Geographical assessment of green areas per capita as an indicator of sustainable development: A study on economic geography

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Doi: 10.21608/ajsr.2023.296405

Receiving the search 20 – 7 - 2022
Acceptance of publication 15 – 8 - 2022

Amer, Sabah Ali (2023). Geographical assessment of green areas per capita as an indicator of sustainable development: A study on economic geography.***The Arab Journal of Scientific Research***, AIESA, Egypt, 7(6), 1-24.

https://ajsr.journals.ekb.eg

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Abstract

This study is intended to monitor changes in the vegetation cover in the Dammam Governorate during the period 2000 – 2020 and subsequent changes in green areas per capita during the same period. Also, The paper explores the potentials for achieving the target green area per capita in the Eastern Region by the end of 2022, which is 4.5 square metres per capita. To achieve this goal, the study relied on the data from previous studies and the field study related to the use of remote sensing technology to monitor the changes that occurred in land use during the study period in terms of vegetation cover and urban sprawl. The results showed that the average per capita share of vegetation in the Dammam Governorate amounted to 18.27 square metres per person in 2000 but decreased in 2020 due to population increase and the growth of the urban area, reaching 6.14 square metres per person. However, it exceeded the per capita average. The study concluded the necessity of preserving vegetation cover for its role in supporting the level of well-being of human societies, with an emphasis on the role of strategic plans for cities in providing large areas of vegetation cover and thus preserving the per capita share of sustainable vegetation cover.

Keywords: Vegetation, residential urbanization, industrial urbanism, quality of life, social welfare

Introduction

The environment is the main source of national income resources for all countries in the world. Ensuring the protection of these resources requires sustainable development. Vegetation cover is one such resource, and natural or agricultural vegetation cover is the product of human effort. Plants are considered the

ISSN: 2537-0367 **eISSN : 2537-0375**

most important components of their vital system, as they play a distinct role as raw materials in the field of food and medicine production. To complement economic well-being, soil erosion must be prevented to reduce the high thermal burden of the desert climate. Moreover, vegetation cover can assist in purifying air from dust and pollutants, in addition to providing some products with high nutritional and medicinal value, which will increase its economic importance. Therefore, there is a tendency of all departments and municipalities in the various regions and governorates of the Kingdom to increase vegetative areas. Additionally, there is a need to raise the per capita share of the vegetative area and provide a safe and comfortable environment, which will contribute to the wellbeing of society. A proper vegetative area is an indicator of environmental sustainability and, as a result, Vision 2030, as it indicates a positive change in all parts of the Kingdom, including the Dammam Governorate.

Research problem

Vegetation cover is of great importance in protecting the natural environment of the study area and its sustainability and compatibility with Vision 2030, the Saudi Green Initiative and the Middle East Green Initiative. Vegetation cover per capita in the Eastern Region reached 4.1 metres per person by the end of 2021, and the target was 4.5 metres per person by the end of 2022 (Al-Jubeir, 2022). Thus, this study sought to determine the per capita share of vegetation cover in the Dammam Governorate according to its natural and human environmental characteristics during the study period and the extent to which it can achieve the target percentage by the end of 2022 compared to the per capita vegetation cover at the level of the eastern region.

ISSN: 2537-0367 **eISSN : 2537-0375**

Objectives

This study aims to conduct the following sub-studies in the study area:

1. Geographical analysis of vegetation cover distribution
2. Monitoring changes in vegetation cover per capita
3. Determining the most important factors affecting the vegetation cover
4. Evaluating the efforts of government agencies to protect vegetation cover

Study hypotheses

1. Vegetation is one of the indicators of sustainability in the Dammam Governorate.
2. Urban development in the Dammam Governorate negatively affects vegetation cover.
3. The decline in vegetation cover in the Dammam Governorate reduces its per capita share.
4. The vital role of government agencies is to contribute to the sustainability of vegetation cover.

Methodology

The study relied on the spatial analytical approach to show the effect of the interaction of environmental elements on the distribution of vegetation cover in the region, as well as the inductive, regional and descriptive approaches used to reveal the characteristics of the study area, including its natural and human phenomena, which distinguishes it from the neighbouring regions. The study procedures were based on collecting written and illustrated scientific material and maps of the study area issued by several bodies specialising in vegetation cover, such as centres affiliated with the Ministry of Environment, Water and Agriculture and the Saudi Digital Library, a field study based on interviews with officials and consultants in the Ministry of Environment, Water and Agriculture and on observation. The Normalized Difference Vegetation Index (NDVI) was employed

ISSN: 2537-0367 eISSN : 2537-0375

to extract vegetation area from satellite images in the governorate. For this purpose, two satellite images were processed: Landsat 7 (ETM+) and Landsat 8 (OLI-TIRS) using ERDAS IMAGINE 2014. NDVI is calculated using the following equation:

NDVI = (NIR - RED) / (NIR + RED).

Generally, high values of NDVI refers to healthy vegetation cover, while a low NDVI value indicates to sparse vegetation cover (Abdo, 2013, p. 297). Application of NDVI to detect changes in vegetation cover requires the availability of satellite images for two different dates (Al-Saleh, 2010, p. 154). Thereafter, the extracted vegetation covers were analysed using ArcMap 10.5.

Terminology of the study

Vegetation: This includes evergreen plants, tropical and semi-tropical meows and agricultural lands that play an important role in the biological water cycle and the Earth's energy balance, weather and climate through evaporation (Greatly, 2011).

Residential urbanisation: This is a type of human settlement in which buildings are built on land or a region according to models that confirm the benefit of humans from the resources of the environment. It shows the interaction between humans and the resources of the surrounding area.

Industrial development: This specializes in the production of consumer goods, regardless of the type of producer or consumer. The buildings of these facilities are chosen for their locations according to planning under certain conditions that represent the basic factors that control their locations as well as the shape of the buildings and building materials. Industrial development in a region is of economic importance.

Quality of life: It has several definitions, all of which include the individual's feeling of satisfaction, comfort and

ISSN: 2537-0367 **eISSN : 2537-0375**

happiness with the life he or she lives and is based on an index of equate income, a clean environment, and all basic services.
Social welfare: This includes providing non-profit services, i.e. free of charge, for all segments of society that need any service and care that they cannot provide. These services may be provided by volunteer individuals in the community or the state.
Study area

The Dammam Governorate is located geographically in the eastern region of the Kingdom of Saudi Arabia, between latitudes of 22' 26° and 30' 26°N and longitudes of 40' 49° and 16' 50°E. The area of Dammam is 800 km2, which is the ministrative and economic capital of the region. It houses the headquarters of the emirate and has a seafront overlooking the Arabian Gulf from three sides – the east, the northeast, and the southeast. King Abdulaziz Port is the largest port on the Persian Gulf and the second-most important port in the Kingdom of Saudi Arabia. Its industrial cities are among the most important industrial cities in the Kingdom. It consists of the first industrial city, which was established in 1973 and is located southeast of Dammam near the Arabian Gulf at the intersection of King Abdul Aziz Street and King Fahd Street. The second city was completed in 1978, 40 km from King Abdul Aziz Port in Dammam, while the third city was established in 2012 and is located on the East Coast Ro, 5 km from Half Moon Beach and 70 km from the Dammam train station. The three cities house 1,084 different industries. Factories produce 20% of Saudi's industrial production, including the production of foodstuffs, furniture, printing and its supplies, plastics, various building materials, auto parts and semi-finished goods, which are raw materials for industrial cities (Saudi Authority for Industry, Modon).

ISSN: 2537-0367 **eISSN : 2537-0375**

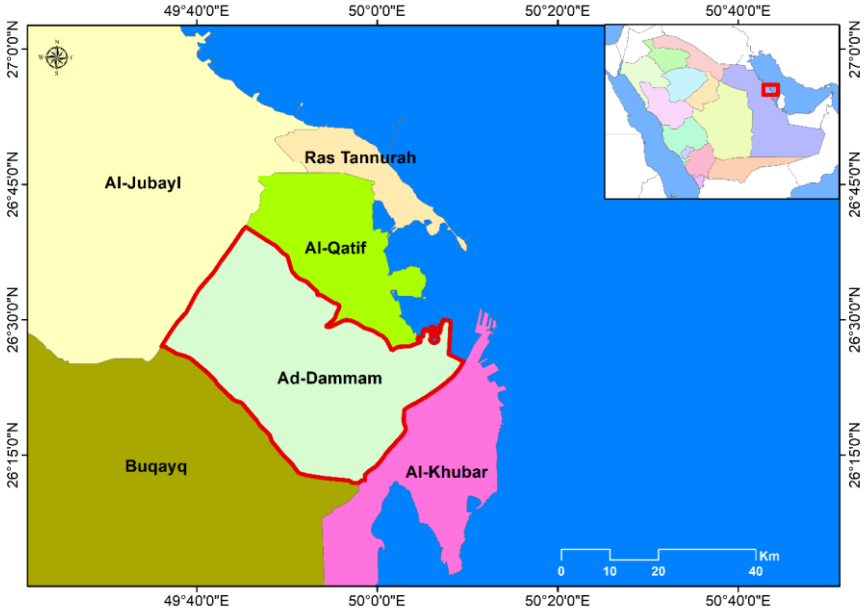

Figure (1): Dammam Governorate situation

The Dammam Governorate includes King Fahd Airport, many universities, including King Faisal University and Abdul Rahman Al-Faisal University, and many important commercial centres and tourist attractions, including the Dammam Corniche, Half Moon Beach and King Fahd Park. The governorate is bordered on the east by the Persian Gulf, on the west by Abqaiq, on the north by the Dhahran and Jubail governorates and on the south by Al-Khobar (Figure 1).

Previous studies

With regard to scientific, geographical and non-geographical studies, there are several studies, whether in relation to vegetation cover or in the field of per capita share of it, and among these studies that dealt with vegetation is the study of Muhammad, Amani Hussein (2021) with regard to vegetative changes in the environment of the main sabkhas in the eastern

ISSN: 2537-0367 **eISSN : 2537-0375**

region, using remote sensing techniques, a study in environmental geography, where the change of the natural vegetation cover in the sabkhat environment was monitored during the period from 2000 to 2019 and through the use of automated processing of satellite visuals. The study of Al-Mohammad et al. (2018), entitled: Detecting and analysing changes in vegetation cover in the Wi Al-Arab basin from 1984 to 2015, using spectral vegetation indicators. The Jordan Valley cracks the soil of the basin, which occupies 75% of the area of the region, and because temperature, precipitation, humidity and evaporation have an important role in the growth of cover in the region. Among the relevant studies is the research of Murabit (2018) entitled Economic Well-being and Ecosystem Quality, which revealed a direct relationship between resource consumption rates and growth rates. In any country, the rate of resource consumption after the emergence of a global crisis increases in a non-ideal way, and there is an inverse relationship between increased exploitation and the quality of the ecosystem. This necessitates the development of systems for the use of these resources to ensure their sustainability. With regard to per capita vegetation cover, the study by Sheikh (2009) came about the reasons that led to the reduction of per capita vegetation cover. To study the state of the vegetation cover in the Jazan Governorate, it was found that the Jazan region witnessed a deterioration in the green vegetation cover during the period from 1987 to 2002 as a result of the increasing exploitation of green spaces.

Results and Discussion

Spatial distribution of land uses in the Dammam Governorate in 2020

The built-up area of Dammam involves residential and other types of land uses covering a total area of 1050 km^2 in 2020 (Figure 2) (Table 1).

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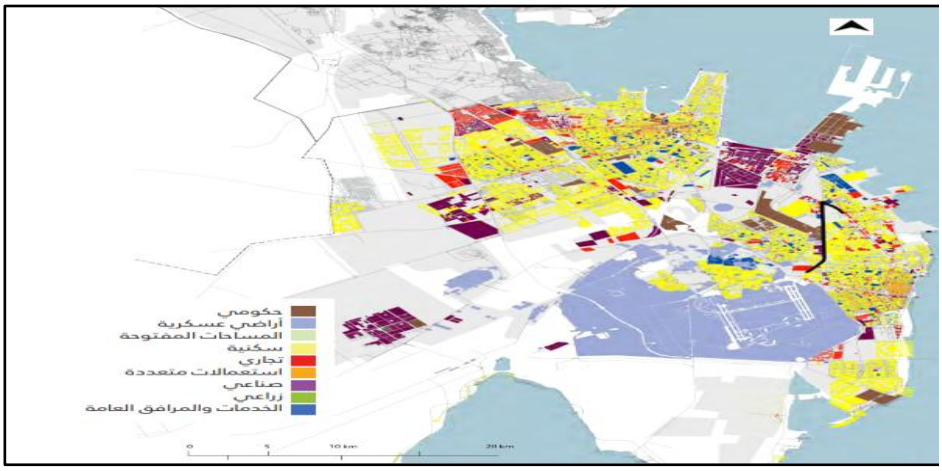

Figure (2): Land uses in Dammam Governorate in 2020

Source: Ministry of Municipality and Rural Affairs

The topography of the waterfront clearly controlled and guided the expansion of Dammam that extends longitudinally from north to south, east and southeast. Accordingly, the built-up area of Dammam expands from east to west, while small population centres are scattered in the west and southwest, where sand dunes, sabkhas and barren lands are prevailing (Figure 2). Meanwhile, the industrial zone extends in the east and southeast of Dammam, while commercial land uses are spread throughout the governorate with clear concentration at east and west of the governorate.

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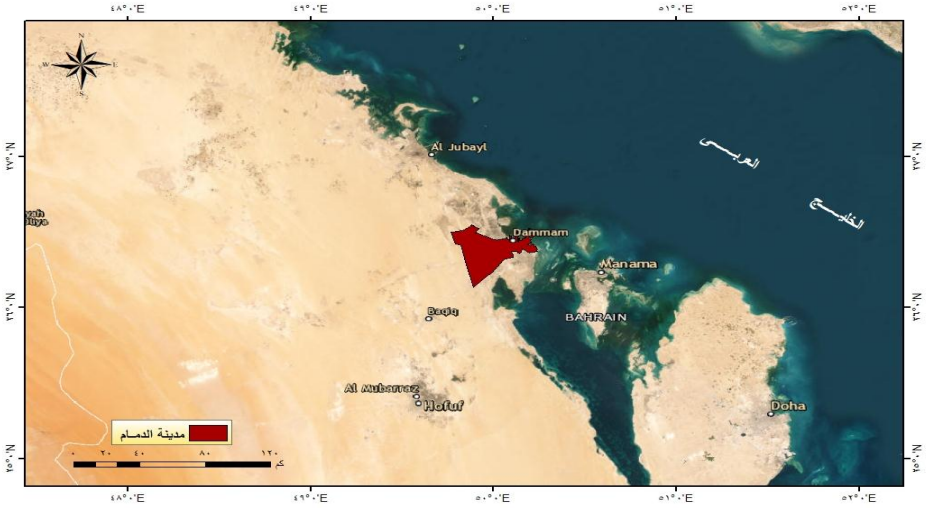

Figure (3): Satellite image showing the location of the study area

Also, it was found that other urban services, such as government services and public utility are evenly distributed. It is useful to understand the role of population distribution and the distribution of vegetation cover can be seen as the spread of vegetation cover appears in succession with the distribution of the urban range of the Dammam Governorate (Figure 4). It increases in density in the residential urban range, and its spacing in the areas of residential urbanization, forming an area of 15356 km^2, representing 19.2% of the governorate's area in 2020, and this area of vegetation has a length of 1,744.187 km to create a good environment that supports the potential presence of vegetation in the province (Table 1).

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Table (1) Change in vegetation ranges, urban range, and road lengths During the years 2000-202

Type	2000	2020	Change %
Vegetation (km^2)	13871	15356	10.7
Built-up area (km^2)	652	1050	61.0
Road lengths (km)	754.296	1.744.187	131.23

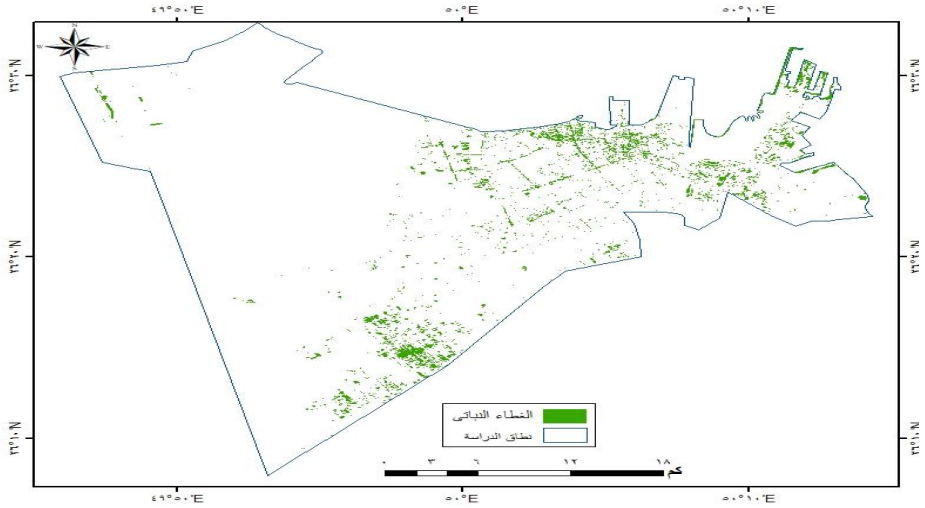

Figure (4): Vegetation ranges in Dammam Governorate in 2020

The development of the average per capita vegetation cover in Dammam governorate

The comparison between the area of vegetation cover, the urban range, and the lengths of roads between the years 2000 and 2020 (Figures 4 and 5) clearly reveals a clear growth for the three phenomena in the year 2020 (Table 1).

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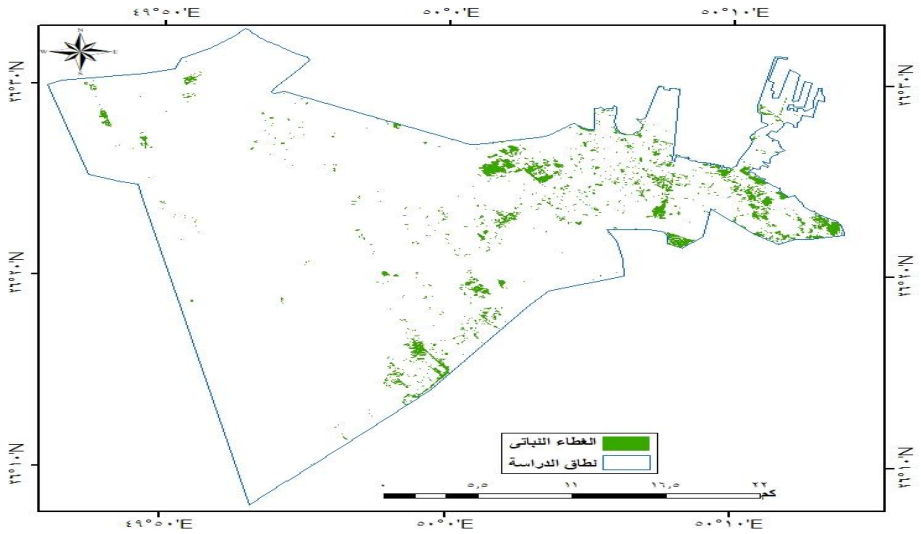

Figure (5): Vegetation ranges in Dammam Governorate in 2000

Compared to the year 2000. It is noted that the rates of change provide information about the environmental characteristics of the Dammam Governorate during the study period. The vegetation distribution sites for the year 2020 in the governorate are the same areas as they were in the year 2000 (Figures 4 and 5) with an increase in the area of green plants for the year 2020 , and its extension to new areas of Dammam city neighbourhoods according to its urban extension. This confirms the continuation of the strategy of interest in improving the environment in which the residents of Dammam Governorate live and their quality of life.

It was noted that the changes that occurred after the year 2000 necessitated an increase in the area of vegetation cover for the year 2020, and it included an increase in the urban area and an increase in the population, and this was accompanied by the establishment of the third industrial city and more government programmes that are concerned with

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developing green vegetation cover and are represented by decisions and initiatives. This led to an increase in vegetation cover in the governorate for this year, and from these facts per capita, it is possible to determine the per capita share of vegetation cover for this period (Table 2).

Table (2) Per capita vegetation cover in Dammam governorate for the years 2000 and 2020

Year	Vegetation area (m^2)	Population	Per capita/m^2
2000	13871	759	18.27
2020	15356	2500	6.14

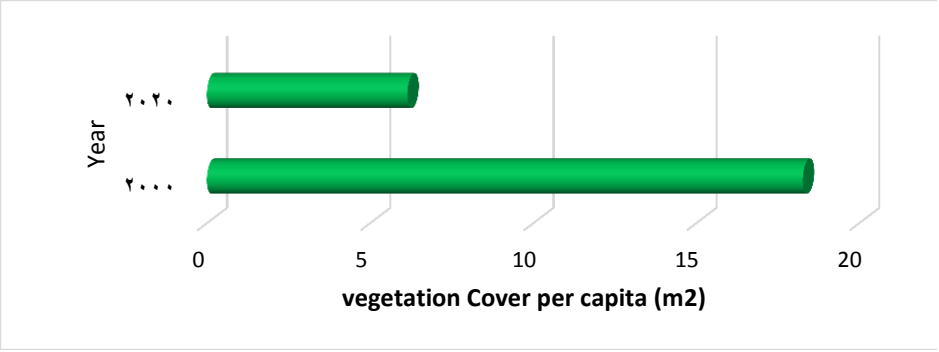

Figure (6): changes in vegetation cover per capita during the period 2000-2020

The data in table 2 and figure 6 show the capabilities possessed by the Dammam Governorate to provide an environment of social well-being for its citizens, in line with the goals of sustainability. The per capita green vegetation cover averaged 18.27 m2 per person in 2000 and decreased to 6.1 m2 per person in 2020. And despite the increase in the area of vegetation cover by 10.7% compared to the year 2000, and this decline does not negate the interest of the state and officials in maintaining the economic well-being of the individual in

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Dammam, achieving the goals of sustainability and reaching Vision 2030, several factors resulted in this decline, including the increase in the growth rate population, which amounted to 229.3%, in addition to the global disturbances such as fluctuating oil prices, the COVID-19 pandemic, the climate change crisis, the growth of the urban scale, and industrial growth, which negatively affected the preservation of that high percentage of per capita vegetation cover in Dammam Governorate, which represents social well-being and part of economic well-being. It provides a better standard of living in which the number of the population is proportional to the per capita share of vegetation cover, and according to the possibility of the governorate, it is expected that the per capita share of this service may rise and reach the rate recommended by the United Nations, which is 9 m 2 per person (Lebanon Portal for Development and Knowledge, 2018). This creates a positive result in the psychological impact of the individual and its reflection on its economic side. As well as evidence of the efficiency of the economic performance of the productive institutions in the governorate, and at the same time the members of the current generation enjoy a luxurious life, while preserving these resources for subsequent generations by increasing the area of green space (Murabit, 2018), and from another point of view, the statistics of Table 2 and with the continuation of the initiative to increase the green area during the years 2021 and 2022 enable it to surpass the targeted per capita share in the eastern region by the end of 2022 by 4.5 square metres (Al-Jubeir, 2022). This is a good thing for the citizens in Dammam Governorate, and it seems that the small area of Dammam Governorate compared to other major governorates in the Eastern Province, such as Al-Ahsa Governorate, helped it reach this percentage in per capita vegetation cover among the governorates of the Eastern Region.

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The source is based on Table 1 of the vegetation cover area:

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Sustainable development of vegetation cover in Dammam Governorate

From the previous presentation, we can conclude the features of the sustainable development of vegetation cover in the Dammam governorate, which can be classified into two parts. The first represents obstacles to the development of vegetation, the most important of which are

1- Climate variables, represented amounting to rain, average temperatures, and humidity. Dammam suffers from a lack of rain, as the average amount of rain in the winter rainy season was 1.7 mm and in the spring 4.0 mm, while the summer months are dry (Saudi Arabia). 2020, p. 28); therefore, the effectiveness of rain increases with vegetation only in the rainy season, especially with the decrease in temperatures during that period, as the winter months average 25.6 degrees Celsius and the spring 29.6 degrees Celsius, while the summer average reaches 46 degrees Celsius (ibid. p. 26). This causes the plant cover to suffer from a water deficit in the study area as a result of evaporation and transpiration processes. And where the first of them affects the percentage of soil moisture, and it has an inverse relationship with temperature and the amount of rain, as is scientifically recognized.

2. Rapid urban growth: As previously shown, the rate of increase in the urban area in Dammam Governorate in all its main residential, industrial and commercial areas exceeds the rate of increase in vegetation cover (Table 1). This may cause a decrease in vegetation cover per capita in subsequent years if it

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continues at this pace, associated with a double increase in the population of the governorate.

3. Industrial zone: The geographical distribution of industrial cities and the resulting pollution may negatively affect the growth rate of vegetation cover in the long term.

The second section of the features of sustainable development in Dammam Governorate is represented in the components of the sustainability of the vegetation cover, and the most prominent of these components are:

1- The efforts of the state in developing vegetation cover, and this is evident in what is being done by all parties concerned with vegetation cover, whether at the state or governorate level, including the announcement issued in 1440 AH by Council of Ministers Resolution No. (417) dated 7/19/1440 AH to establish the national centre for vegetation cover development, which is one of the objectives of managing and investing lands for pastures, forests and national parks, preserving plant genetic resources and vegetation outside reserves in all environments, protecting them from natural hazards, and developing national cadres for the sustainable use of vegetation cover, and among its contributions is the National Parks Program Who seeks with his projects to achieve Vision 2030 (Saudi Press Agency 1443 AH).

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Figure (7): The vegetation on the Dammam Corniche
Source: By the researcherduring a field visit on October 7, 2022.

Similarly, the Saudi Green Initiative, and in this field the role of the Ministry of Environment, Water and Agriculture, which is one of the official institutions in the country concerned with vegetation cover, announced the implementation of executive regulations for the development of vegetation cover. Covering and combating desertification, based on Article 48 of the environmental system, Royal Decree No. 165 and No. 729 of 1441 AH (Kingdom of Saudi Arabia, A 1442 AH), and the eastern region from other regions. that represents the state, with the aim of increasing the per capita share of the citizens of Dammam and improving the urban landscape through a green eastern initiative within the Saudi Green Initiative, as green spaces were planted in the gardens and streets of Dammam Governorate from February to April of this year. General on an area of 12050 square metres and the number of 1162 different trees. Seasonal flowers with more than 900,000 flowers and with

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the decision to continue their maintenance (Al-Jamaan, Sultan, 2022).

Figure (8): A neighborhood garden in Dammam
Source: By the researcherduring a field visit on October 7, 2022.

2. Increasing the cultural awareness of community members regarding the importance of vegetation cover through the impact of the COVID-19 pandemic and the role of educational and media institutions on the importance of vegetation cover for human health and its psychological impact, which helped spread the phenomenon of practicing sports in the face of the Dammam Corniche and public parks within the neighbourhoods and the Authority that have special paths, then became a familiar phenomenon for all groups of society in figures 7 and 8.

Conclusion

The results of the study revealed that the elements of sustainable development of vegetation cover in the Dammam

ISSN: 2537-0367 **eISSN : 2537-0375**

Governorate are not intended to develop vegetation by increasing the horizontal area of it only, but rather to develop and improve the environment for the development of community members and then achieve economic development. Officials in the country, such as the Council of Ministers, the Ministry of Environment, Water and Agriculture and the Eastern Province Municipality, decided on plans based on achieving the principles of sustainability. Several projects were implemented to increase the green area through affiliated units and are still continuing, which led to an increase in the vegetation area in the governorate and achieving per capita vegetation cover in 2020 m 6.14 m2 per capita, at a rate that exceeds the expected percentage of per capita. In the eastern region for 2020, which is 4.5 square metres, as expected, Al-Jubeir (Al-Jubeir, 2022), which is close to the per capita share set by the United Nations, is 9 m2 per capita (op), and this decline in per capita share. In 2020, it decreased to 6.14 m2 compared to 18.27 m2 in 2000, and this was not accompanied by a decline in the vegetation cover area. As the rate of increase in the year 2020 was 10.7% compared to the year 2000, and the urban growth rate for the same period increased by 61%, this indicates that there is a lack of proportionality between the area of vegetation cover. The urban scale in the province of Dammam, while the rate of increase in vegetation cover was less than 11%, and the rate of urban sprawl reached nearly two-thirds of what it was at the beginning of the period. Likewise, the population increase rate of 229.3% revealed a doubling of the population, in addition to global turmoil such as oil price volatility, the COVID-19 epidemic, the climate change crisis and the expansion of industrial scale. This affected the decline in per

ISSN: 2537-0367 **eISSN : 2537-0375**

capita vegetation cover for the year 2020, and despite this decline, the statistics in Table 2 show the possibility of increasing per capita share in the Dammam Governorate in 2022 from what it is. In 2020, it is possible, and with the continuation of the initiative to increase the green area in the Kingdom of Saudi Arabia and the eastern region in particular, during the years 2021 and 2022, which means an increase in per capita vegetation cover in the Kingdom of Saudi Arabia. province in the future.

However, the following measures can support sustainability of vegetation cover in the study area:

- Continuous support for the level of well-being of human societies in the region by supporting its vital system, especially vegetation cover
- More scientific research related to social well-being is needed because of its strong relationship with economic aspects
- Supporting products that preserve vegetation and meet consumer needs for various materials
- Increasing awareness and education on the importance of individuals obtaining an appropriate share of vegetation cover due to its importance in building societies economically
- Continuous development of strategic plans for the growth of vegetation cover and social welfare to keep up with all new developments and to maintain an average per capita share of sustainable vegetation cover
- Increasing per capita vegetation cover according to the concept of environmental sustainability

ISSN: 2537-0367 **eISSN : 2537-0375**

- Educating the community about climate change and soil suitability when cultivating plants
- Raising awareness of not cultivating vegetation creates pressure on natural resources
- Cooperation with the National Center for Vegetation Development and Combating Desertification to activate the objective of its projects to protect vegetation cover

ISSN: 2537-0367 **eISSN : 2537-0375**

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