Investigating The Changes In Air Pollutants In Tehran And The Trend Of Changes In The Land Use Of Green Spaces

Ali Sayyadi[1*], Mohammad Javad Amiri[2], Gholam Reza Nabi Bidhendi[3]

[1*]Ph. D student in Environmental Planning, Kish International Campus, University of Tehran, Tehran, Iran
[2]Assistant Professor, Graduated Faculty of Environment, College of Engineering, University of Tehran, Tehran, Iran
[3]Department of Environmental Engineering, Faculty of Environment, University of Tehran, Tehran, Iran

***Corresponding Author:** Ali Sayyadi
*Ph. D student in Environmental Planning, Kish International Campus, University of Tehran, Tehran, Iran,
Email: sayyadi.ali@ut.ac.ir

Abstract
Air pollution in big cities is one of the biggest problems in the world right now, which is one of the most important cities of Tehran. As the capital of Iran, Tehran is facing severe air pollution problems. Therefore, this research aims to Investigate the changes in air pollutants in Tehran and the trend of changes in the land use of green spaces in the last 40 years in this city. For this purpose, Landsat satellite images and their sensors and NDVI vegetation index were used. Also, the trend of changes in the primary air pollutants, including pollutants (CO-SO2-NO2-O3-PM10-PM2.5) and the air quality of Tehran city, was obtained using GIS and IDW zoning methods. The research results showed that the density of the primary pollutants in most areas of Tehran is increasing, and the air quality of Tehran (AQI) is also inappropriate for most areas and age groups. Also, the results of the satellite analysis showed that the trend of vegetation and green space in Tehran has been decreasing in the studied years. According to the findings and results of the research, it is evident that the trend of pollutant changes and air quality in Tehran is increasing and inappropriate. In addition to various factors influencing this trend, reducing vegetation and green space is an influential environmental variable. Furthermore, it requires detailed planning in this field.

Keywords: air pollutants, green space, and vegetation, IDW method, Landsat satellite images, NDVI index

1. INTRODUCTION[1]

Air quality and air pollution directly affecting human health, the environment, and the ecosystem is a subject that has been heavily analyzed in scientific research (Mathys et al., 2023). These effects are mainly seen in large cities, where the primary sources of air pollution emissions and higher population density are found (Querol et al.,2021). Air pollution is the fifth risk factor for mortality in the world. More than 90% of the world's population lives in places where the World Health Organization (WHO) recommended guidelines for healthy air are exceeded (Aix et al., 2022).

It has advocated ten µg/m3 as a "safe" exposure level for 2.5 PM (Mir et al., 2022); nitrogen dioxide (NO2), carbon dioxide (CO2), and particulate matter. Suspended (PM) sulfur dioxide (SO2) is one of the essential air pollutants released through combustion, urban motor traffic, domestic and industrial greenhouse gases, Etc (Tan-Soo et al., 2022). There is much evidence that shows that ambient air pollution endangers the health of the population (Gulia et al., 2022); so exposure to air pollutants can cause oxidative stress, epigenetic changes, DNA, Systemic inflammation, and endocrine dysfunction that may play a role in the occurrence and development of diseases (Wu et al., 2021).

In recent years, epidemiological studies have shown that air pollution is a potential risk factor for infertility and unwanted pregnancy, which has consequences such as miscarriage, stillbirth, premature birth, and pregnancy (shi et al., 2021). The International Agency classifies air pollution as a human carcinogen and is responsible for approximately 3.1 million premature deaths worldwide each year and 3.2% of the global disease burden alone (Cai et al., 2021).

In 2019, air pollution surpassed the effects of other common chronic diseases such as obesity (high BMI), high cholesterol, and malnutrition, becoming the fourth leading cause of death worldwide (Li et al., 2017). Air pollution in big cities is one of the biggest problems in the world right now. In Tehran, air pollution has been caused by the increase in population and industrial development. Tehran's air pollution is lower than international standards, and the government of the Islamic Republic of Iran has introduced pollution as a high-priority environmental and health challenge (Gharagozlou, 2014). One of the fundamental reasons for air pollution in Tehran is the exhaust of about 1.4 million motor vehicles, including about 0.5 million motorcycles, which work in a very crowded road space, and 70,000 industrial units (Keikhosravi et al., 2021).

The reported average concentrations of pollutants such as carbon monoxide (CO), particulate matter (diameter less than 10 microns (PM-10)), and sulfur dioxide (SO2) in downtown Tehran in 2007 were two to three times higher than the average recommended by It has been WHO/USEPA. This growth in the number of cars in the last two years has aggravated the situation (Gharagozlou, 2014).

Tehran, the capital of Iran, is facing severe air pollution problems. According to some recent studies, it was concluded that the estimated health impact for the city of Tehran shows the need for urgent action to reduce the health burden of air pollution (Hashemi et al., 2022).

1.1. Literature review

Many studies were conducted on air pollutants in Tehran, the most recent of which are as follows (Motlagh et al., 2023), in research on the integrated value model to evaluate the sustainability of solar energy systems in residential buildings in Tehran in the direction designed to minimize urban air pollution in Tehran. This research aims to design an integrated value model for sustainability assessment, the Analytical Hierarchy Model (AHP), and sensitivity analysis. The research results showed that one square meter of PV and PV/T can prevent The emission of 211 and 488 kg of CO2 annually has 1.2 and 1.9 grams of PM pollutants. In a research (Hashemi et al., 2022), they investigated the relationship between the concentration of PM2.5 and the occurrence of suspected and positive cases of covid-19 in the medical centres of Tehran. The purpose of this research is to investigate the role of the air quality index (AQI) and PM2.5 and their relationship with the occurrence of suspected cases (SC) and positive cases (PC) of Covid-19 in Tehran, the capital of Iran. The results and statistical analysis (Pearson's correlation test) showed that as the AQI level increased, the number of suspicious cases (SC) and positive cases (PC) also increased (Namdar Khojaste et al .,2022). This study investigated the relationships between cases of COVID-19 in two short-term (6 months) and long-term (60-month) soot and air pollutants (NO, NO2, NOx, CO, SO2, O3, PM2 5 and 10 PM) by integrating geostatistical interpolation models, regression analysis, in Tehran. The study results showed that a higher incidence rate of COVID-19 was significantly associated with exposure to higher concentrations (Shahrokhi Shahraki et al., 2022). Their research focused on high-resolution modelling of Tehran air pollutants and validation with surface and satellite data. This study addresses how skilful regional air quality modelling can be made globally available. This paper uses a global dataset for a fine-resolution regional air quality before an urban area. The research results showed a high correlation and a strong relationship between used and global data.

Keikhosravi et al. (2021). They investigated the effect of inversion and air pollution on the number of patients with Covid-19 in the Tehran metropolis. This research investigates the downward curve between the increase in inversion height and air pollutants on the number of coronavirus patients. The results of the research showed that there is a significant relationship between the increase or decrease in the height of the inversion and air pollutants and the increase in the coronavirus, and in all periods of investigation, with the increase in the height of the temperature inversion, the pollutants increase, and at the same time, the number of patients with covid-19 increases on the surface of the earth.

Boostani et al. (2022). The research identified the critical uncertainties of the city of Tehran to achieve the development of a low-carbon city using the scenario writing method. This research aims to find practical solutions for developing a low-carbon city with cooperation and organizational support. To achieve this goal, examining the most critical indicators in different dimensions, the obtained uncertainties, and the possible scenarios were analyzed using the Scenario Wizard software. In the end, the authors found that by using green infrastructure and promoting collaboration and partnership, it is possible to reduce the adverse effects of the urban environment and move towards a low-carbon city. The issue of green space is considered one of the fundamental issues of urban issues because, in addition to the irreplaceable values of the environment, it has a direct relationship with the city's beauty, the reduction of pollution, and the health and vitality of the citizens. Due to the diverse environmental, social, cultural, and economic functions of urban areas, green space is considered an essential and valuable indicator in urban areas. Quantitatively and qualitatively, these uses should be in such a way that they can provide the citizens' needs according to the cities' ecological conditions and their future expansion process. Also, they should be able to provide continuous environmental performance. In this way, it is essential to pay attention to the use of green space in terms of its facilities and conditions for citizens. As the country's capital, Tehran is one of the most populated cities in Iran. In recent years, due to the excessive expansion of the city, it has faced severe threats; So that in the past few years, we have seen excessive pollution and breathing problems for citizens. Considering the role of green space in the ecological and environmental performance of Tehran city in reducing air pollutants of Tehran city, their monitoring is inevitable. By conducting research studies, we can find the reasons for these phenomena and provide the best possible solution to solve those problems. For this purpose, remote sensing data and GIS can be used due to their advantages.

2. MATERIALS AND METHODS

2.1. The Location of the Study Area

Tehran is the largest and most important city in Iran and one of the largest cities in the world. This metropolis consists of 22 regions; in Figure (1), you can see the location of Tehran city along with the divisions of the regions.

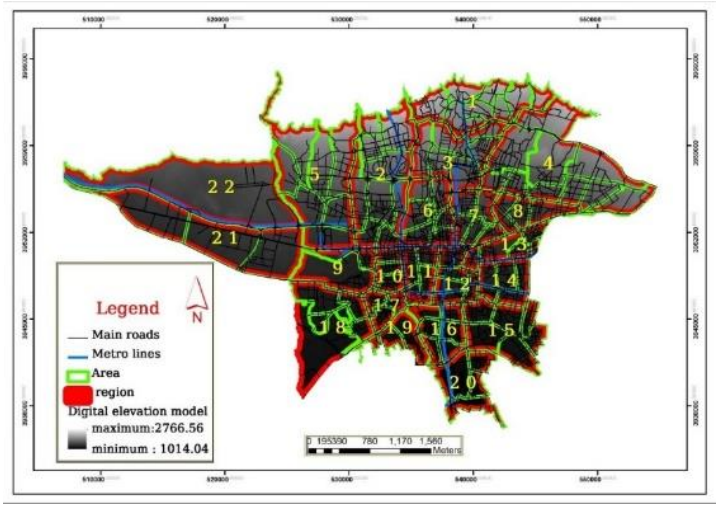


Figure 1, The Location of the Study Area.

2.2.Methodology

The current research is descriptive-analytical and practical in terms of purpose. Landsat satellite images have been used in this research for environmental and spatial analysis of Tehran city. For this purpose, the US Geological Survey and NASA website have prepared Landsat satellite images in (TM-ETM-TIRS) sensors and the years 1984 to 2020. Also, in this research, the techniques of thermal remote sensing and geographic information system were used, which were combined effectively and efficiently.

This research aims to Investigate the changes in air pollutants in Tehran and the trend of changes in the land use of green spaces in the last 40 years in this city. For this purpose, using Landsat satellite images and its sensors and NDVI vegetation cover index, the trend of green space and vegetation changes in different years and 22 regions of Tehran is obtained. GIS and its modelling are obtained. Finally, the maps of green space and vegetation changes and air pollutants of Tehran city in the studied years are obtained.

It should be mentioned that the raw remote sensing data collected by different sensors from the earth's surface may have deficiencies and errors; Therefore, to use satellite images, it is necessary to eliminate deficiencies, compensation, and errors.

Also, in this study, ARC Gis 10.9 software is used to prepare the output, and IMAGIN ERDAS, Envi5.2, and IDRISI software are used to process, analyze and analyze Landsat images and finally prepare green space maps. Table (1) Landsat satellite images It shows the sensors used in this research, such as from 1984 to 1998 Landsat 5 and "TM" sensors, 2000 to 2014 Landsat 7 and "ETM" sensors, and from 2016 to 2022 from Landsat 8 and "TIRS" sensors is used.

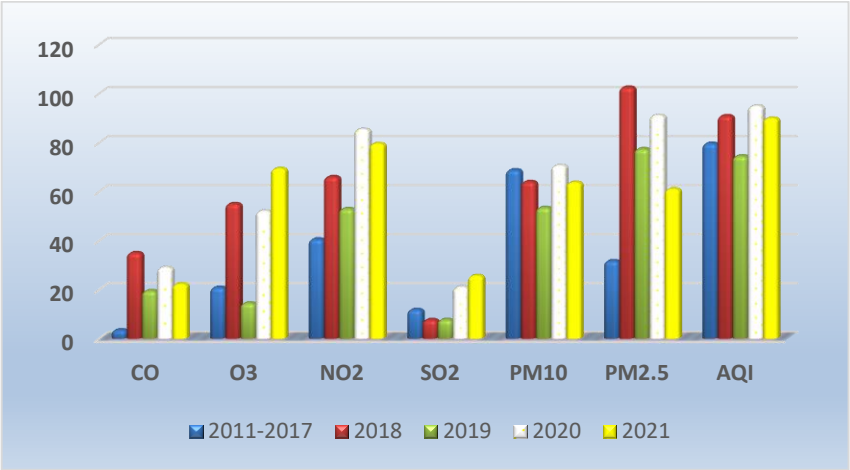
Table 1, Specifications of Landsat satellite images

Date of taking the image	Satellite LANDSAT	Sensor	PATH	ROW	Thermal band	Coordinate system WGS84"UTM
1984	5	"TM"	164	035	6	ZONE39
1987	5	"TM"	164	035	6	ZONE39
1990	5	"TM"	164	035	6	ZONE39
1992	5	"TM"	164	035	6	ZONE39
1994	5	"TM"	164	035	6	ZONE39
1996	5	"TM"	164	035	6	ZONE39
1998	5	"TM"	164	035	6	ZONE39
2000	7	"ETM"	164	035	6	ZONE39
2002	7	"ETM"	164	035	6	ZONE39
2004	7	"ETM"	164	035	6	ZONE39
2006	7	"ETM"	164	035	6	ZONE39
2008	7	"ETM"	164	035	6	ZONE39
2010	7	"ETM"	164	035	6	ZONE39
2012	7	"ETM"	164	035	6	ZONE39
2014	7	"ETM"	164	035	6	ZONE39
2016	8	"OLI_TIRS"	164	035	10-11	ZONE39
2018	8	"OLI_TIRS"	164	035	10-11	ZONE39
2022	8	"OLI_TIRS"	164	035	10-11	ZONE39

Also, in this research, in addition to satellite data, in order to analyze the air pollutants of Tehran, the data of Tehran Air Pollution Control Company from 2001 to 2022 have been used.

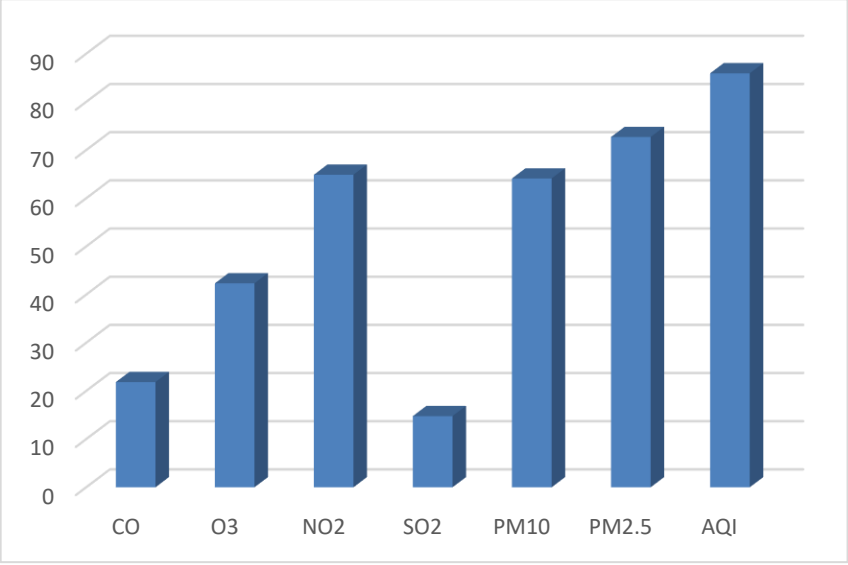
2.3. Air pollutants in Tehran

According to the report of Tehran City Air Control Company, during the year 2021, Tehran City had two clean days (6%), 249 good days (68.2%), 108 unhealthy days for sensitive groups of society (29.6%), and six unhealthy days (is 1.6%). The number of days with unfavourable conditions decreased from 123 days in 2020 to 114 days in 1400, which primarily applies to unhealthy conditions. Suspended particles smaller than 2.5 microns were 23 days of ozone pollutants, eight days of suspended particles smaller than 10 microns, and 13 days of nitrogen dioxide pollutants were beyond the limit. It is worth mentioning that on some of the polluted days, more than one pollutant was above the health limit. The number of days with unfavourable conditions for the ozone pollutant showed a significant decrease compared to 2013 and the other mentioned pollutants. The number of polluted days has increased. Also, during the year 2021, more than one pollutant exceeded the permissible limit on 23 days, during which three pollutants exceeded the standard limit on two days, and on 21 days, two pollutants exceeded the standard limit. And. The average concentration of O3, PM10, and SO2 pollutants in Tehran in 2021 slightly increased compared to the previous year, and the annual average concentration of NO2, PM2.5, and CO pollutants decreased relatively compared to the same period of the previous year. Therefore, the concentration of air pollutants in Tehran is different in different years. Graph (1) shows the trend of changes in air pollutants in Tehran from 2011 to 2021, which you can see. Based on this chart, the amount of primary and index pollutants in The air quality of Tehran city (AQI) has been increasing in the mentioned statistical years.



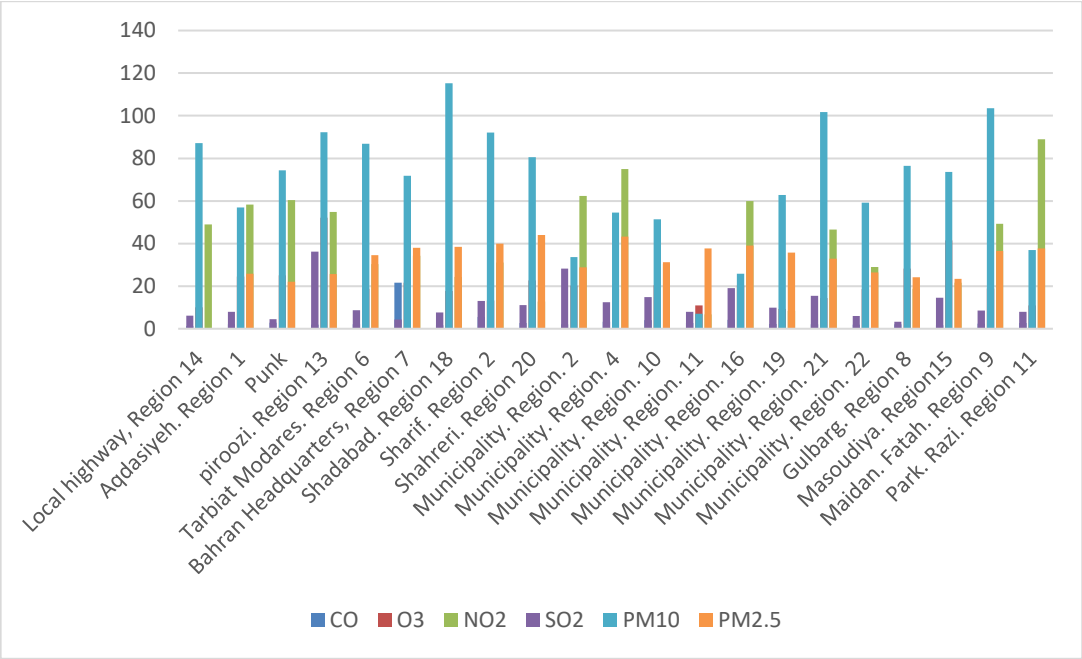
Graph 1, The trend of changes in air pollutants in Tehran from 2013 to 2014

Graph (2) shows the average of the primary air pollutants in Tehran from 2011 to 2021, and you can see, based on this graph, PM2.5 and PM10 pollutants have increased over ten years compared to other pollutants.



Graph 2, The average of the primary air pollutants in Tehran from 2013 to 2014

Also, graph (3) shows the trend of changes in the primary air pollutants of Tehran in quality control monitoring stations. As you can see, the pollutant of airborne particles (PM10) has been increasing in all stations.



Graph 3, The trend of changes in the central air pollutants of Tehran city in quality control monitoring stations

3. Findings

3.1. Land use and green space

One of the influential factors in reducing or increasing green space in Tehran city in consecutive years is the spatial changes in land use. These are examples of changes in land use, the intensity of space use, building densities, and urban boundaries. Urban land use changes are also an economic and spatial category. The change in the type of uses and tendencies of society to intervene in space reflects the structure of the city's space economy. The space economy in Tehran is based on the development of land with a high price and urban quality in the prosperous areas of the city. The predominant tendency is for residential, commercial, office, and tourism uses. The most significant demand for changing the uses of green spaces, residential areas, and reserved lands has been for development. The concentration pattern of these changes in the city of Tehran is in the form of a cluster. Research findings show that the economy of space in the city of Tehran is based on the development of land with a high price and urban quality in the prosperous areas of the city. The high concentration of these interventions in areas 1, 2, and 3 of Tehran is quite evident. The trends of land use interventions and changes in Tehran must be balanced. It specifies the spatial distribution pattern of land uses and spatial autocorrelation. The dominant tendency is for residential, commercial, administrative, and tourism uses, and tremendous demand for land use change is also for green and garden, residential, industrial, and urban development reserve lands. The continuation of this process causes the excessive use of building surfaces instead of vegetation and gardens, and as a result, the main reason for environmental problems and climate changes, such as the increase in air pollutants in different areas of Tehran.

3.1.1. green space

Changes in the reduction of green space in Tehran have significantly impacted the increase of air pollutants in the city at different times. In order to investigate these changes, remote sensing technology, which aims to identify and separate earth phenomena and place them in specific groups or layers, has been used from 1984 to 2022.

3.1.2. Analysis of green space utilization in Tehran from (1994-1998)

One of the methods used to obtain land use and green space maps before classification is band composition in Landsat images; in this research, TM and ETM sensors have a band composition of 2-3-4, and TIRRS has a band composition of 3-2-2. 5 have been used. Band 4 is the infrared wind in this composition, with the highest reflection in this vegetation band (green space). In Figures (2 and 3), band combinations have been used to prepare the land use and vegetation map for the studied areas from 1984 to 2022. As you can see, the studied area is divided into five classes green space and vegetation with green colour, urban use with colour Pink, barren and abandoned land with white colour, bad land or mountain with purple colour, and roads with mesh colour classified and marked.

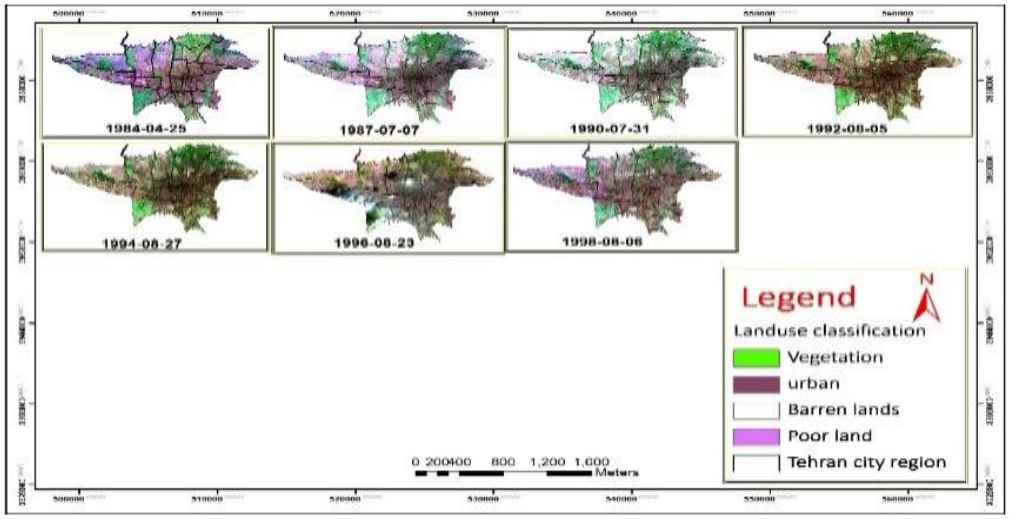


Figure 2, Green space and vegetation use map of Tehran city in the studied years (1994-1998)

In 1984, regions 1-3-18-22, respectively, had more vegetation density than other regions, and the city centre had low and weak vegetation due to the density of residential areas. The year 1987 compared to 1984 was similar in terms of vegetation density, and as in 1984, regions 1 and 3 had more vegetation density than other regions. The year 1990, compared to 1987 and 1984, has included many lands use changes so that vegetation and green spaces have been reduced, and urban and barren lands have covered some of them. In 1992, compared to 1990, we did not see many changes in the field of vegetation reduction, and as in previous years, the foothill areas of Tehran, including the northern, southern, western, and eastern regions, have more vegetation density than the central regions. 1994 refers to In 1992 and previous years, the amount of vegetation-green space has decreased, and residential areas and barren lands have replaced much vegetation. In 1996, a significant decrease in green space and vegetation was observed. This decrease is more noticeable in areas 1-3-4-5, which had more vegetation than other areas in the previous year. In 1998, compared to 1996, there were not many changes in the use of green space and vegetation, but as in 1996, compared to other years, the amount of vegetation was reduced and added to residential use and barren land.

3.1.3. Green space utilization analysis of Tehran city since (2000-2022)
Figure (3) shows the trend of green space usage changes in the studied years (2000-2022), which you can see.

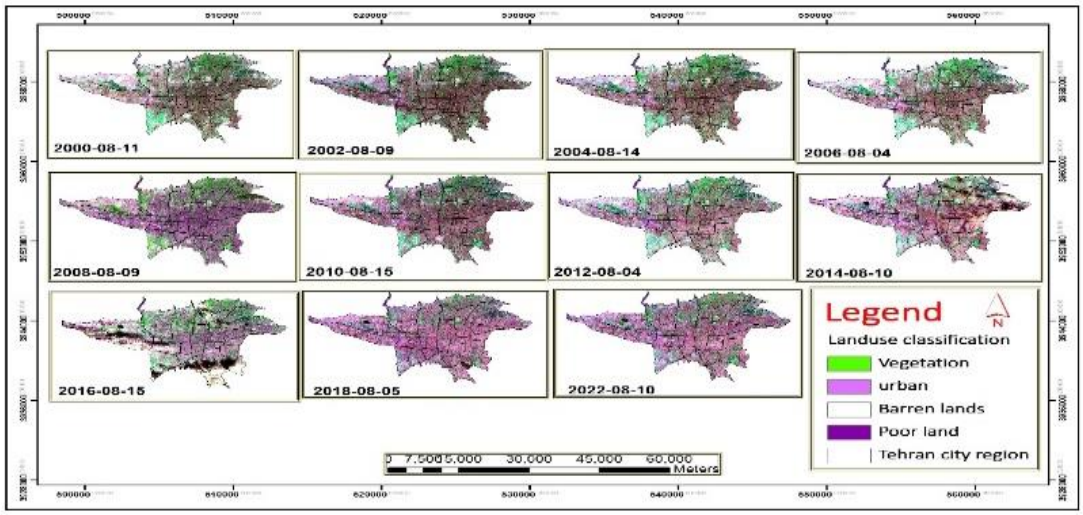


Figure 3, Green space and vegetation use map of Tehran city in the studied years (2000-2022)

The year 2000 is the beginning of fundamental changes in use, including green spaces and vegetation. These changes are more in the mountainous and northern lands due to the value of the land compared to other areas. In fact, from this year to 2022, the increase in population and the price of land are two crucial factors that cause a decrease in vegetation and green space and an increase in urban use. Vegetation in 2002 had fewer changes compared to 2000 and more changes compared to 1998, 1996 and previous years. Urban growth and urban development, including road construction, have been one of the factors in reducing green space compared to previous years. 2004 has had many changes compared to 2002. These changes have happened both in the northern and foothill areas and in the central and southern areas, and we have witnessed a decrease in the percentage of vegetation and green space. In 2004 and previous years, we saw a decrease in vegetation. Urbanization and urban development accelerated in 2008, and we saw an increase in the population growth

rate, road construction, and communication network development. These factors are more noticeable in the northern and eastern regions. Wetter has caused the reduction of green space and vegetation. 2010 compared to 2008 and previous years, we saw a decrease in vegetation. 2012 compared to 2010, we saw a decrease in vegetation and green space in all areas of Tehran. This decrease in vegetation cover has been more in the foothills-central, southern, and eastern regions.
The acceleration of urbanization and land development since 2014, i.e., 2014, 2016, 2018, and 2022, has been about ten years apart. In these years, the growth rate Urban population, migration from villages to Tehran city, development of amenities, Etc. in Tehran city have caused the development of urban lands. This land development has yet to consider vegetation and green space planning, which has caused a reduction in vegetation and green areas in the long term. Among the areas under development, we can mention the south of Tehran city in 2018. The creation of new towns and cities of Andisheh and the Chitgar region, including the lake and its construction, are examples of these cases.
Nevertheless, one of the most critical cases is land development. In the last ten years, we can refer to various government plans, including national housing, the national housing movement, Etc. Although such plans can be suitable for replacing the population, without considering spatial planning Green and vegetation have caused the decreasing trend of green areas and vegetation.

3.1.4. Vegetation index and green space

One of the influential components in the investigation of vegetation density is the use of vegetation indices, which have been introduced so far. However, one of the most famous indices is NDVI, obtained using Landsat satellite images in this research. NDVI is one of the most famous, simplest, and most valuable indicators known in vegetation studies; it has a simple calculation process and the best dynamic power compared to other indicators. This index is more sensitive to vegetation changes and less sensitive to atmospheric and soil effects, except in low vegetation. The NDVI index is calculated from the following equation:

$$\text{NDVI} = \frac{NIR-RED}{NIR+RED}$$

According to Figure (4), Tehran city's vegetation and green space zoning maps from 1984 to 1998 have been obtained using Landsat satellite images and the NDVI vegetation index.
Table (2) also shows Tehran's minimum, maximum, and average vegetation and green spaces from 1984 to 1988.

Table 2, Statistical characteristics of the vegetation index in the studied years (1994-1998)

year	min	max	average
1984	-0.986111	0.457143	-0.185496
1987	-0.534137	0.261538	-0.062188
1990	-0.258427	0.168831	-0.066498
1992	-0.954023	0.964912	-0.104852
1994	-0.241830	0.134328	-0.109042
1996	-1.000000	0.140845	-0.103234
1998	-0.328244	0.147541	-0.100571

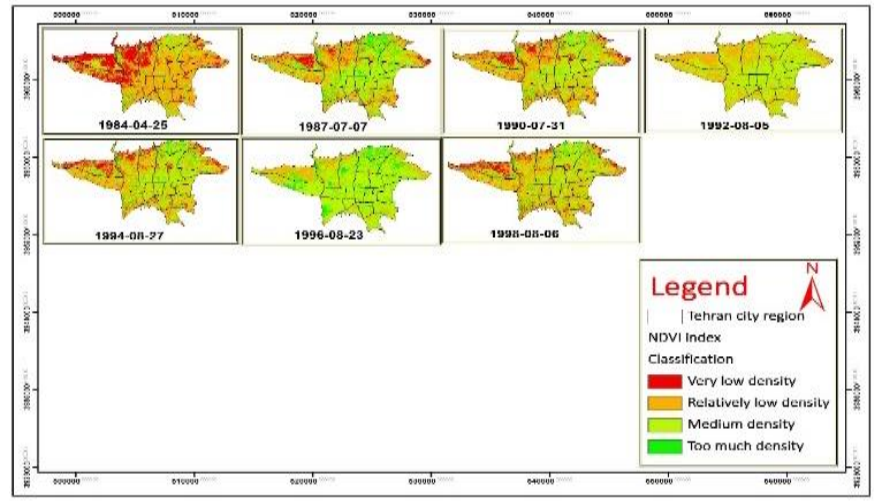


Figure 4, Map of NDVI index in the studied years (1994-1998)

According to figure (4) and table (2), it was concluded that the trend of vegetation and green space in Tehran city in the studied years (1984-1998) was a declining trend.

3.1.4.2. Green space utilization analysis of Tehran city using NDVI index from the year (2000-2022)
According to Figure (5), Tehran city's vegetation and green space zoning maps from 2000 to 2022 have been obtained using Landsat satellite images and the NDVI vegetation index.

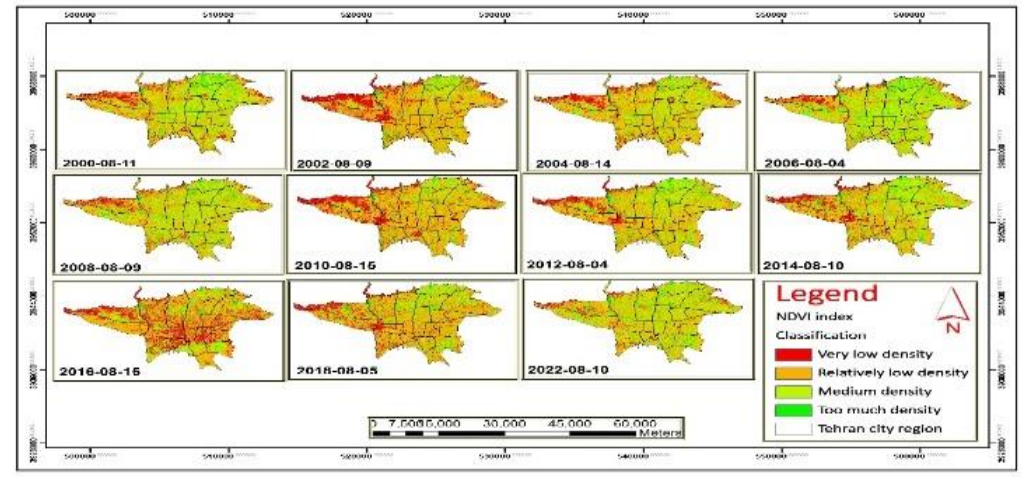


Figure 5, Map of NDVI index in the studied years (2000-2022)

Table (3) also shows Tehran's minimum, maximum, and average vegetation and green spaces from 2000 to 2022.

Table 3, Statistical characteristics of the vegetation index in the studied years (2000-2022)

year	min	max	average
2000	-0.222798	0.080460	-0.106403
2002	-0.591054	0.456311	-0.257536
2004	-0.320463	0.229167	-0.075519
2006	-0.287582	0.148325	-0.074552
2008	-0.362069	0.177914	-0.076653
2010	-0.564576	0.354839	-0.255000
2012	-0.540785	0.443609	-0.050618
2014	-0.430986	0.486486	-0.048782
2016	-0.570850	0.962264	0.038093
2018	-0.480519	0.437500	-0.060799
2022	-0.347280	0.195122	0.040224

According to figure (5) and table (3), it was concluded that the trend of vegetation and green space in Tehran city in the studied years (2000-2022) was a declining trend.

3.2. Zoning of air pollutants in Tehran:

In order to prepare air pollutant zoning maps of Tehran city from 2011 to 2021, the average of pollutants was considered, and geographic information systems (GIS) and IDW zoning method were used for spatial modelling, and the maps The primary pollutants of Tehran city have been prepared separately. Figure (6) The average zoning map of the primary air pollutants of the city of Tehran has been drawn in different pollutant measuring stations, which can be seen. In this figure, the primary pollutants (CO-SO2-NO2-O3-PM10-PM2.5) in 10 years (from 2011 to 2021) have been considered for preparing a zoning map. Figure (6) zoning map The primary air pollutants and air quality of Tehran city in the studied years are drawn as you can see

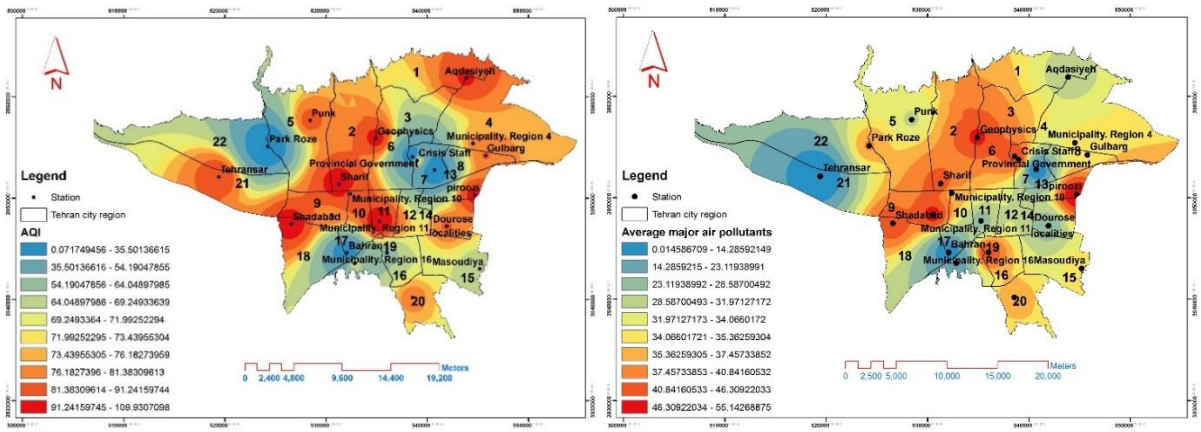


Figure 6, Map of primary air pollutants (left) and air quality index of Tehran (right)

According to Figure (6), the concentration of pollutants in most areas of Tehran is increasing, and the air quality in Tehran is also unsuitable for most age groups. In the following figures, the zoning map of air pollutants in Tehran is drawn, which can be seen.

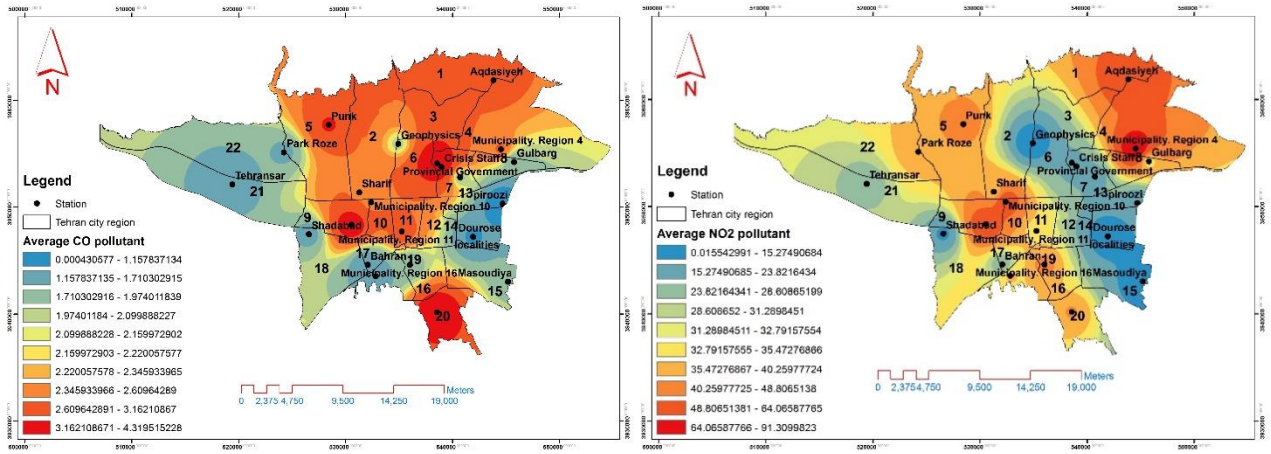


Figure 7, Map of pollutant zoning of carbon monoxide (right side) and nitrogen dioxide (left side)

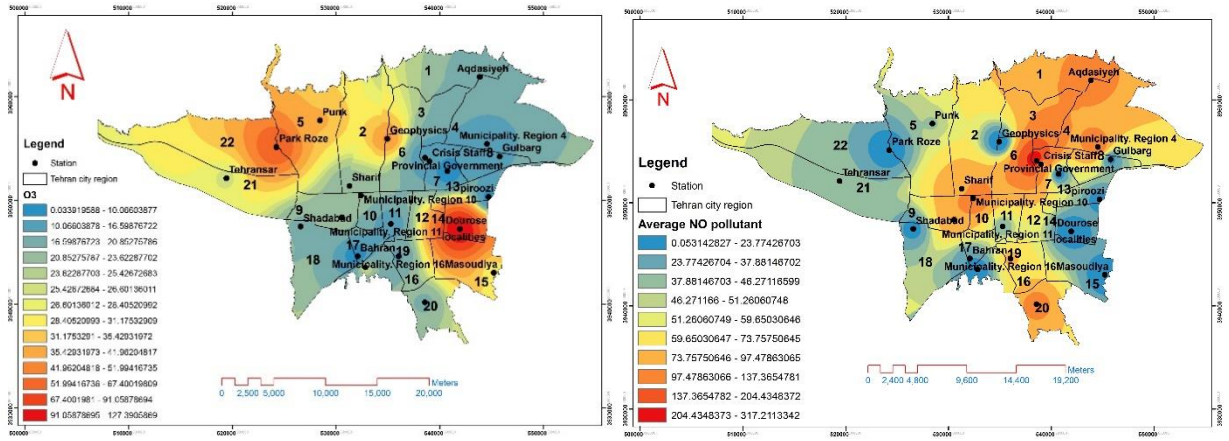


Figure 8, Zoning map of ozone pollutants (right side) and sulfur dioxide (left side)

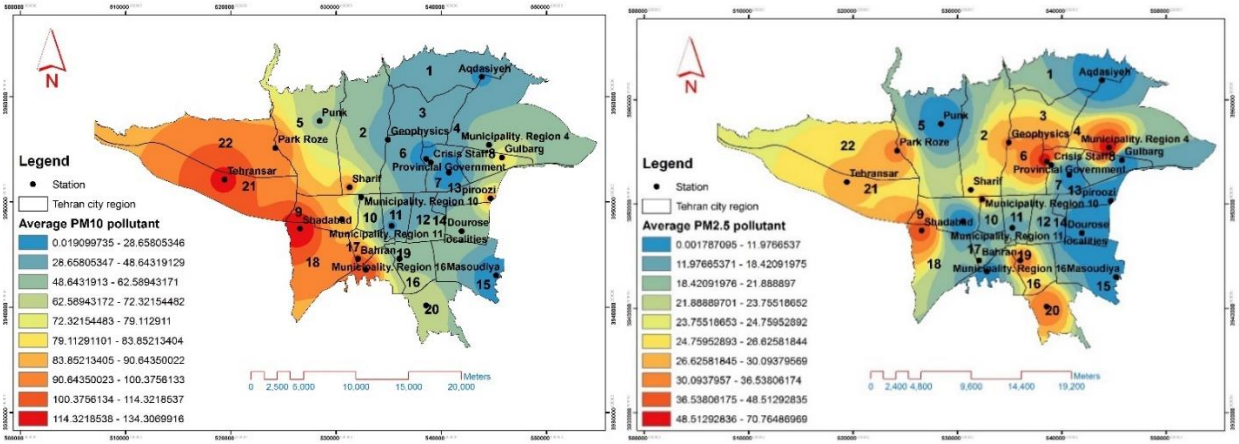


Figure 9, Pollutant zoning map of 10-micron suspended particles (right side) and 2.5-micron suspended particles (left side)

According to the zoning maps, the density of the primary air pollutants, including (CO-SO2-NO2-O3-PM10-PM2.5) has been an increasing trend in most areas of Tehran.

3.2.1. The relationship between air pollutants and green spaces

As one of the essential elements in urban planning and management, green space has significant effects in controlling and improving the air in cities. Therefore, green space will effectively improve the comfort level of citizens and, ultimately, the stability of the urban environment by reducing the temperature and increasing humidity and reducing the heat island phenomenon and the runoff. Urban green space is one of the social infrastructures, and one of its benefits is reducing air

pollution and eliminating the adverse effects of pollution. One of the most valuable functions of green spaces in cities is their environmental functions in reducing urban air pollution, making green spaces the breathing lungs of cities. In terms of reducing environmental pollution, green belts as a mass. A very resistant tree plant is suitable for reducing air pollution by filtering, preventing, and absorbing air pollutants.
Furthermore, it is well proven that plants remove air pollution, such as hydrogen fluoride, sulfur dioxide, and some photochemical reaction compounds and heavy metals, such as mercury and lead, in the air. Unfortunately, the city of Tehran is not an exception to this rule, and over the years, we have seen a reduction in vegetation and green space and an increase in urban land instead. According to the form of Tehran city, which is surrounded by mountains, the reduction of green space and the increase of urban land will increase the concentration of air pollutants in the city. Diagram (5) shows the changes in Tehran city's vegetation and green space in the years under study. According to this diagram, the percentage of vegetation cover in Tehran in different years under study has been decreasing trend.

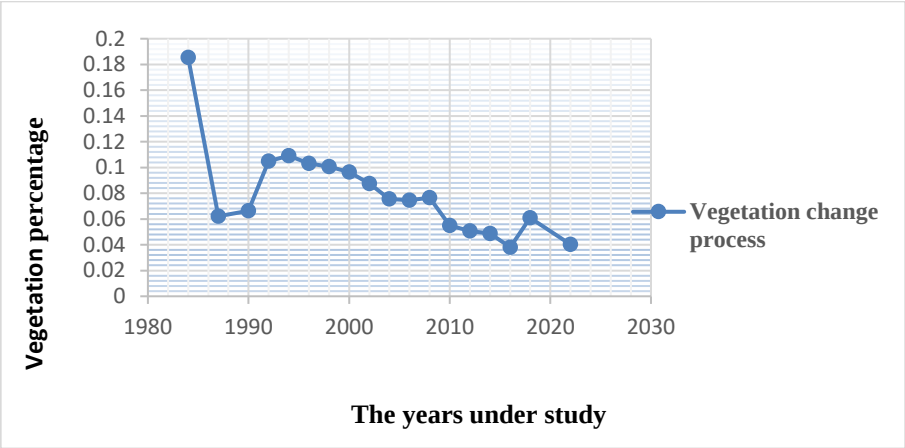


Diagram 5, The trend of vegetation and green space changes in Tehran in the years under study

Graph (6) shows the amount and percentage of changes in the main air pollutants of Tehran city in the studied years. According to this graph, the percentage of changes in Tehran's pollutants in different years and under study has been an increasing trend.

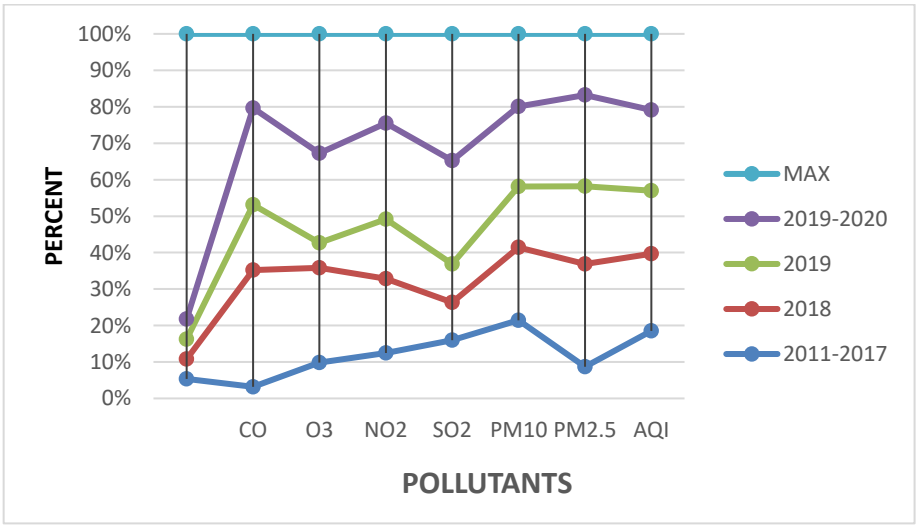


Chart 6, The amount and percentage of changes in the main air pollutants of Tehran city in the studied years

According to graphs (5) and (6), it can be concluded that the relationship between the changes in air pollutants in Tehran and the reduction of vegetation has been an upward (increasing) and downward (decreasing) process, respectively. That is, over the years. The higher the number of air pollutants in Tehran, the lower the percentage and amount of vegetation cover.

4. CONCLUSIONS

This research aims to Investigate the changes in air pollutants in Tehran and the trend of changes in the land use of green spaces in the last 40 years (1984-2022) in this city. For this purpose, using Landsat satellite images and their sensors, including Landsat 5 and "TM" sensors, Landsat 7 and "ETM" sensors, and Landsat 8 and "TIRS" sensors, were used.
Also, using the NDVI vegetation index, the trend of green space and vegetation changes in the studied years and 22 districts of Tehran was obtained. Also, the trend of changes in the primary air pollutants, including pollutants (CO-SO2-

NO2-O3-PM10-PM2.5) and the air quality of Tehran city, was obtained using GIS and IDW zoning methods. Finally, the change maps of Green space and vegetation and air pollutants of Tehran city were obtained in the studied years. Also, this study used ARC Gis 10.9 software to prepare the output, and IMAGIN ERDAS, Envi5.2, and IDRISI software to perform processing, analysis, and analysis. The analysis of Landsat images and, finally, the preparation of green space maps were used.

The research results showed that according to the graphs and zoning maps of the density of the primary pollutants in most areas of Tehran, the increasing trend and the air quality of Tehran (AQI) are also inappropriate for most areas and age groups. Also, PM2.5 and PM10 have increased more than other pollutants over ten years. Also, using satellite images, the zoning maps of Tehran's vegetation and green spaces from 1984 to 1998 and 2000 to 2022. Landsat and NDVI vegetation index have been obtained, and it was concluded that the trend of vegetation and green space in Tehran in the studied years (2000-2022) and (1994-1998) was decreasing. According to the findings and results of the research, it is evident that the trend of pollutant changes and air quality in Tehran is increasing and inappropriate. In addition to various factors influencing this trend, reducing vegetation and green space is an influential environmental variable.

Moreover, it requires detailed planning in this field. It can also be concluded that there is an inverse relationship between the trend of changes in air pollutants in the city of Tehran and the decrease in vegetation cover, so there is an upward (increasing) and downward (decrease) process between the changes in the air pollutants in the city of Tehran and the decrease in vegetation cover, respectively.) can be considered. During different years, the higher the number of air pollutants in Tehran, the lower the percentage and amount of vegetation cover.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the valuable comments and suggestions of the reviewers, which have improved the quality of this paper. This article was done in cooperation with Iran Meteorological Organization, and we are very grateful to this organization for providing the data.

REFERENCES

1. Aix, M. L., Petit, P. and Bicout, D. J., 2022. Air pollution and health impacts during the COVID-19 lockdowns in Grenoble, France. Environmental Pollution, 303, 119134. DOI: 10.1016/j.envpol.2022.119134.
2. Boostani, P., and Sadeghiha, M., 2022. Identification of critical uncertainties in Tehran in order to achieve the development of low carbon city by using scenario writing method. Cleaner Engineering and Technology, 6, 100405. https://doi.org/10.1016/j.clet.2022.100405.
3. Cai, W. J., Wang, H. W., Wu, C. L., Lu, K. F., Peng, Z. R. and He, H. D., 2021. Characterizing the interruption-recovery patterns of urban air pollution under the COVID-19 lockdown in China. Building and environment, 205, 108231. DOI: 10.1016/j.buildenv.2021.108231.
4. Gharagozlou, A., Tayeba, A., Dadashi, M. and Abdolahi, H., 2014. Zoning of CO emissions in Tehran in the medium term by using third quartile as the exposure candidate. Journal of Geographic Information System, 6(05), 526. DOI: 10.4236/jgis.2014.65043.
5. Gulia, S., Shukla, N., Padhi, L., Bosu, P., Goyal, S. K. & Kumar, R., 2022. Evolution of air pollution management policies and related research in India. Environmental Challenges, 6, 100431. DOI: 10.1016/j.envc.2021.100431.
6. Hashemi, F., Hoepner, L., Hamidinejad, F. S., Abbasi, A., Afrashteh, S. and Hoseini, M., 2022. A survey on the correlation between PM2. 5 concentration and the incidence of suspected and positive cases of COVID-19 referred to medical centers: A case study of Tehran. Chemosphere, 301, 134650. DOI: 10.1016/j.chemosphere.2022.134650.
7. Keikhosravi, G. and Fadavi, S. F., 2021. Impact of the inversion and air pollution on the number of patients with Covid-19 in the metropolitan city of Tehran. Urban Climate, 37, 100867. DOI: 10.1016/j.uclim.2021.100867.
8. Li, V. O., Han, Y., Lam, J. C., Zhu, Y. and Bacon-Shone, J., 2018. Air pollution and environmental injustice: Are the socially deprived exposed to more PM2. 5 pollution in Hong Kong?. Environmental science & policy, 80, 53-61. DOI: 10.1016/j.envsci.2017.10.014.
9. Mathys, T., de Souza, F. T., da Silveira Barcellos, D. and Molderez, I., 2023. The relationship among air pollution, meteorological factors and COVID-19 in the Brussels Capital Region. Science of The Total Environment, 857, 158933. DOI: 10.1016/j.scitotenv.2022.158933.
10. Motlagh, S. H. B., Hosseini, S. A. and Pons-Valladares, O., 2023. Integrated value model for sustainability assessment of residential solar energy systems towards minimizing urban air pollution in Tehran. Solar Energy, 249, 40-66. DOI: 10.1016/j.solener.2022.10.047.
11. Mir, K. A., Purohit, P., Cail, S. and Kim, S., 2022. Co-benefits of air pollution control and climate change mitigation strategies in Pakistan. Environmental Science & Policy, 133, 31-43. DOI: 10.1016/j.envsci.2022.03.008.
12. Namdar-Khojasteh, D., Yeghaneh, B., Maher, A., Namdar-Khojasteh, F. and Tu, J., 2022. Assessment of the relationship between exposure to air pollutants and COVID-19 pandemic in Tehran city, Iran. Atmospheric Pollution Research, 13(7), 101474. DOI: 10.1016/j.apr.2022.101474.
13. Querol, X., Massagué, J., Alastuey, A., Moreno, T., Gangoiti, G., Mantilla, E., Dueguez, J., Escudero, M., Monfort, E., Garcia-Pando, C.P., Petetin, H., Jorba, O., Vazquez, V., Rosa, J., Campos, A., Munoz, M., Monge, S., Hervas, M., Javato, Rebeca, j. and Cornide, M. J., 2021. Lessons from the COVID-19 air pollution decrease in Spain: now what?. Science of The Total Environment, 779, 146380. DOI: 10.1016/j.scitotenv.2021.146380.
14. Shahrokhishahraki, N., Rayner, P. J., Silver, J. D., Thomas, S. and Schofield, R., 2022. High-resolution modeling of gaseous air pollutants over Tehran and validation with surface and satellite data. Atmospheric Environment, 270,

118881. https://doi.org/10.1016/j.atmosenv.2021.118881.
15. Shi, W., Sun, C., Chen, Q., Ye, M., Niu, J., Meng, Z., Bukulmez, O., Chen, M. and Teng, X., 2021. Association between ambient air pollution and pregnancy outcomes in patients undergoing in vitro fertilization in Shanghai, China: A retrospective cohort study. Environment international, 148, 106377. doi: 10.1016/j.envint.2021.106377.
16. Tan-Soo, J. S., Finkelstein, E., Pattanayak, S., Qin, P., Zhang, X. and Jeuland, M., 2022. Air quality valuation using online surveys in three Asian megacities. Resources, Environment and Sustainability, 10, 100090. https://doi.org/10.1016/j.resenv.2022.100090.
17. Wu, B., Liu, C., Zhang, J., Du, J. and Shi, K., 2021. The multifractal evaluation of PM2. 5-O3 coordinated control capability in China. Ecological Indicators, 129, 107877. DOI: 10.1016/j.ecolind.2021.107877.