%) values increased after COVID-19 (Table 14).

3.2 Discussion

Ecological footprint and carbon footprint studies in Turkey are among the topics that keep up to date. In studies conducted in the field of education in Turkey, Akyüz et al. (2016) calculated the footprints of academicians of the Faculty of Agriculture, Ege University. As a result of this calculation, the ecological footprint value for academicians of the Faculty of Agriculture, Ege University was found to be 3.17 kha, and the carbon footprint average was 15.32 tons. As a result, it is seen that academicians, who are expected to be more conscious, have an above-average ecological footprint as a result of their professional status. Eren et al. (2017) in their study, academicians of the Faculty of Agriculture, Mustafa Kemal University determined that the ecological footprint average is 3.08 kha and the carbon footprint average is 14.31 tons. According to these results, at least 3.08 earth are required for academicians of the Faculty of Agriculture for a sustainable life. Başoğlu (2018) determined that the average ecological footprint of the Faculty of Engineering employees was 2.53 kha and the average carbon footprint was 15.55 tons. At least 2.53 worlds are required for Adıyaman University Faculty of Engineering employees. In the studies, it is seen that ecological footprint and carbon footprint evaluations are made in certain areas (education, tourism, etc.) or scales (university, province, etc.).

Tollefson (2021), in his article published, stated that global fossil fuel-related carbon emissions decreased by 5.4% in 2020 with covid-19 and it is expected to decrease a little more. In addition, it was stated in the study that the decrease in fossil fuel-induced carbon emissions will stop in a short time and will increase again. In this study, it is seen that the carbon footprint in Turkey has decreased by about 10% with covid-19. One reason for the decrease in the carbon footprint is the use of fossil fuels. Tollefson's study and this study show parallelism in the covid-19 epidemic process (Tollefson, 2021).

Mancini et al. (2016) Forest ecosystems of the Carbon Trace have tried to plan what capacity is possible. More than the amount of carbon that can be obtained from carbon can be used as a basis for consumption. (Manciger et al.,) We aim to reveal the product to be obtained with this study in 2016. It can be used in its lifetime, use in its lifetime.

Li et al. (2015) calculated the Carbon Footprint of university students with their personal energy use and lifestyles. In this study, it was aimed to show what should be considered for a more livable campus and how the participants should be conscious. Bucsky (2020) revealed in his study that the use of personal vehicles and bicycles has increased during the COVID-19 process, while public transportation has decreased significantly. The latest data on the development of global CO₂ emissions in 2020 feeds the expectation that some environmentally beneficial individual changes may not take long. On an annual basis, global CO₂ emissions fell by as much as 7% in 2020 (Lehmann et al., 2021). In a study conducted in Switzerland during the strict measures brought by COVID-19, reductions of approximately 60% in average daily distance were observed, with reductions of over 90% in public transport. In addition, bicycle use has greatly increased in this process (Bucsky, 2020; Lehmann et al., 2021; Li et al., 2015; Molloy et al., 2021) With the results of our study, we aimed to change the Carbon Footprint based on how the living conditions

Table 10 Change between pre-COVID-19 and post-COVID-19 individual carbon footprint

		N	Mean Rank	Sum of Ranks
Pre COVID-19 carbon footprint	Negative Ranks	372 ^a	345,38	128,481,00
Post COVID-19 carbon footprint	Positive Ranks	237 ^b	241,62	57,264,00
	Ties	41 ^c		
	Total	650		

a. Post COVID-19 carbon footprint < Pre COVID-19 carbon footprint $p < 0.000$

b. Post COVID-19 carbon footprint > Pre COVID-19 carbon footprint

c. Post COVID-19 carbon footprint = Pre COVID-19 carbon footprint

changed by a major epidemic such as Covid-19 changed the consumption habits of individuals. Even if the Covid-19 epidemic is completely over, it is estimated that living conditions will not fully return to the past. This situation can be used to determine how the current situation affects us, as well as be prepared for a new epidemic that may occur in the future.

Brown et al. (2008) measured CO₂ emissions caused by fossil fuels and electricity used in homes, in their study in the USA. This study aimed to calculate the carbon footprint of 100 metropolises (Brown, 2008; Pandey et al., 2011). In this study, while calculating the carbon footprint, factors such as fossil fuel, electricity consumption, transportation, and lifestyle are also included. Thus, the individual carbon footprint can be calculated more reliably.

Label et al. (2007) aimed to calculate the carbon footprint of five metropolises belonging to the Aysa region between 1980 and 2000. He stated that with this study, emission values per capita could be calculated in a comparable way (Lebel, 2007; Pandey et al., 2011). With the research conducted by the University of Pennsylvania in 2007, the carbon footprint of the university was tried to be calculated. All structural and consumption-oriented carbon emissions of the university were analyzed with the calculation tool belonging to an organization called “Clean Air Cool Planet”. It has been calculated that with the studies and developments focused on clean campus areas, it has been reduced by approximately 30% from 1993 to 2006 (Pandey et al., 2011). With the 2012 London Olympic Games, sustainability targets were set for the first time in a large organization. During this organization, calculations were made including all the consumption of the athletes, visitors, media, and the organization area. This study is an important step in raising awareness and identifying the burden of large organizations (Pandey et al., 2011). In this study, the change in carbon emission was revealed. The outputs of these studies can be used to facilitate reaching the level of consciousness necessary for a sustainable world.

Using the example of the largest European Political Science conference, Jäckle (2021) found that the carbon footprint of an online conference would be at least 97–200 times smaller than it would be if the meeting took place face-to-face. In a similar study conducted in Switzerland, École Polytechnique Fédérale de Lausanne (EPFL) researchers measured the carbon footprint of academic air travel between 2014 and 2016, and

Table 11 Distribution of Carbon Footprint in Turkey and 7 Regions in Turkey

	Pre COVID-19 carbon footprint (kg)	Post COVID-19 carbon footprint (kg)	Change (%)
TURKEY	5938,659,923	5339,329,438	%10,09
Marmara	5151,848	4543,642	%11,80
Eastern Anatolia	4339,978	5133,605	%18,28
Mediterranean	8358,553,023	7234,979,867	%13,4
Black Sea	5289,43,364	4468,57,864	%15,51
Central Anatolia	5513,639	4799,94	%12,94
Aegean	5501,718	4880,785	%11,28
Southern Anatolia	5785,126	5657,323	%2,20

Table 12 The semantics of lifestyle change Pre-COVID 19 and Post-COVID 19

Descriptive Statistics						Marginal Homogeneity Test	
	N	Mean	Std. Deviation	Min	Max		Pre COVID- & Post COVID-19 lifestyle
Pre COVID-19 lifestyle	650	2,05	,475	1	3	Distinct Values	3
Post COVID-19 lifestyle	650	1,90	,444	1	3	Asymp. Sig. (2-tailed)	<,001

Table 13 Cross table of lifestyle change pre-COVID-19 and post-COVID-19

Crosstabulation					
		Post COVID-19 lifestyle			Total
		Environ- mentalist	Normal	Luxury	
Pre COVID-19 lifestyle	Environmental	53	5	1	59
	Normal	39	458	5	502
	Luxury	7	53	29	89
Total		99	516	35	650

Table 14 Annual distribution of carbon footprint components in Turkey

	Heat- ing + Elec- tricity	Transport	Life style	Personal Car
Pre-COVID-19	808,80	1488,20	2009,84	1626,76
Post COVID-19	958,98	971,49	1840,61	1568,23
Change (%)	%18,56	%34,72	%8,42	%3,59

the results were that the carbon footprint increased up to 10 times as the title increased. It also determined that 10% of EPFL researchers account for almost 60% of total emissions from EPFL air travel (Ciers et al., 2019). The inability of the academic community to hold scientific meetings (Conferences, Seminars, workshops, etc.) face-to-face during the COVID-19 period was initially thought to be negative. However, the fact that this is the age of technology has eliminated this negative situation and the problem has been solved with online meetings, and the contribution of this situation to the environment has been positive. In the studies conducted by Ciers et al (2019) and Jäckle (2021), the emergence of changes in travel and lifestyle provided a reduction in carbon emissions. During the normalization period after the COVID-19 process, online academic meetings should be continued for environmental awareness. Not only for the academic community but also in different fields, this situation can be used as a plus to reduce carbon emissions.

The personal carbon footprints of two lecturers living in Ireland were found to be similar to the average in their country of residence, twice the global average. A key takeaway from the study is that it is difficult for (environmentally conscious) individuals to drastically reduce their carbon footprint when they live and participate in a high carbon footprint society. Therefore, social change is needed to realize a sustainable society that operates within biophysical boundaries (Fitzpatrick et al., 2015).

Le Quéré et al. (2020) estimated the impact of COVID-19 on emissions using three levels of containment, six sectors of the economy (energy, transport, industry, land transport, public buildings, and commerce, housing and, aviation), proxy data, and observed changes in activities. Recent analyzes of the 17% reduction in CO₂ emissions during quarantines have shown significant variation across economic sectors. In the analyzes made, the biggest decrease was in land transportation (transportation). Le Quéré et al. (2020), study also supports the CO₂ reduction achieved as a result of this study (Table 14) (Le Quéré et al., 2020).

The process of ensuring the continuity of positive results in the carbon footprint after COVID-19 can be achieved by ensuring the continuity of consumption patterns and habits, and by raising awareness. Abad-Segura et al. (2020), in their study, showed that recent studies have focused on this area. He mentioned that with the right education and awareness, people's individual and social ways of thinking can be changed positively, and regional and global changes can be created in this way (Abad-Segura et al., 2020). Ensuring the continuity of this can be created by new sustainability initiatives to be implemented by the states and sanctions to be made to prevent carbon gas emissions.

4 Conclusions

The main starting point of this article is the economic crisis experienced by countries or cities, natural disasters, epidemics that negatively affect life, and changes in people's lifestyles. The fact that people act collectively, state-based, or individually in such situations has caused their living standards to decrease to the minimum level. The luxury and excessive consumption expenditures of individuals have been replaced by basic needs. It has been argued that this situation will positively affect the carbon footprint in Turkey.

As a working hypothesis, she suggested that the carbon footprint would decrease. According to the study, the carbon footprint in Turkey was calculated as 5938 kg before COVID-19 and 5339 kg after COVID-19, and individuals in Turkey were sensitive to the

environment. The 10% reduction in carbon footprint revealed that the restrictions in the COVID-19 period had an impact on carbon emissions. The hypothesis of the article is that the carbon footprint will decrease after the COVID 19 epidemic, and this is supported by the data.

The calculated data consists of heating, electricity, transportation, and lifestyle components. According to the data obtained, the effect of curfews, not using public transportation, switching from luxury spending to minimum spending in lifestyle, and decreasing the use of public transportation and personal vehicles are seen.

It is thought that closing the factories in certain periods due to restrictions in the Marmara region, which is the center of industry, has positive effects on carbon emissions. The carbon footprint in the Black Sea region decreased by 15%, making it the region with the lowest carbon footprint among the regions. It can be said that the decrease in the carbon footprint in this region is due to the withdrawal of people from the city to the village regarding the prohibitions.

Although the carbon footprint in Turkey has decreased after COVID-19, suggestions can be made regarding conscious and environmentally friendly consumption (recycling within consumption) in order to preserve existing resources and leave a world with an unaltered nature and atmosphere for future generations.

- To raise awareness about the harm caused by unconscious consumption to both nature and people by instilling a love of nature in children from a young age,
- It should be ensured that people are encouraged to reduce the use of personal vehicles and to use public transportation. In addition, studies should be carried out to use environmentally friendly fuels, hybrid vehicles, and bicycles in transportation, which have less impact on the carbon emissions of the fuel types of transportation vehicles.
- Seminars, advertisements, and public service announcements should be created to raise awareness about the effects of changes such as reducing the use of packaged products in people's lifestyles, not consuming more than necessary, and avoiding waste.
- People should take measures to save energy in their homes and workplaces and avoid wasting water.
- In order to ensure that household and workplace wastes are included in the recycling, garbage should be created by segregation in homes and offices. Municipalities should increase the number of recycling bins and work to ensure their use.

It was made as an indicator of how people's living conditions in home quarantine affect their carbon footprint in a difficult process like the pandemic. In future studies, the carbon footprint distributions of people in Turkey with the COVID-19 vaccination process can be re-measured and calculated. Doing this will shed light on the change in environmental awareness and awareness of people after a process such as a pandemic. The increase in the number of people who have moved from a luxurious lifestyle to an environmentalist lifestyle, seen in the results of the article, has shown that people can continue their lives at a minimum level in these processes. The continuation of conditions such as the permanence of changes in lifestyles can be a measure of both the reduction of carbon emissions and the permanence of sustainability. By adding children's groups, carbon footprint studies can be done by a different perspective.

This study using Tatar's (2012) Carbon footprint calculation algorithm; It can contribute to future studies on sustainability, ecological footprint, and their calculation and can be useful for strategic plans. In addition, it is thought that it will contribute to social sciences

as well as to environmental sciences. It can support studies on how consumption habits change with emotions such as the desire to survive and fear, and how permanent this is.

In this study, carbon footprint emissions in Turkey were measured individually before and after COVID-19. It has been assumed that Turkey has been positively affected by carbon footprint emissions during the pandemic process. However, this assumption is based on the individual carbon footprint. Continuing studies also include how the carbon footprint affects commercial areas (factories, industries, production facilities, etc.) with COVID-19. In Turkey, the operation of factories and workplaces has been stopped for a long time.

Recycling is as important as reducing carbon emissions in Turkey. Nature is the most important tool that transforms carbon dioxide into nature as a useful component. Trees remove carbon dioxide from our world without the need for any tools or technology. Therefore, forests should be protected, managed, and repaired in order to leave a world whose nature and air have not changed for future generations.

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