The role of green areas in reducing air pollution in Karbala

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Abstract:

Most Iraqi cities suffer from increasing rates of air pollution and a lack of green areas, which is one of the most important ways to reduce air pollutants and raise air quality. This study represented an analysis of the relationship between the Spatial distribution of green areas on the one hand and the locations of concentration of various types of air pollutants on the other hand.

Because green areas in the city are of multiple types, each type has varying capabilities to reduce air pollutants. The researcher drew and identified each of these types and determined its percentage of the total area of green urban infrastructure in the city.

Air pollutant distribution maps were drawn based on geographic information system programs and remote sensing techniques. The locations and concentrations of air pollutants were determined based on images from the Sentinel-5 satellite and through the Google Earth Engine platform. Accordingly.

the researcher arrived at a set of information regarding the concentration locations of various air pollutants and the areas that must be enhanced with green areas to raise air quality. The researcher also concluded that the total area of green urban infrastructure in the study area has reached 31.64 km2 in 2023, as it needs to be strengthened and distributed according to reality requirements to reduce air

pollution, as well as the importance of remote sensing techniques in monitoring air pollution and its sources.

Keywords: Green areas; Air Pollution; Sentinel-5; Karbala city; Google Earth Engine.

دور المناطق الخضراء في الحد من التلوث الجوي في مدينة كربلاء

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المستخلص:

تعاني معظم المدن العراقية من تزايد معدلات تلوث الهواء وقلة المناطق الخضراء التي تُعدُّ من اهم طرق الحدِّ من الملوثات الجوية ورفع جودة الهواء، مثلت هذه الدراسة تحليلا للعلاقة بين التوزيع المكاني للمناطق الخضراء من جهة وأماكن تركز الملوثات الجوية بمختلف أنواعها من جهة أخرى، ولكون المناطق الخضراء في المدينة تكون بأصناف متعدِّدة وان لكل صنف منها قدرات متفاوتة في الحد من الملوثات الجوية، فقد قام الباحث برسم وتحديد كل صنف من هذه الأصناف وتحديد نسبته من المساحة الكلية للمناطق الخضراء في المدينة (البنية التحتية الحضرية الخضراء)، تم رسم خرائط توزيع الملوثات الجوية بالاعتماد على برامج نظم المعلمات الجغرافية وتقنيات الاستشعار عن بعد، حيث تم تحديد أماكن تواجد الملوثات الجوية وتركزها بالاعتماد على مرئيات سانتنيل-5 ومن خلال منصة Google Earth Engine ، و عليه توصل الباحث الى مجموعة من المعلومات التي تخص أماكن تركز الملوثات الجوية المختلفة والمناطق التي يجب تعزيزها بالمناطق الخضراء لرفع جودة الهواء، كما استنتج الباحث أن المساحة الاجمالية للبنية التحتية الحضرية الخضراء في منطقة الدراسة قد بلغت 31.64 كم2 لعام 2023 إذ انها بحاجة الى تعزيز وتوزيع بحسب متطلبات الواقع للحد من التلوث الجوي فضلا عن أهمية تقنيات الاستشعار عن بعد في رصد التلوث الهوائي ومصادره.

الكلمات المفتاحية:

المناطق الخضراء، التلوث الجوي، سانتنيل-5، مدينة كربلاء، كوكل إيرث إنجن.

1. Introduction:

The problem of air pollution is in fact one of the most prominent challenges facing the environment and public health in most cities around the world, especially large cities, including the holy city of Karbala. Air pollution in Karbala is one of the environmental challenges that requires attention and rapid response due to its negative impact on the health of the city's residents and quality of life.

Sources of air pollution in Karbala release a variety of air pollutants, including automobile, industrial, and factory emissions as well as other emissions from a variety of sources. These pollutants include airborne particulate matter (PM), carbon emissions, and many other pollutants that negatively affect air quality and population health.

However, there is an important role that green areas can play in mitigating the effects of air pollution. Plants absorb carbon dioxide (CO_2) and secrete oxygen, which improves air quality and provides a healthier environment for residents.

Therefore, due to the importance of maintaining air quality and the health of Karbala's residents, investing in creating and maintaining green areas has become an urgent necessity. Trees and plants are also an integral part of sustainable solutions to confront the problem of air pollution and improve air quality in the city of Karbala. The researcher used the descriptive method and digital analysis by describing the reality of green areas studying their distribution in geographic information systems and using remote sensing techniques to determine the distribution of air pollutants.

2. Air Pollution:

Environmental pollution is one of the most important environmental issues and includes air, water, and solid waste pollution, in addition to the loss of biological

diversity. Environmental pollution affects all living organisms, humans, animals, and plants. The most prominent causes of environmental pollution are urbanization, population growth, transportation, industries, encroachment on green areas, and deforestation. Environmental pollution leads to undesirable environmental changes (Gamage et al., 2022, p. 64). Environmental pollution can be defined as a group of factors that occur naturally or through human intervention and in which people live and affect their activity, production, and health (Kareem Hassan Alwan & Bachai, 2023, p. 3). About 40% of the world's deaths were due to water, air, and soil pollution, in addition to overcrowding. Also, 91% of the world's population is exposed to unhealthy levels of pollution (Quader, 2022, p. 66).

According to the website (Our World in Data[1]), which many researchers cite in their scientific research, such as :(Wohllebe, 2019) and (Roghani et al., 2021), Deaths due to air pollution reached 6.67 million in 2019, as shown in Figure 1, is the third most fatal risk in the world.

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[1](Our World in Data) website is a website whose mission is to publish research and data to make progress in confronting the world's biggest problems.
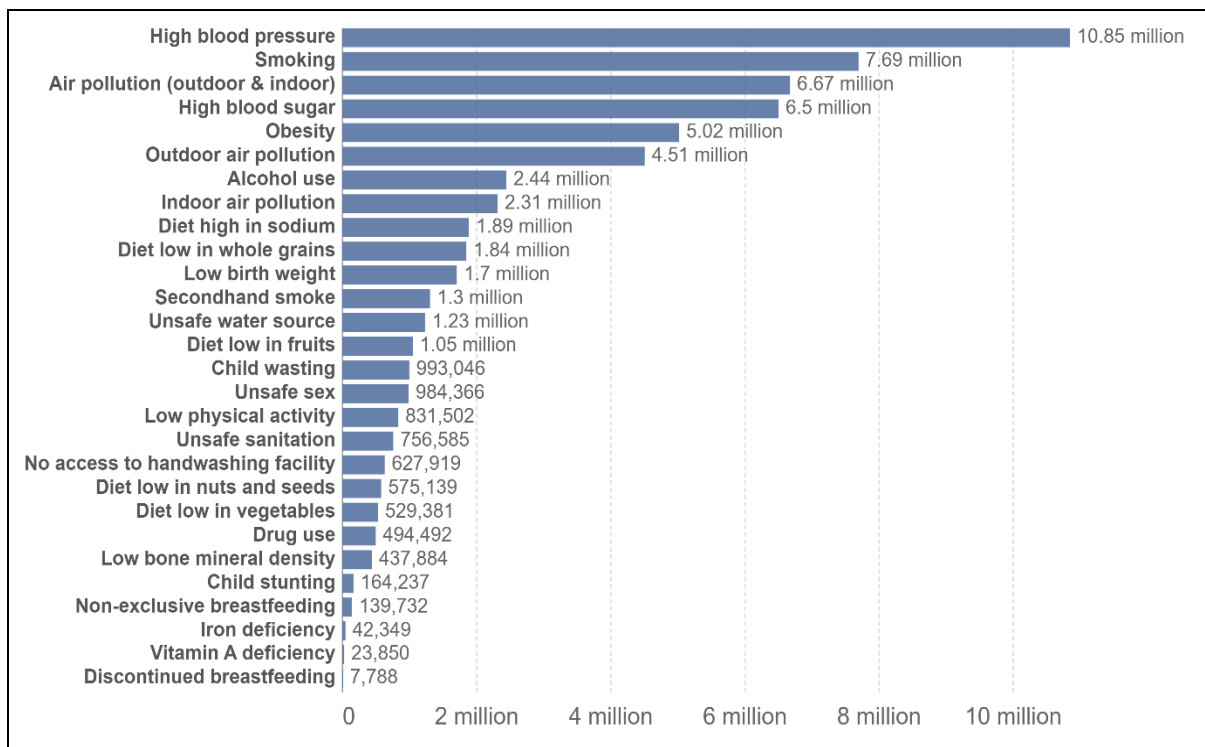
Figure 1: Number of deaths in the world according to risk factors for the year 2019

(Source: https://ourworldindata.org)

Map 1 shows the death rate resulting from air pollution in the continent of Asia, calculated as the number of deaths per 100,000 people in one country. Air pollution is greater in low-income countries for two reasons. The first is that indoor pollution rates are high due to reliance on solid fuels for cooking, and air pollution increases as countries become industrialized.
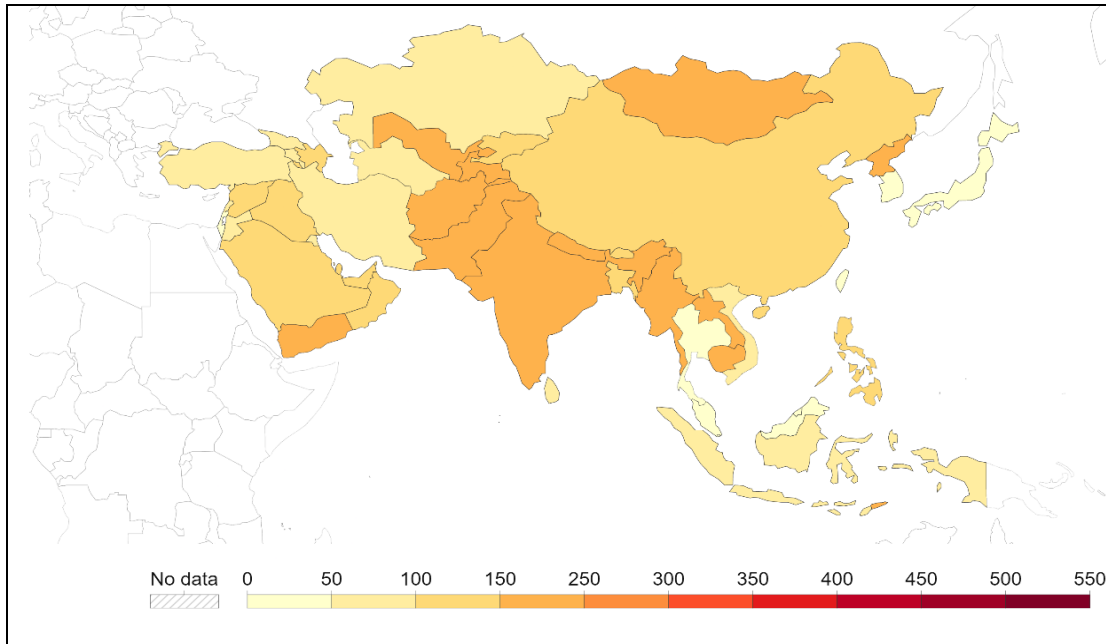
Map 1 Estimated annual number of deaths attributed to air pollution per 100,000 people in Asia for the year 2019

(Source: https://ourworldindata.org)

Air pollution is the most dangerous type of environmental pollution and the most common cause of death. Figure 2 shows the causes of death by type of pollution in the world. Air pollution was the largest cause of death and led to 7 million deaths, that is, more than three-quarters of the total deaths due to pollution, which amounted to 9.19 million deaths, followed by water pollution, causing 1.8 million deaths, then land pollution, causing 390,000 deaths.
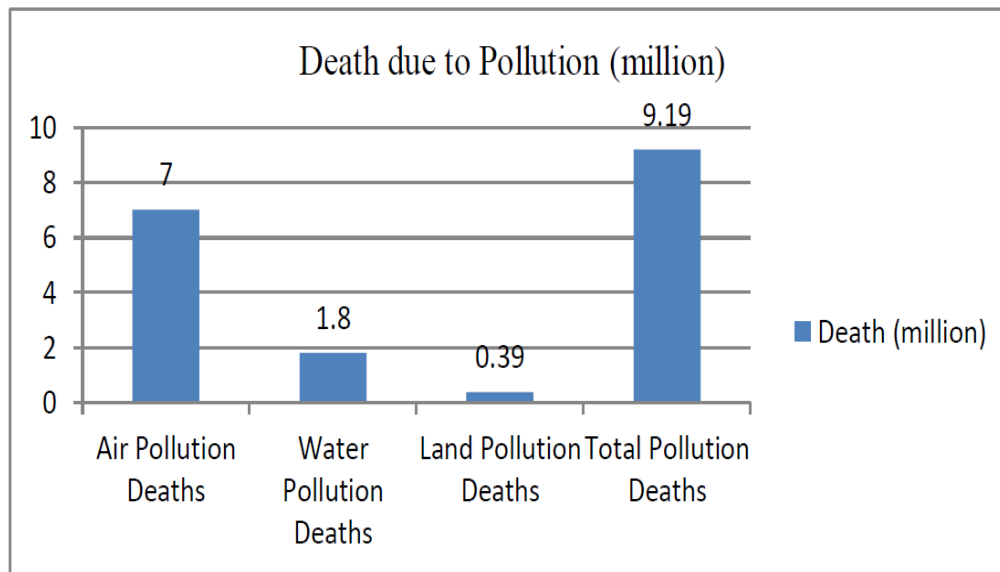
Figure 2: Deaths due to pollution in millions
(Source:(Quader, 2022, p. 68))

3. study area:

It includes the location, green urban infrastructure, the most prominent sources of air pollution, the distribution of air pollutants, and its relationship to the distribution of green areas.

3.1. Location:

The location of Karbala Governorate is between latitudes (31° 33') and (33° 39') north, and longitudes (43° 57') and (44° 4') east. It is in central Iraq and is bordered by Babil Governorate to the east and northeast, Anbar Governorate to the west and northwest, and Najaf Governorate to the south. The study area (the city of Karbala) is the center of the governorate, as in map 2. The area is characterized by high temperatures that may reach 50 degrees Celsius in the summer, while in the winter the temperatures sometimes drop below zero degrees Celsius (Maarez et al., 2021, pp. 1–2).
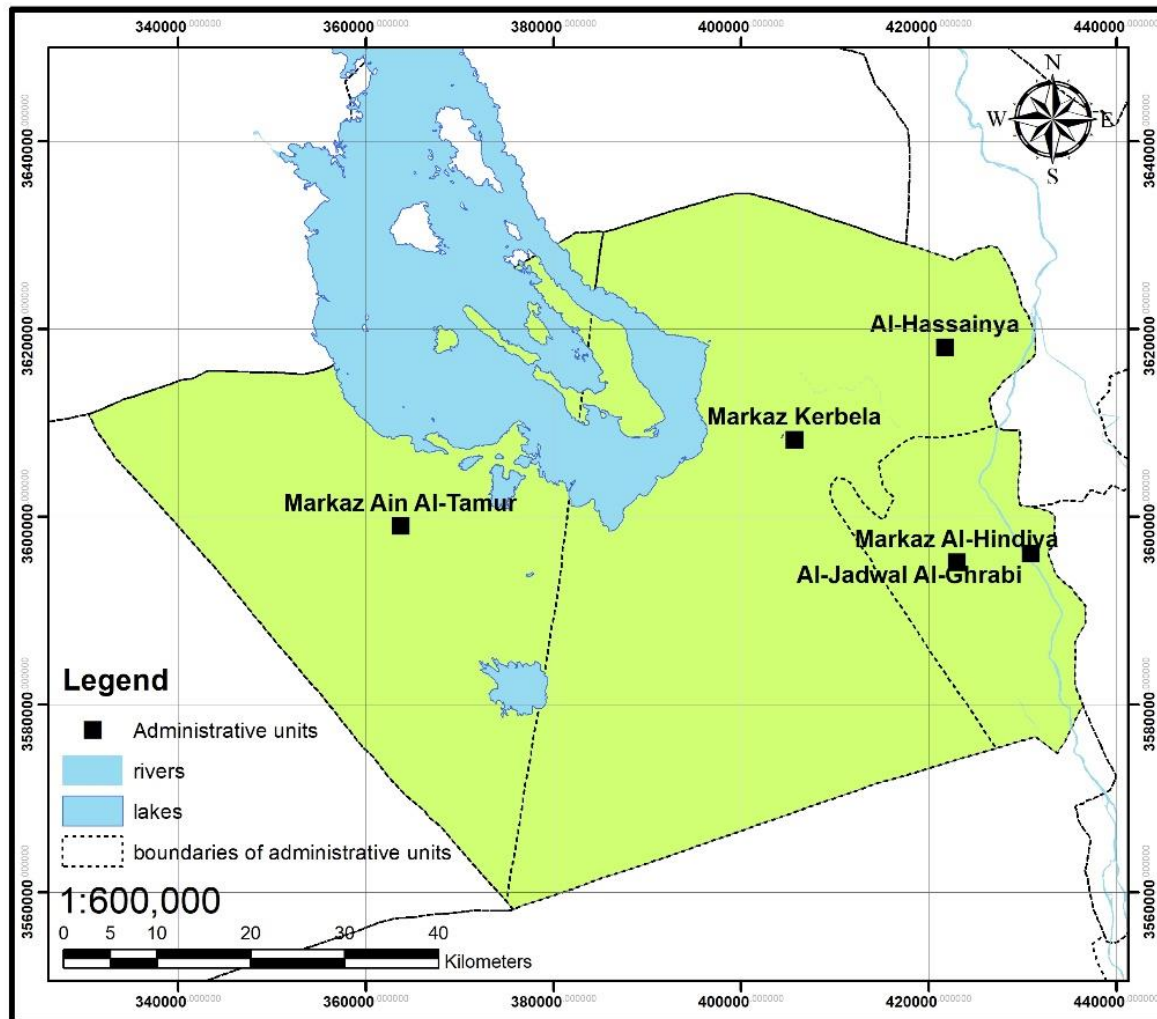
Map 2: Karbala city location

Source: Researchers based on (Kareem Hasan Alwan et al., 2021, p. 2) and GIS

3.2. Green areas:

The environmental quality of cities is closely and directly related to the amount of green spaces available in them, as they are necessary and important (Eduarda Irgang dos Santos et al., 2022, p. 2).

The successful management of land and its uses, including green areas, contributes to achieving the well-being of society in addition to solving problems such as air pollution, as this management must have wisdom and intelligent knowledge at various levels (Kareem Hassan Alwan & Omran, 2023, p. 4). This is

achieved by analyzing the relationship between land uses and the phenomena that occur in the city, based on modern technologies that save time and are highly accurate.

Green areas regulate the local climate by providing shade, through evaporation processes, and acting as wind buffers. In addition to its work on regulating air quality through the dry deposition process and through carbon absorption, as well as regulating the acoustic environment by reducing noise and providing sounds that have positive effects on humans, such as the sounds of tree leaves and the sounds of birds .(Wang, 2016, p. 13).

It also moisturizes the air, regulates wind and solar radiation levels, acts as a germicide, and provides a positive emotional and psychological environment (Finaeva, 2017, p. 2). The presence of green areas in cities works to reduce air pollution, as they isolate carbon dioxide as well as other polluting gases and produce oxygen .(Nieuwenhuijsen, 2021, p. 5).

It is also worth noting that one of the most important goals of urban sustainability in the environmental field is to increase the provision of green spaces, protect biodiversity, reduce the emission of environmental pollutants, and try to limit them (Dhahir et al., 2023, p. 4).

Researcher (W. S. Alwan et al., 2021, p. 136) also emphasized that the expansion and increased planting of parks, gardens and trees in cities has an important role in purifying the air from pollutants stuck in it and thus improving the surrounding environment and raising its efficiency.

The area of urban green spaces and parks increased after 2003 in the city of Karbala (Salman, 2016, p. 260).

In order to improve the social and economic conditions after that date, the green urban infrastructure of the city of Karbala can be classified, as in Figure 3 which

shows snapshots of the reality of the green areas in the holy city of Karbala, in their various types and shapes, into:

1. Public green areas.
2. Street trees.
3. Green belts.
4. Farms and orchards.

In addition to the green areas among other uses of the land, the natural vegetation spread in some parts of the city.

Figure 3: Pictures showing the types of green areas of the holy city of Karbala
Source: Prepared by the researcher

The total area of green areas (green urban infrastructure) in the city of Karbala in the year 2023 is equal to 31.64 km2 as in Map 3, and the percentage of each type of green urban infrastructure in the city will be as shown in Table 1 .

Table 1: Percentage of each type of green urban infrastructure for the year 2023

	Types of green areas	Percentage of each type %
1	Public green areas	%1.78
2	Street trees	%1.76
3	Green belts	%6.75
4	Farms and orchards	%85.80
5	Other green areas and natural vegetation	%3.92
	Total	%100

Source: Researcher based on geographic information systems

Map 3: Green Urban Infrastructure in Karbala City
Source: Researchers by GIS
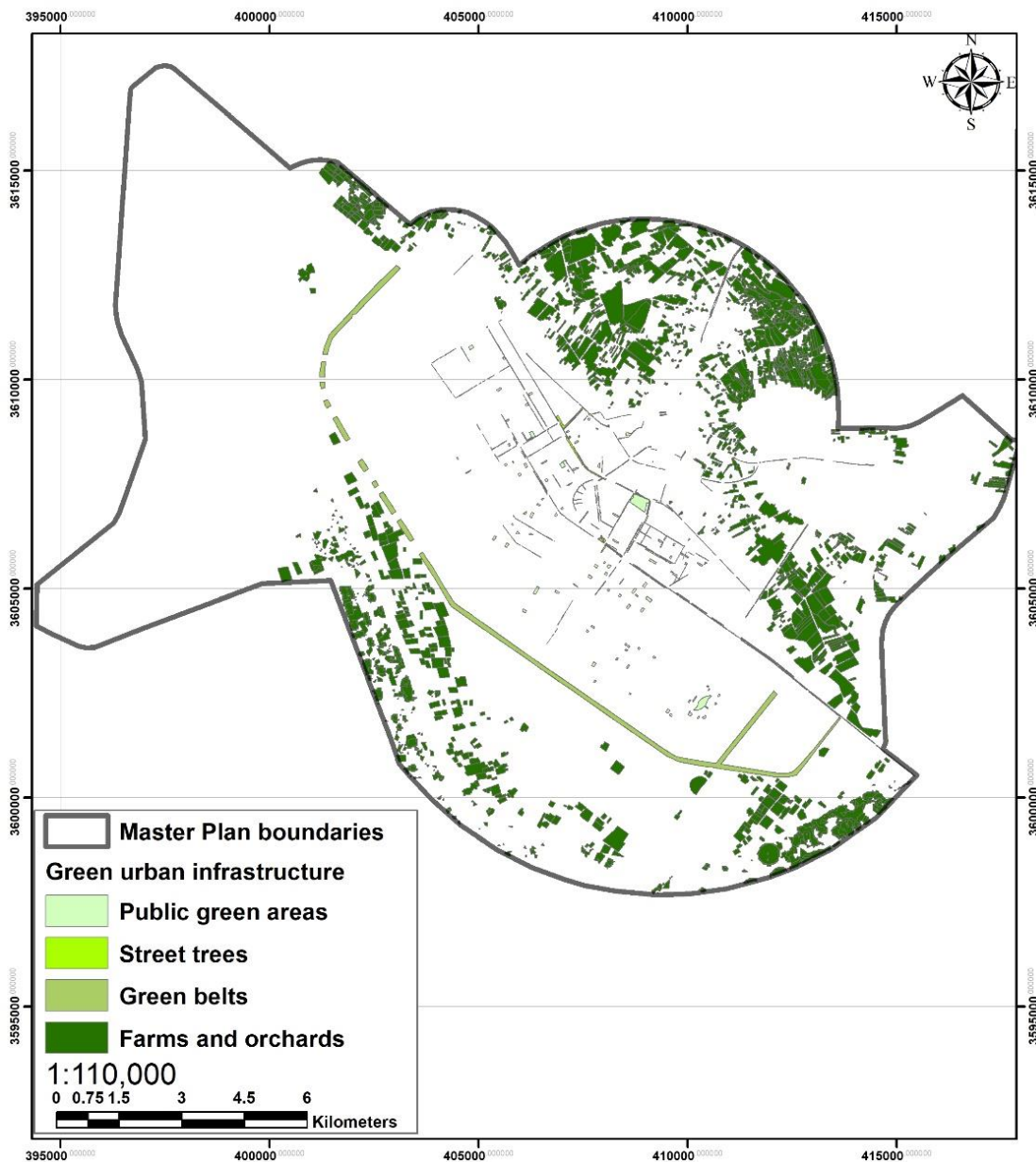
3.3. Sources of air pollution:

Air pollution rates for all gases in the city of Karbala increase in the summer and decrease in the winter, as a practical study proved that the presence of total suspended particles in the air of the city of Karbala was higher than the permissible limit, especially in the months of April and May, and carbon dioxide

gases are concentrated in the northern part of the city. Concentrations of toxic nitrogen dioxide gas, as well as sulfur dioxide gas, exceed the internationally permissible limit in the city, as well as hydrogen sulfide gas, whose values in the city of Karbala exceeded the internationally accepted limit (Al-Anbari et al., 2018, p. 5).

The most prominent causes of air pollution in the city of Karbala can be classified according to (International Center for Technical Research, 2007, pp. 3–8):

1. Gases produced by the combustion of vehicle fuel and electrical generators.
2. Hydrocarbon is produced from dye, chemical, dairy, and textile factories located in the city, in addition to car repair workshops in the industrial district.
3. Dust that flies due to the movement of cars and winds in unpaved streets, sidewalks, and uncultivated areas.
4. The air is polluted due to the putrefaction of surface water that mixes with sewage water, as untreated sewage flows into many drainages in the city of Karbala.

One of the sources of air pollution in the study area is the presence of many sand and gravel quarries west of the city of Karbala and in the southwest. It is considered one of the largest quarries in Iraq, with an area of more than 56 km2, as shown in Map 3. They are used in construction work in buildings and various projects, as excessive excavation without adhering to the controls and specifications approved by the relevant government agencies leads to soil erosion and the scattering of dust and sand and their flight through the wind into the city. Causing environmental pollution to the city's air, as in Picture 1, which shows work in one of these sites (the Geologists Syndicate in the Holy Karbala Governorate).
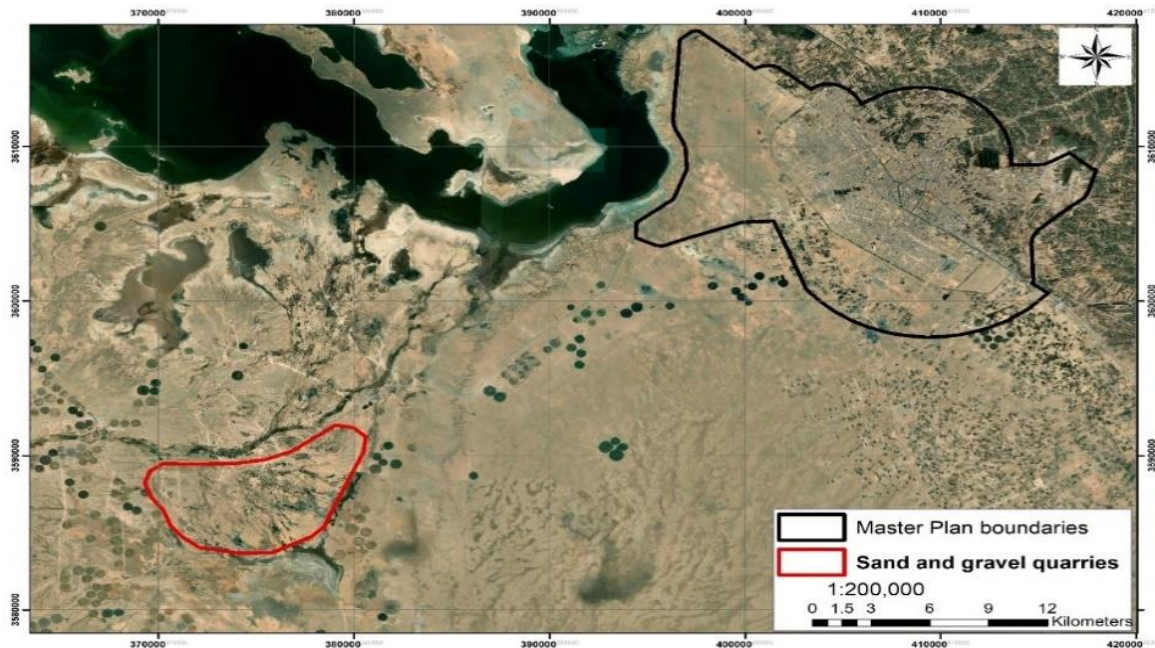
Map 3: location of sand and gravel quarries southwest of the city of Karbala
Source: Researchers by GIS

Picture 1: Working in one of the sand quarries west of the city of Karbala
Source: researcher

3.4.Distribution of air pollutants:

The air is polluted by the presence of substances in it that cause harm to human health and other living organisms or lead to climate damage. These harmful

substances in the atmosphere include gases, particles, and molecules such as carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone gas, and airborne particles (PM) (EROL et al., 2023, p. 575) .

Accordingly, maps will be prepared for the distribution of these pollutants in the air of the city of Karbala to analyze the relationship between them and the distribution of green areas within the city, based on:

1. Sentinel-5P satellite images: which is concerned with monitoring air quality, polluting gases, and climate. It has been shown that these visuals are an effective and valuable tool for monitoring air quality and determining the extent of exposure of certain areas to air pollution to various types of air pollutants (Hassaan et al., 2023, p. 1.).

2. Google Earth Engine platform: which is considered a geospatial analysis system and used by scientists in remote sensing research. It includes the Code Editor platform, which works with cloud technology that provides the ability to use and analyze spatial data, through the Application Programming Interface (API). Complex analysis operations can be performed and the results displayed and exported using the programming languages JavaScript or Python.

   It is one of the best analysis, processing, and interpretation tools and is used to classify and analyze Earth observation data with high efficiency and at a reasonable cost. This platform is invaluable when there is a need to process huge amounts of Earth observation data over vast areas and for long periods of time and at high speed, as the required data is available within the platform (Hasan et al., 2022, pp. 55–56.).

3. GIS software (Arc Map): to produce final maps of air-polluting gases and green urban infrastructure. Geographic information systems provide the

user with the possibility of spatial analysis and thus extract indicators that can be adopted by the decision-maker (Ebraheem et al., 2021, p. 6).

The work steps are summarized by entering the Code Editor platform within the Google Earth Engine platform and starting to write the appropriate programming code to obtain the required data after defining the study area, as in Figure 4, where the JavaScript programming language was used to write the required code to obtain data on polluted gases in the study area. Then export the extracted visuals and insert them into a geographic information systems program for the purpose of analyzing the relationship between the locations of pollutant gas concentrations and the distribution of green areas of various types.
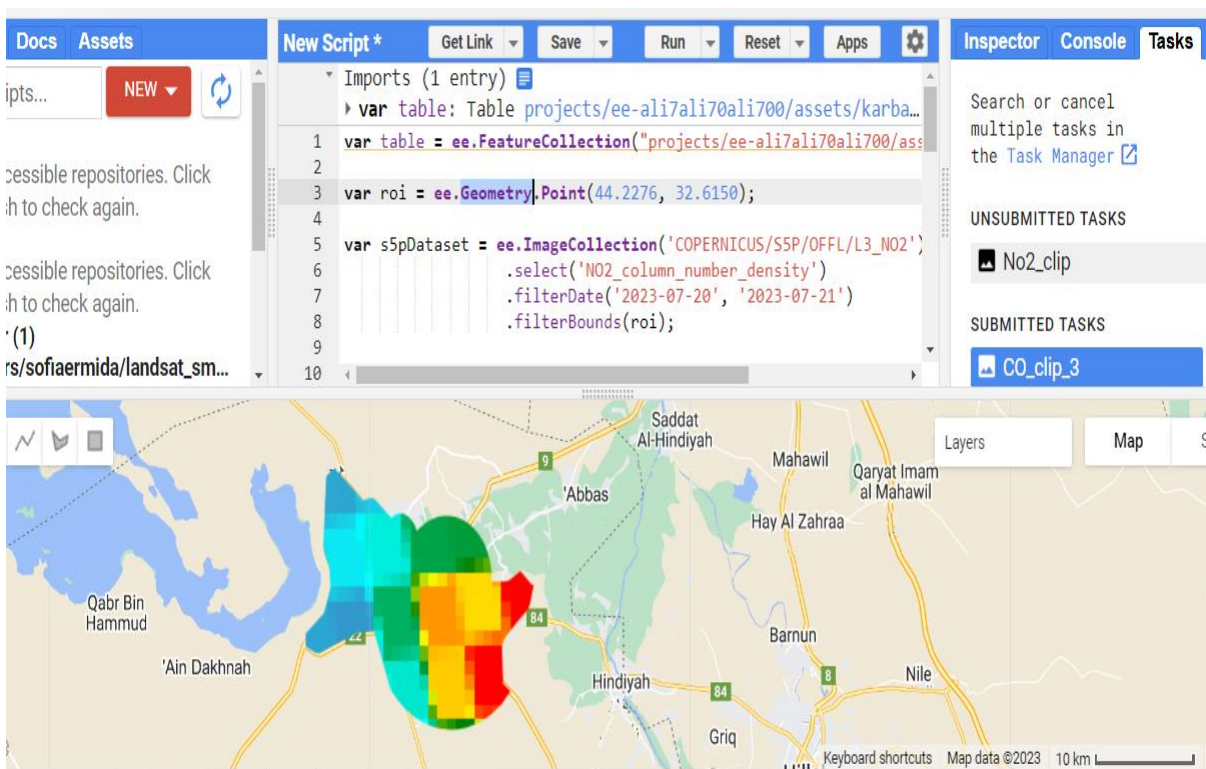

Figure 4: Code Editor platform
Source: Google Earth Engine platform

1) Carbon emissions:

Carbon emissions are considered one of the most dangerous gases polluting the air in cities, resulting from the combustion of fuel and the movement of cars,

factories, and gas-powered devices. Green areas and plants have the ability to absorb these emissions and reduce them. Map 4 shows the concentration of these emissions and the distribution of green areas.
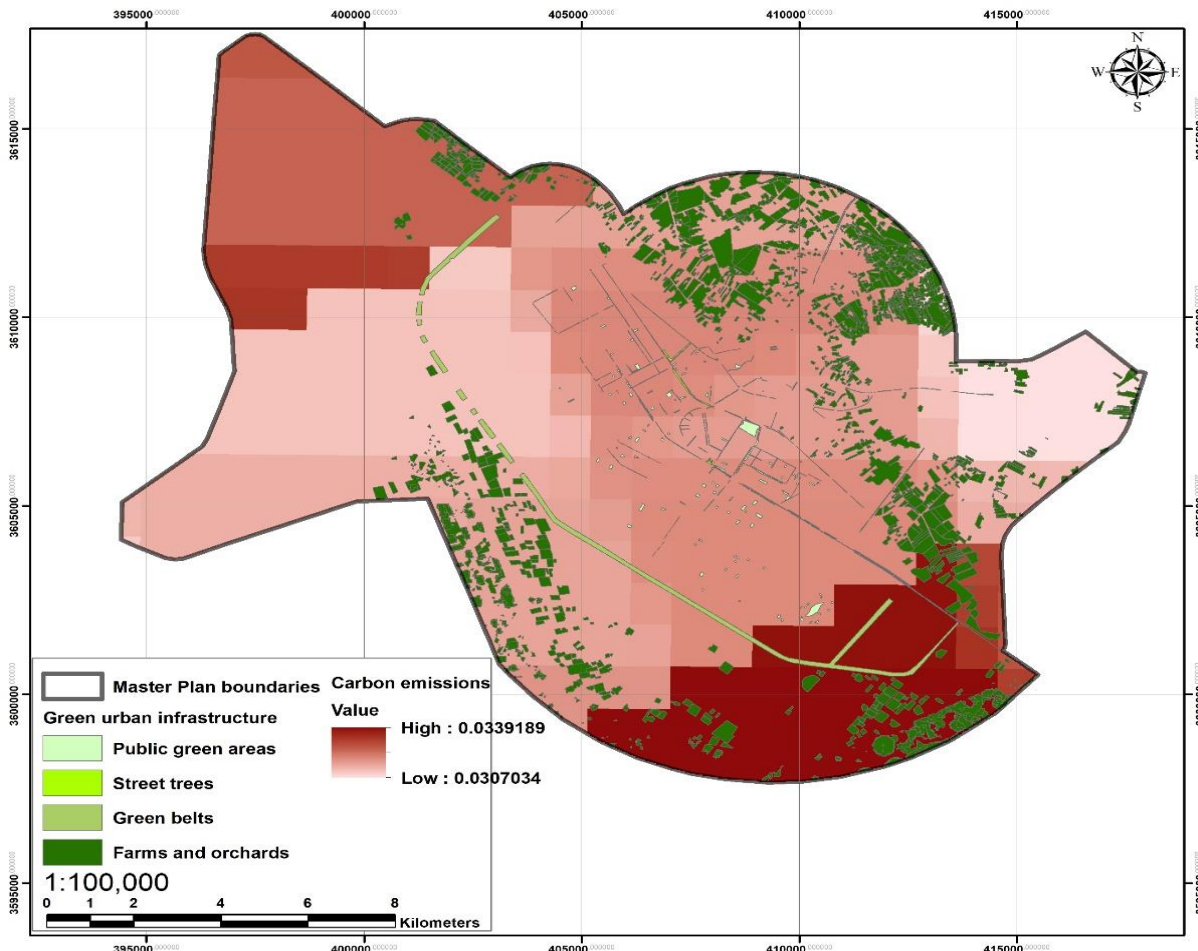
Map 4: Carbon emissions and green areas in the city of Karbala
Source: Researcher based on GIS

As it is evident that levels of carbon emissions are low in the central part of the city, with varying degrees of concentration, resulting from the natural movement of cars in the city and other sources of pollution, the presence of green areas in this part of the city has the ability to reduce levels of carbon emissions. The concentrations of this pollutant increased in the northwestern and southeastern

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parts of the city because the southeastern part contains the industrial district area, which is considered a source of many pollutants that are swept away by the prevailing northwestern winds in this direction, and therefore it needs to increase green areas to reduce carbon emissions. The northwestern part lacks green areas, despite the fact that it contains some polluting industries and despite the heavy traffic of transport trucks there.

2) Sulfur dioxide gas (So2):

It is one of the main air pollutants that results from the combustion process of materials that contain sulfur, such as fossil fuels, coal, and others. It contributes to the formation of acid rain and poses risks to human health when its concentrations rise. It is shown in Map 5 that the percentage of this gas is not high throughout the city, but its percentage is relatively high in two locations on the same map, the reason for this is the concentration of traffic (transport trucks in particular), in addition to the presence of some industries and electric power generators and the lack of vegetation in this area.
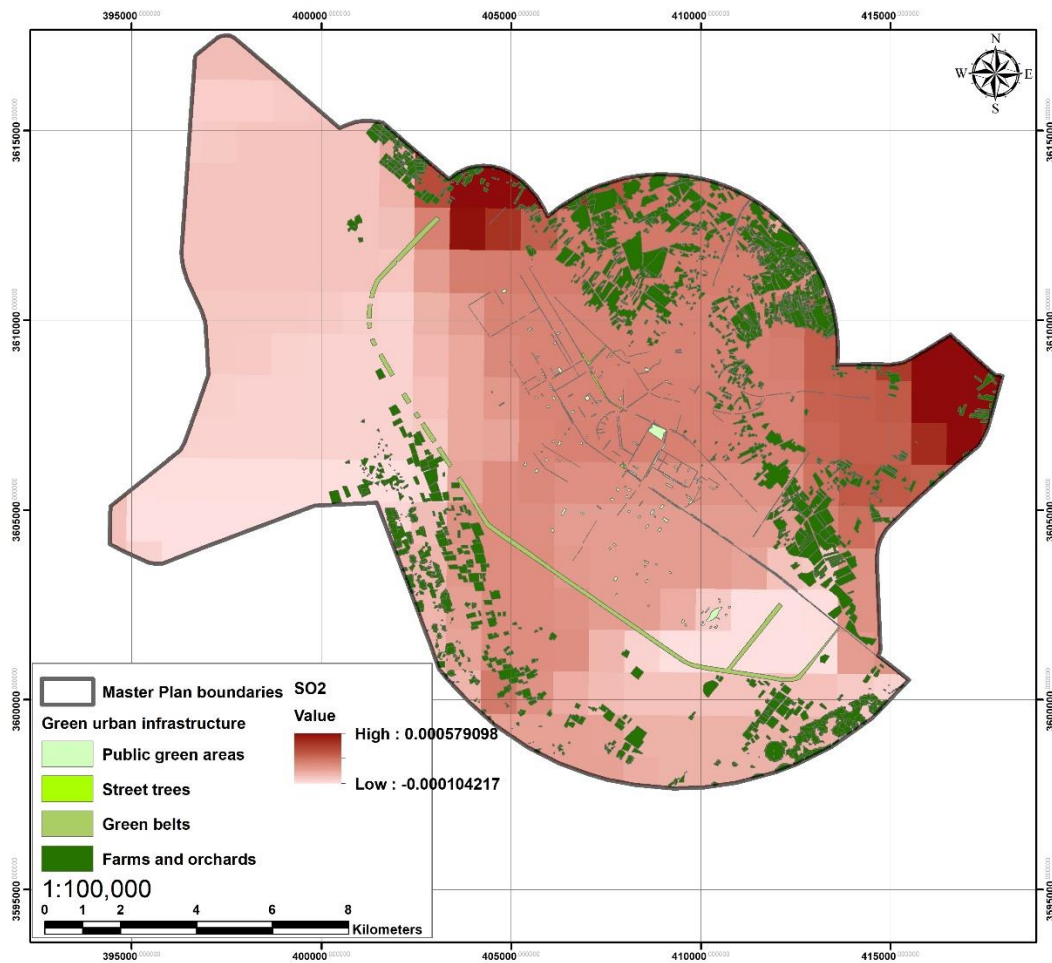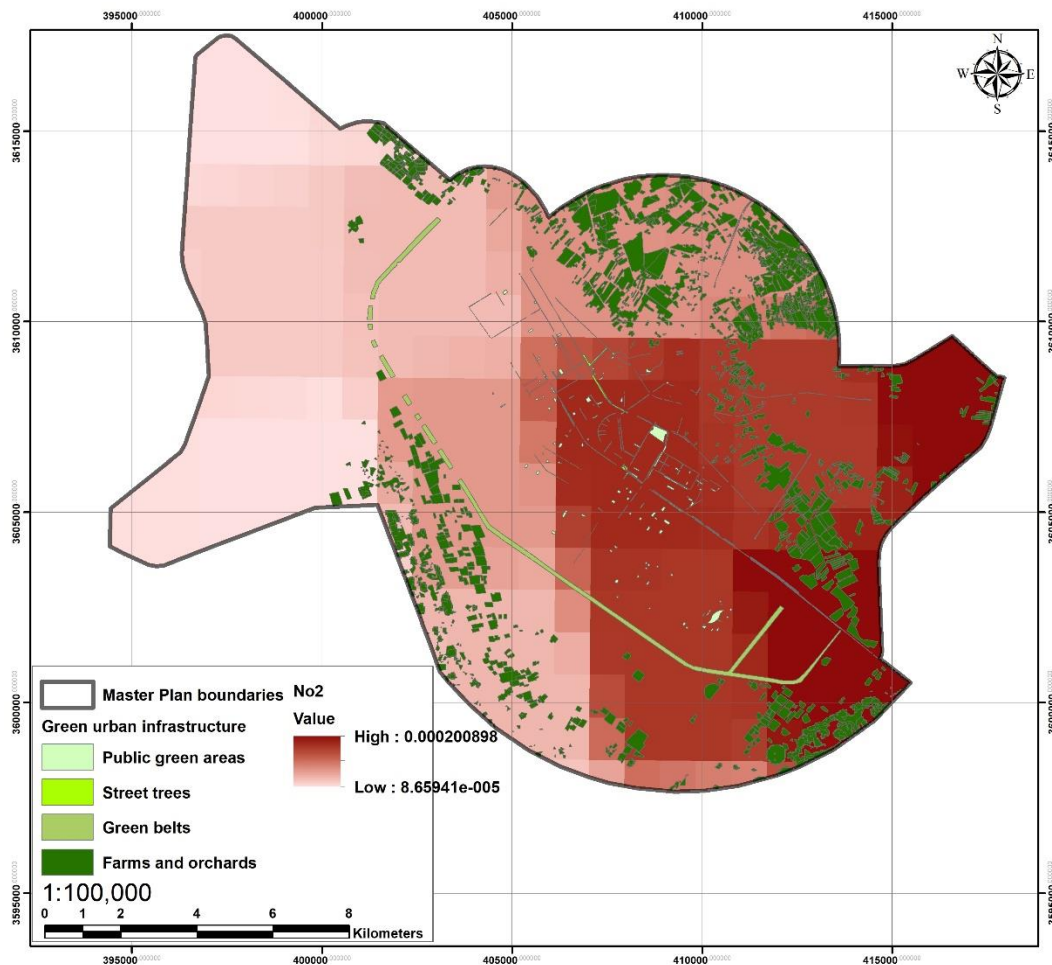
Map 5: distribution of sulfur dioxide gas in the city of Karbala Source: Researcher based on GIS

3) Nitrogen dioxide gas (No2):

It is one of the air-polluting gases resulting from the combustion of fuel during the movement of various means of transportation, electric power generators, and various industries, especially the chemical and petroleum industries, in addition to domestic uses such as cooling, heating, and the use of ovens. It is also worth noting that this gas is emitted from the use of nitrogen fertilizers and from the combustion of organic materials. In general, cities are one of the sources of this air-polluting gas, which has effects on air quality and human health.

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Map 6: distribution of nitrogen dioxide gas in the city of Karbala
Source: Researcher based on GIS

It is noted in map 6 that the percentage of gas presence in the western part of the city is low because it is an uninhabited area and movement is relatively low. The percentage of gas increases towards the southeastern part of the city due to the presence of orchards in the northern part of the city, which work to limit the presence of this gas. The prevailing winds are northwesterly winds, and thus they push the gas towards the southeast of the city .

4) Ozone gas (O3):

It is one of the gases that pollute the air when its levels rise in the surface layer of the atmosphere and pose health risks to humans. This gas is formed from

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emissions of volatile organic compounds or from emissions of nitrogen dioxide, of which industries and automobile traffic are among the most important sources. These emissions interact with oxygen and sunlight to form ozone gas in cities, that is, in general, the chemical interaction of various air pollutants leads to the formation of this gas.
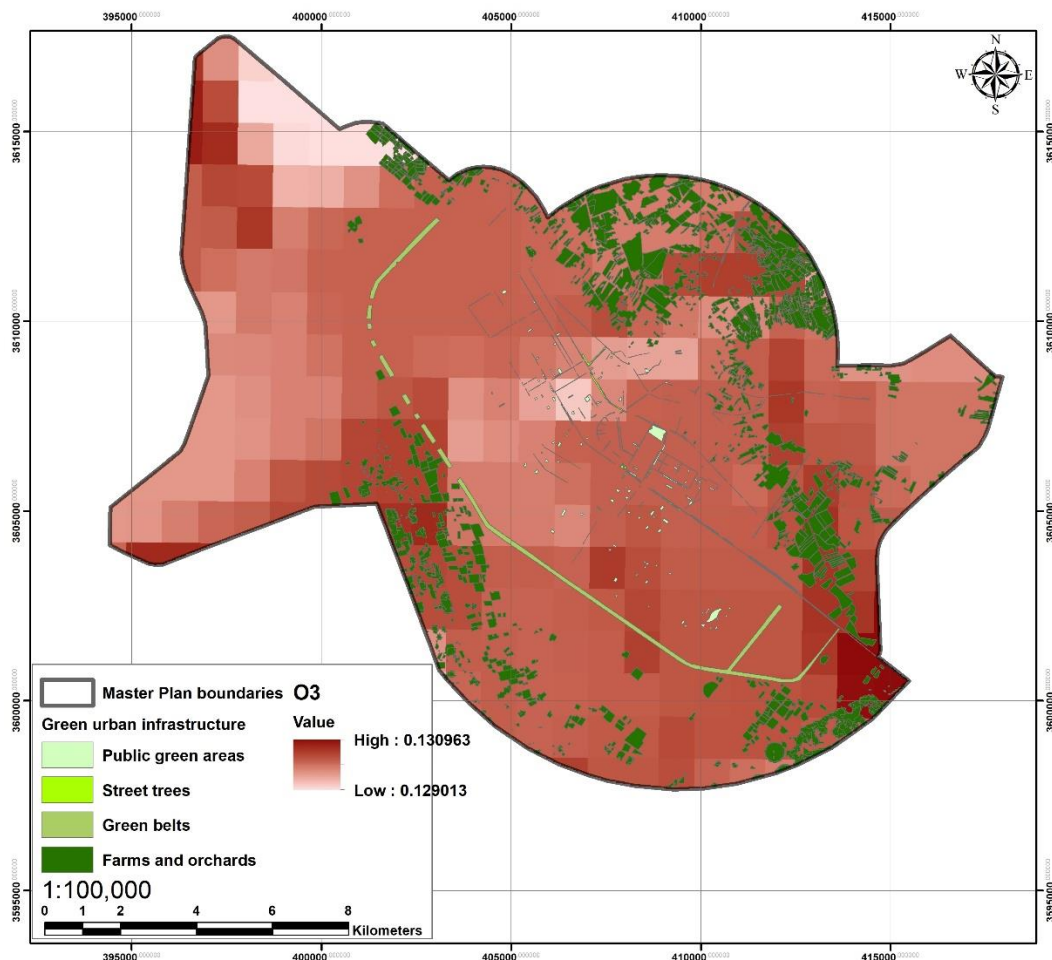
**Map 7: ozone gas distribution in the city of Karbala**
Source: Researcher based on GIS

It is noted in Map 7 that this gas is present in the city of Karbala in approximately equal proportions in all parts of the city due to the presence of other polluting gases of various types in varying proportions in all parts of the city, where their

chemical interaction leads to the formation of ozone gas, as was previously indicated.

5) Purifying the air from impurities:

Green areas and trees act as windbreaks and purify the wind of dust and particles suspended in the air that cause many health and respiratory diseases in humans. The winds coming from the Western Desert are considered a major source of dust and suspended particles in the air in the holy city of Karbala. Some industries, agricultural activities, cooling and heating systems, and etc. are also considered sources of air pollution with suspended particles.
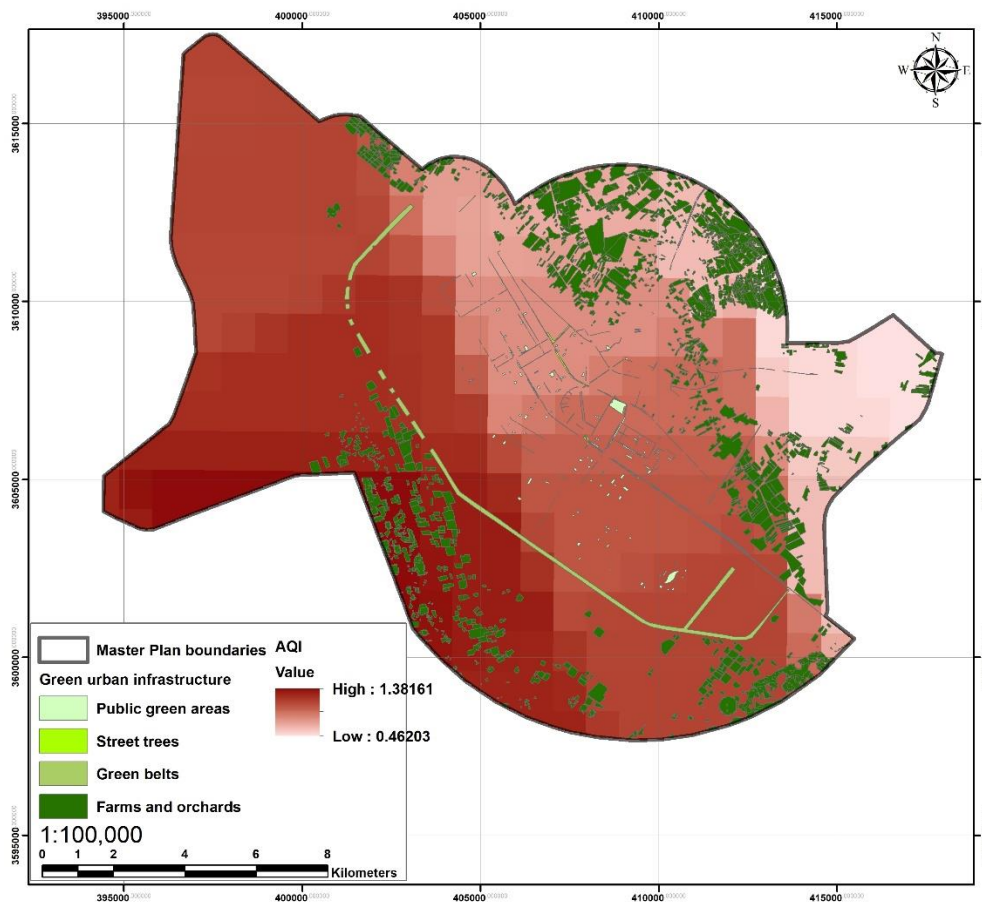
**Map 8: distribution of suspended particles in the air in the city of Karbala
Source: Researcher based on GIS**

Map 8 shows the concentration of dust and suspended particles in the air in the western part of the holy city of Karbala and gradually decreases towards the eastern part of the city, where it decreases significantly in the area that includes the northern orchards of the city. The green belt purifies the northwestern winds from suspended particles to some extent, and it needs to increase its efficiency in appropriate ways for air purification purposes.

Results and Discussion:

In conclusion, we can discuss the effective role of green areas in reducing the effects of air pollution and improving air quality according to our understanding. Analysis and data showed that the study area faces serious challenges related to air pollution and its impact on human health and air quality. The results indicated the vital role of green areas in absorbing harmful gases and improving air quality. Trees work to purify the air of impurities and dust, Therefore this demonstrates the importance of enhancing and maintaining green areas and working to replace gray areas with green, as well as taking effective measures to increase green areas and distribute them optimally because investing in green areas is an investment in the environment, human health, and well-being.

Conclusions:

1- The number of deaths due to air pollution is much greater than the number of deaths due to water or soil (land) pollution. Air pollution is the third most dangerous cause of death, according to statistics conducted in 2019.

2- Green areas have an important role in reducing air pollution in the study area.

3- The total area of green areas (green urban infrastructure) in the city of Karbala for the year 2023 is equal to 31.64 km2.

4- Public green areas occupied 1.78% of the total area of urban infrastructure in the study area, street trees 1.76%, green belts 6.75%, farms and orchards 85.80%, and other green areas and natural vegetation 3.92%.

5- The most prominent sources of air pollution in the study area are the combustion of vehicle fuel, electric generators, various laboratories and car repair workshops, and dust that flies due to the movement of cars and winds in unpaved streets and drainages into which sewage water flows and sand and gravel quarries west of the city of Karbala and in the southwest.

6- Sentinel-5P satellite images serve as a valuable effective tool for monitoring air quality and determining the exposure of certain areas to air pollution to various types of atmospheric pollutants.

7- The Google Earth Engine platform is one of the best analysis, processing, and interpretation tools and is used to process huge amounts of Earth observation data over vast areas and for long periods at high speed.

8- Carbon emissions concentrations are higher in the northwestern and southeastern parts of the city.

9- The inefficiency of the current green belt in purifying the northwestern desert winds from dust and impurities as required.

Recommendations:

1- Preserve the current green areas and prevent encroachment on them.

2- Increasing green areas in the study area, specifically in the northwestern areas and areas of heavy traffic and large transport vehicles.

3- Developing mass transportation systems to reduce air pollution.

4- Use types of trees that purify the wind of impurities and dust.

5- Adoption of remote sensing techniques by agencies concerned with the environment and environmental quality.

6- Reducing sewage leakage into open drainage.

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