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## Comparison of Maps of the Nitrogen Dioxide Concentration, Dust, Wind and Vegetation in Shiraz and Mashhad Cities

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### Abstract

The expansion of urbanization and the development of cities, the increase in population, the development of industrial activities and the excessive consumption of fossil fuels have greatly increased air pollution and made it more than the capacity of the environment. In our country, the release of air pollutants in some big cities has reached a dangerous level, Mashhad is considered one of the most polluted cities in the country on some days of the year. In this study, nitrogen dioxide data from OMI sensor and meteorological parameters such as wind, surface temperature and horizontal visibility for the period from 2004 to May 2021 have been used to investigate the air pollution caused by nitrogen dioxide in Mashhad and Shiraz. The results show that the highest (lowest) amount of nitrogen dioxide occurs in the cold (hot) seasons of the year. So that the highest amount of nitrogen dioxide in January is equal to  $5.56 \times 10^{15}$  molecules per square centimeter and the lowest amount in September is equal to  $10^{15} \times 4.18$  molecules per square centimeter. The standard deviation of nitrogen dioxide also shows that the greatest changes occur in the cold seasons of the year. The correlation coefficient of nitrogen dioxide with wind and surface temperature is -0.36 and -0.57, respectively, which shows the greater importance of temperature in the changes of nitrogen dioxide. Also, the correlation coefficient of nitrogen dioxide with horizontal visibility is -0.15, which shows that with the increase in air pollution caused by nitrogen dioxide, horizontal visibility decreases.

**Keywords:** Dust Map, Nitrogen Dioxide Concentration Map, Shiraz, Mashhad

### 1. Introduction

Air pollution is one of the most important issues that have always been raised in connection with the climate and various aspects of it have been considered. The United States Health, Welfare and Education Organization has defined air pollution as follows: "If one or more polluting substances are in the air for some time to harm humans, plants and animals or reduce the comfort, peace and pleasures of life, that The air is polluted" (Ahadi, 2014). Air pollutant production sources are divided into two

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categories: natural sources, such as volcanic eruptions, lightning, soil emissions, and human or artificial sources, such as industrial, urban, domestic, and agricultural sources. Air pollutants can also be divided into primary and secondary pollutants. Primary pollutants are the pollutants that are emitted directly from the producing sources, and secondary pollutants are produced and enter the atmosphere as a result of the interaction of factors such as sunlight, humidity and chemical reaction on the primary pollutants. Secondary pollutants include nitric acid, sulfuric acid and ozone, which are produced from primary pollutants such as sulfur dioxide, nitrogen oxides ( $\text{NO}_x = \text{NO}_2 + \text{NO}$ ) and hydrocarbon compounds (Botkin and Keller, 2002). Nitrogen dioxide ( $\text{NO}_2$ ) is a red-orange to brown gas with a boiling point of 21.2 degrees Celsius and a partial pressure that keeps it in a gaseous state. Among the most important sources of nitrogen dioxide production are car exhaust, fossil fuels, power plants, industrial boilers, waste incinerators, heating devices, lightning and volcanoes. (Ghiyasuddin, 2005).

Nitrogen dioxide in combination with radical hydroxide produces nitric acid, which eventually falls on the earth's surface as acid rain. Also, nitrogen dioxide reacts with ammonia, humidity and other compounds in the form of small particles and penetrates deep into the lungs, causing or aggravating respiratory diseases such as asthma, bronchitis and increased cough. Changes in kidney, liver and heart tissues, weight loss, sensitivity to bacteria and viral infections are other effects of this pollutant on health (Hatami, 2008). Atmospheric and climatic conditions have a significant effect on the continuation and aggravation of air pollution. Meteorological parameters affecting air pollution are: wind direction and speed, temperature, precipitation, humidity, solar radiation and horizontal visibility. According to the report of the National Academy of the United States of America, the global temperature of the earth's surface has increased by 0.4 to 0.8 degrees Celsius. Since global warming has a great impact on life on the planet, researchers and researchers have also investigated temperature changes in temporal and spatial scales.

## 2. Introducing the Study Areas

### 2.1. Shiraz

The city of Shiraz, with an area of approximately 240 square kilometers and a population of over one million and 500 thousand people, is the capital of Fars province. This city is located between 51 degrees 49 minutes and 53 degrees 38 minutes east longitude and 29 degrees 2 minutes and 29 degrees 57 minutes north longitude and at an altitude of 1484 meters above sea level. The average maximum temperature of Shiraz in the months of July and August is around 37 degrees Celsius, and the minimum temperature is around 3 degrees Celsius in the months of December, January and February. Shiraz, as the eighth most polluted metropolis in the country, is facing the problem of air pollution due to its rapid development. Its polluting industries are cement factory, wool and glass factory, Dana rubber factory, domestic and commercial sources, oil refinery and petrochemical industries. More than 75% of air pollution is caused by fuel combustion in motor vehicles, of which 22% is related to worn-out cars in this city. The air is more polluted in terms of the amount of carbon monoxide and suspended particles than the permissible limit, which is the main cause of the traffic and traffic of cars. The cars consumed about 85,000 liters of gasoline and 15,000 liters of diesel, which is about 32 tons of carbon monoxide and 3 tons of hydrocarbons and 0.8 have produced tons of nitrogen oxides. The amount of pollutants in some days is more than the permissible limit and the concentration of dust is higher in the summer months. In this study, there are suggestions such as burning gas in cars, strengthening the public transportation system such as buses, subways and encouraging people to use public vehicles, scrapping worn-out cars, expanding the inspection system, and also determining industrial areas in such a way that the pollution caused by them It is provided in order to reduce air pollutants so as not to be carried into the city by the wind.

### 2.2. Mashhad

The studied area of Mashhad is the second largest city in Iran with two million eight hundred and seven thousand four hundred and sixty four people. (Hatami, 2019) The area of the city is about 300 square kilometers (Jahanshiri, 2018) and it is located at 15.59 to 60.36 degrees longitude and 35.43 to 37.8 degrees latitude in the Mashhad plain. This city is one of the industrial, religious and economic cities and also one of the busiest cities in Iran. The mountain range of Hazar Mosque in the northeast, Binalud in the west and southwest of Sarkhs city in the east, and Neishabur and Chenaran in the west surround this city (Sadeghi, 2013).

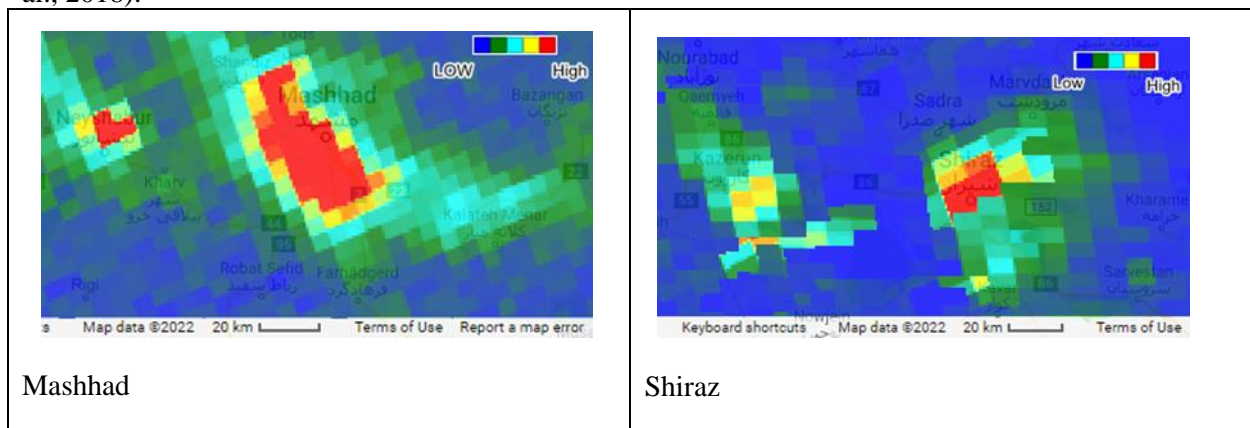
The minimum height of this area is 750 and the maximum is 1800 and the average height is 943 meters. Most of the Mashhad plain has a cold and dry climate. The average air temperature in Mashhad weather station is reported as 13.5 degrees Celsius. The number of frosty days during the year is 100 days on average. Also, the city of Mashhad, as the spiritual capital of Iran, hosts an average of twenty million pilgrims and travelers every year; The result is city congestion and air pollution. According to the available official statistics, there are about 430,000 cars in this city, most of which use fossil fuels, and in the industrial town there are more than fossil fuels (Shamabadi, 2016).

### 3. Material and Methods

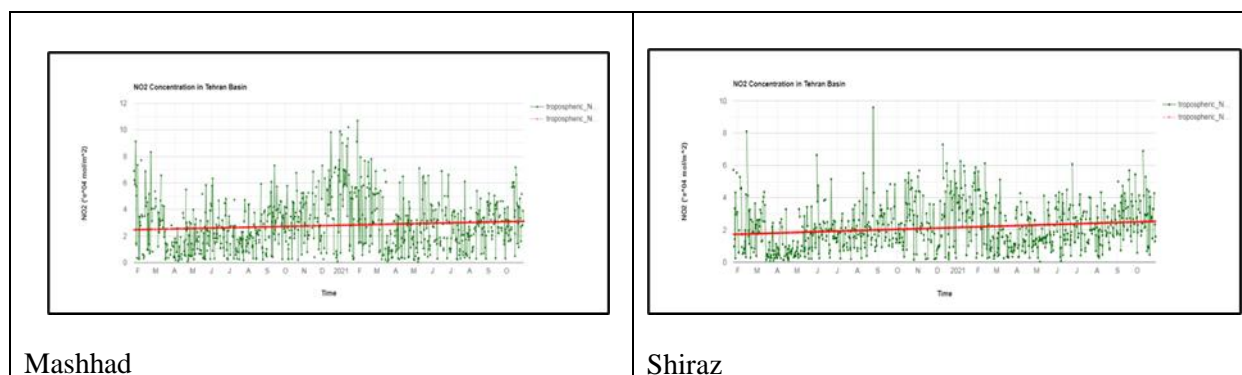
In order to determine the index pollutant of Shiraz city and Mashhad city, using the values measured by the pollution measurement stations, the concentration of each pollutant was obtained in each day of 2019. Then, with the help of air quality index relations, this index was calculated and different air quality levels were determined for each day of 2019. Also, the index pollutant was determined every day. In the end, by summarizing the index pollutants in each day and also by comparing and examining the index pollutant on unhealthy and unhealthy days for specific groups, the index pollutant of Shiraz city in 2019 has been determined.

#### 3.1. Nitrogen Dioxide Concentration

The development of urbanization and urban air pollution is one of the most important issues related to climate today. The expansion of urbanization and the development of cities, the increase in population, the development of industrial activities and the excessive consumption of fossil fuels have greatly increased air pollution and made it more than the capacity of the environment. (Ismailzadeh et al., 2018).



**Figure 1.** Concentration of nitrogen dioxide in Mashhad and Shiraz



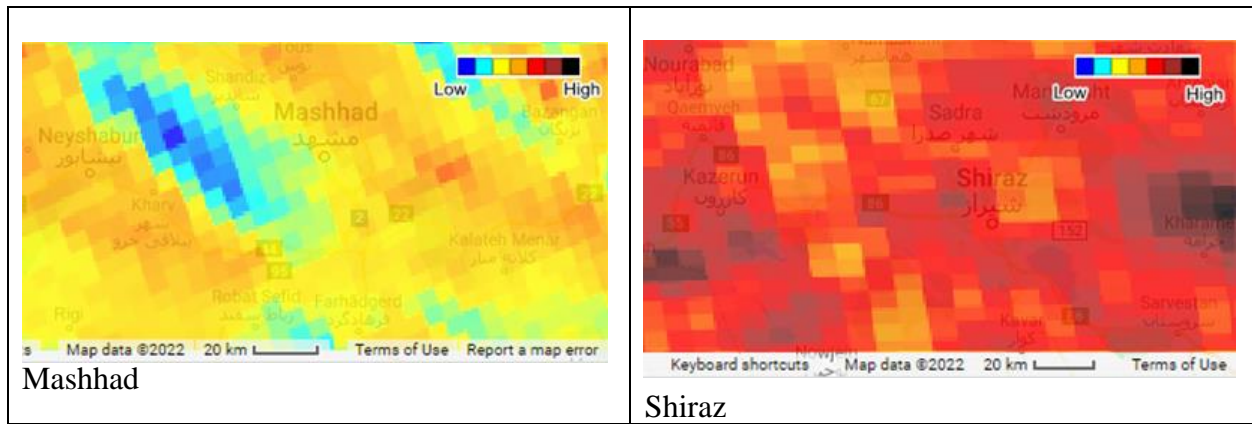
**Figure 2** Diagram of nitrogen dioxide concentration in Mashhad and Shiraz

In our country, the release of air pollutants in some big cities has reached a dangerous level, Mashhad is considered one of the most polluted cities in the country on some days of the year. Nitrogen dioxide is one of the indicators of air pollution. In this study, nitrogen dioxide data from the OMI sensor and meteorological parameters such as wind, surface temperature and horizontal visibility for the period from 2004 to May 2020 were used to investigate the air pollution caused by nitrogen dioxide in Mashhad and Shiraz. The results show that the highest (lowest) amount of nitrogen dioxide occurs in the cold (hot) seasons of the year in Shiraz and Mashhad. So that the highest amount of nitrogen dioxide in January is equal to  $1015 \times 5.56$  molecules per square centimeter and its lowest value in September is equal to  $4 \times 10^{15} \cdot 18$  molecules per square centimeter. The standard deviation of nitrogen dioxide also shows that the greatest changes occur in the cold seasons of the year. Also, the results showed that the prevailing wind in Mashhad city is from the south side and most of the winds in this city have low speed. Also, with the increase in air pollution caused by nitrogen dioxide, horizontal visibility decreases. (Goodhu et al., 2009)

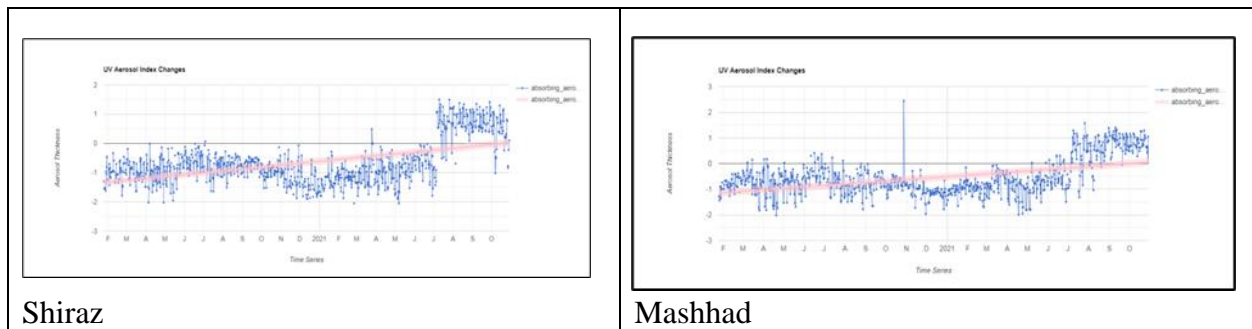
The trend of increasing nitrogen dioxide in the Middle East countries has been fossil fuel consumption. Zhu and his colleagues have investigated the long-term trends of nitrogen dioxide changes in Europe, their results showed that nitrogen dioxide has decreased in Western Europe (Zhu et al., 2012).

### 3.2. Dust

The results of the dust maps showed that the city of Shiraz, especially its southern and central regions, benefited from less moisture paths due to its geographical location and location in low latitudes, and its proximity to the origin of dust, i.e. the deserts of Arabia and Iraq, caused so that it is always exposed to the phenomenon of dust and is damaged in some days of the year. The results obtained from this research show that in the eastern regions of Fars province, the prevailing winds of the region had a speed of 3.6 to 5.7 meters per second. Also, most of the winds that flowed in the eastern half of Fars province caused dust phenomenon in late spring, summer and early autumn, and their origin is western and Mediterranean winds from Europe and toxic winds from It has been the desert of Egypt and Arabia.



**Figure 3.** Dust map of Mashhad and Shiraz



**Figure 4.** Dust diagram of Mashhad and Shiraz

### 3.3. Wind

The wind is important because of the effect it has on the air temperature, and the movements of the wind cause the disturbances related to temperature, humidity and pressure that exist in different horizontal directions of the atmosphere to be eliminated and the air to be balanced. When balance is established in one place, new disturbances are created in another place, so balance is never achieved and wind is an important regulator in nature (Bentley, 2008).



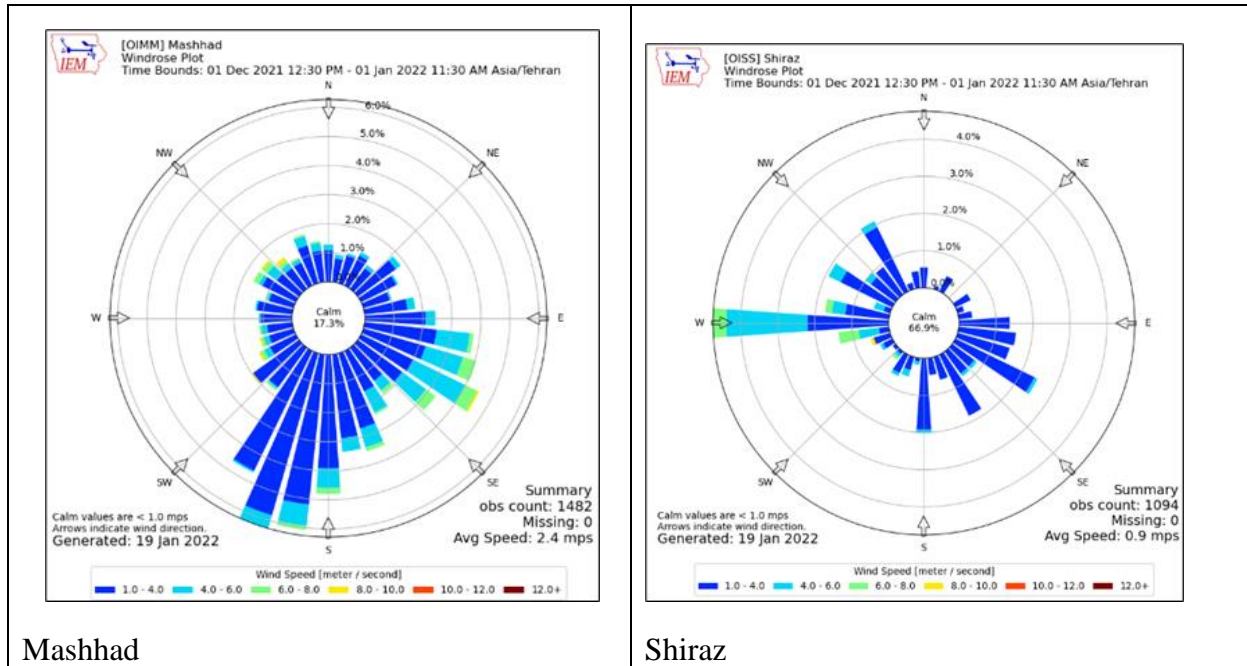


Figure 5. Golbad city of Mashhad

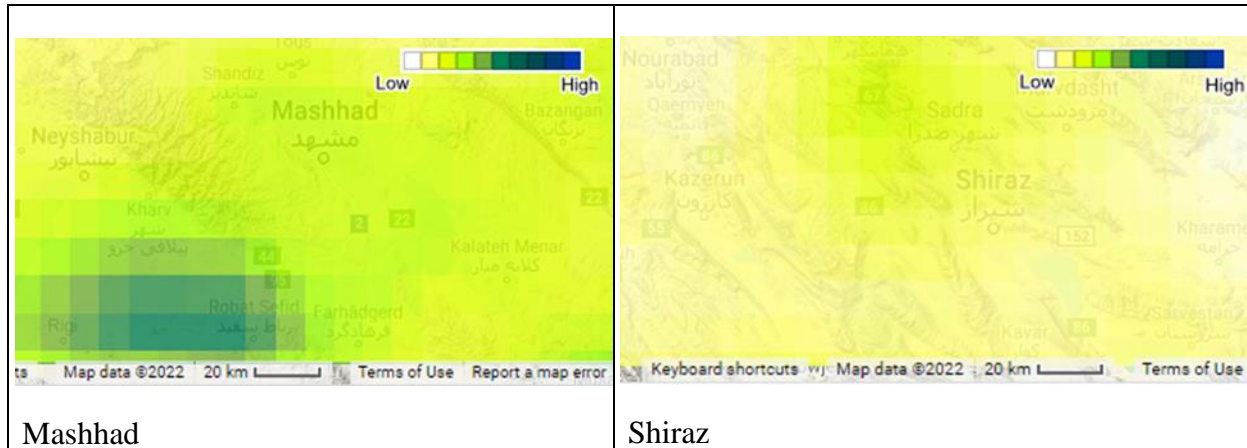
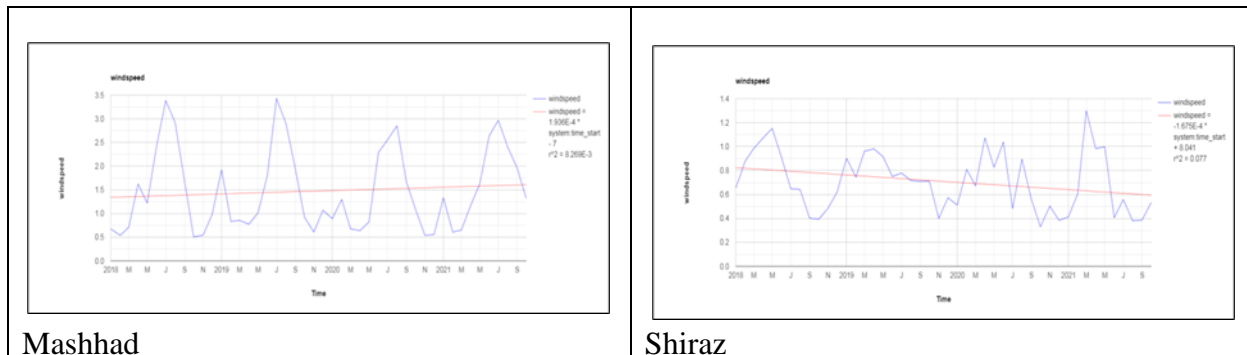


Figure 6. Wind speed in Mashhad and Shiraz



**Figure 7.** Wind speed diagram of Mashhad and Shiraz

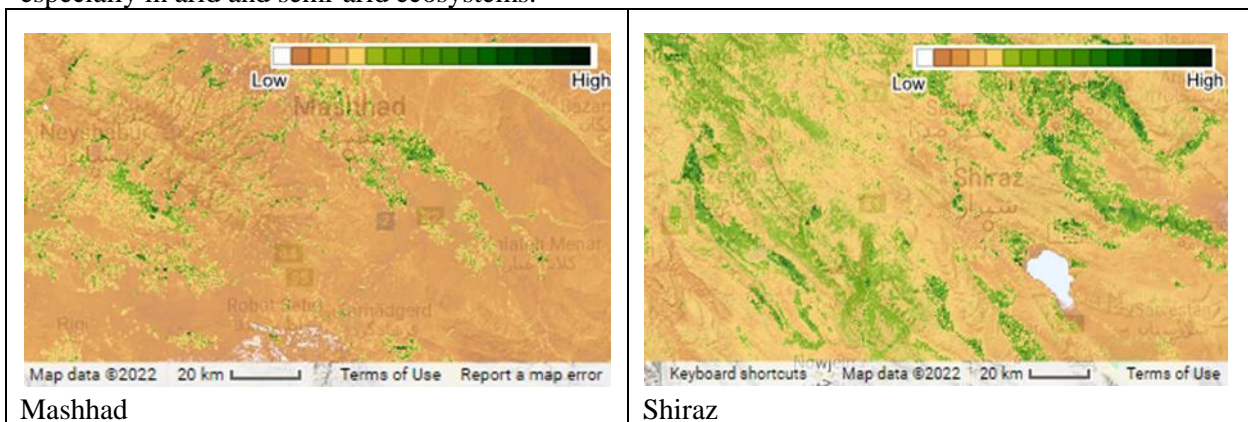
After downloading the average monthly wind speed data and converting these monthly data into seasonal data, a spatial distribution map of the average wind speed of the cold (winter) and hot (summer) seasons of 2021 was prepared. As can be seen in the figures above, in the winter season, the highest average wind speed was observed in the Zagros Mountain range and Fars and Isfahan provinces, and the lowest average wind speed was observed in the southern and eastern regions of Iran. In the summer season, the highest average wind speed was observed in the eastern areas of Shiraz and the lowest wind speed was observed in the Zagros Mountain range and north-northern areas of Shiraz (Mousavi et al., 2019).

According to the meteorological statistics (from 1950 to 2021 AD) of the Shiraz synoptic station, weather elements including temperature, relative humidity, rain, wind, etc. were investigated and then the conditions of human comfort in different months of the year were determined in different ways. Considering the climate of Shiraz and the intensity and direction of the sun's radiation in different months and the direction of the prevailing winds, it led to suggestions for building design in Shiraz.

In order to prepare the surface wind map, first, the monthly average 10-meter wind data of the western and southern directions of the earth's surface, which are in the form of networked systems, were downloaded from the ECMWF website. The data of this site has a spatial zoom of 15 km and a time zoom of 3 hours. These data include two components  $u$  and  $v$ , which represent the west and south winds in Shiraz city, respectively (Miri et al., 2015).

### 3.4. Vegetation

Changes in land cover are among the most important changes in the earth's surface that have significant effects on the environment and environmental processes. Currently, the use of vegetation maps is one of the important elements in producing information for macro and micro planning. One of the most important factors in better soil management is knowing the state of vegetation (Esfandiari et al., 2016). On the other hand, the study of vegetation cover is difficult and limited, especially in arid and semi-arid areas, using traditional methods and field operations. The climatic condition of each region is one of the influential factors in the initial formation of settlements. Precipitation is one of the most important climate parameters, which is one of the influencing factors in vegetation changes, especially in arid and semi-arid ecosystems.



**Figure 8.** Vegetation of Mashhad and Shiraz

The reduction of agricultural land in the suburbs and the removal of vegetation along with the increase in soil surface temperature are considered to be only part of the negative consequences of urban development, especially in the areas that are under urban construction. Vegetation map is a set of

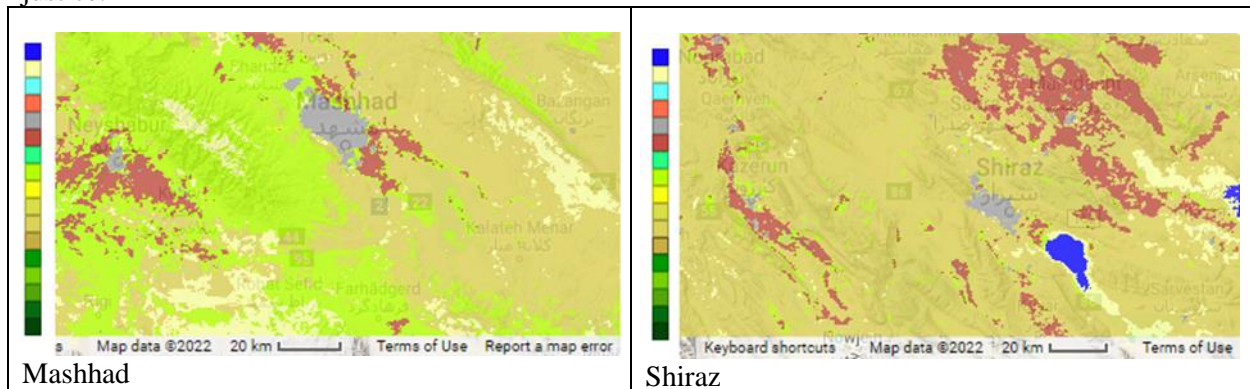
communities or types of plants in a region and by preparing it, you can get a clear picture of the communities or types of plants on the earth. Vegetation map is needed for the purpose of accessing necessary information on natural resources and planning based on it for the progress and development of plant resources and environment in different regions of the country. This collection includes the map of vegetation and trees of Shiraz city, which contains very useful and comprehensive information about vegetation in shape file format.

In Shiraz and the southern regions of Shiraz, with an area of 180 square kilometers, it was considered a unique region in terms of ecological diversity, climate, and the value of natural and agricultural resources. This feature had shaped the morphology and climate of Karabagh Plain until about 10 years ago. According to personal and experimental observations about the ecosystem, especially the vegetation and hydrological status of the region, and by searching past images and people's questions, the Karabakh plain has been becoming dry and desertified due to various factors in the last few years, and in Currently, there are no traces of springs, water channels, many plant and animal species of the past, and halophyte and xerophyte invasive plants that are part of the cover of desert areas are increasing, and agriculture in the region has become more similar to agriculture in dry and desert areas. Many have been abandoned. Even due to its dryness and pressure, a large part of the plain has suffered an underground fire. In addition to the drought, the main human factor has been the increase in population and the subsequent increase in the exploitation of underground water for industrial, drinking and agricultural uses, and it can be said that currently the Karabakh plain has turned into a dry region facing a desert. Is. The speed of this process can be stopped with management and measures such as preventing excessive use of water and basic agriculture, and it is a lack of human factors.

The destruction of vegetation, gardens and farms located in the urban area of Mashhad and its change of use during 26 years has led to a relative increase in the ambient temperature and has had negative effects in the urban area. In general, it can be concluded that the vegetation of Mashhad in Compared to Shiraz city, it is less and Shiraz city has better and more diverse vegetation due to its better climate and more precipitation. In Mashhad city, according to the vegetation maps of the region, during these 9 years, more than 40 % of the area of cultivated land has been reduced and the region is facing the destruction of soil, water and plant resources and this is the true meaning of desertification.

### 3.5. Land Use

Land use planning is actually a set of activities that organizes the human environment according to the demands and needs of the urban society, and this category forms the core of urban planning. Nowadays, due to the ever-increasing development of cities and the imbalance in the distribution of land uses, urban land use management is very important. (Abdollahi et al., 2014) Equitable access to these uses and their optimal use is one of the basic components in sustainable development and social justice.





**Figure 9.** Land use map of Mashhad and Shiraz

What was obtained from the findings of this research shows that: the distribution of uses in the city of Shiraz is contrary to the common standards of the country and the world. Also, in Shiraz itself, the distribution of uses in different areas of the city faces the problem of imbalance, which in this Among cultural-religious uses, transportation, education, urban facilities, and tourism, they have a more inappropriate spatial balance than other uses. Also, the studies show that merely evaluating the uses quantitatively is not enough and should be considered All the aspects and qualitative evaluation of the uses should be included in order to lay the groundwork for the sustainable development of the city.

#### 4. Conclusion

In Iran, the amount of air pollutants in many cities including Tehran, Isfahan, Tabriz, Mashhad, Shiraz, Karaj, Arak and Ahvaz has reached a dangerous level. Among the different cities of the country, the city of Mashhad is one of the most attractive cities for pilgrims, tourists and immigrants in the country due to the presence of historical and cultural monuments, especially the holy shrine of Imam Reza (a.s.) It has created aspects of urban life. On average, 10 people die in Mashhad due to diseases related to air pollution and this number is increasing (Ajmi Torbeghan, 2014). Therefore, this issue has become an acute problem in this city. In order to control and reduce the amount of pollution and its negative impact on people's health, the factors that pollute the air and climatic factors should be identified first.

Shiraz, as the eighth most polluted metropolis in the country, faces the problem of air pollution due to its rapid development. More than 75% of air pollution is caused by the combustion of fuel in motor vehicles, of which 22% is related to worn-out cars in this city. The air is more polluted in terms of the amount of carbon monoxide and suspended particles than the permissible limit, which is mainly caused by traffic and car traffic. Cars consumed about 85,000 liters of gasoline and 15,000 liters of diesel, which produced about 32 tons of carbon monoxide, 3 tons of hydrocarbons, and 0.8 tons of nitrogen oxides. The amount of pollutants in some days is more than the permissible limit and the concentration of dust is higher in the summer months.

The city of Shiraz has eleven urban areas and four fixed air pollution measurement stations that continuously measure and record the pollutants of suspended particles (with a diameter of less than 2.5 microns and 10 microns), carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. he does. Based on the collected data and analysis, in 348 days of 2016, the air quality of Shiraz city was good and average. In 15 days, the air quality was unhealthy for sensitive groups and unhealthy for 2 days. The investigation of the index pollutant during 365 days of the year shows that suspended particles with a diameter of less than 2.5 microns were the index pollutant on a total of 212 days, of which 198 days were of average air quality, 13 days of unhealthy air quality for sensitive groups. And the air quality has been unhealthy for 1 day. After that, there is carbon monoxide, which has been considered as an indicator pollutant for a total of 136 days; 48 days of good air quality, 86 days of average air quality, one day of unhealthy air quality for sensitive groups and one day of unhealthy air quality. Therefore, suspended particles with a diameter of less than 2.5 microns are an indicator pollutant of Shiraz city, which necessitates that air pollution reduction programs in this city be based on the prevention of production and finally reducing the production of this pollutant.

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