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Sustainable Development and Its Impact on Reducing Carbon Footprint by Using Computer Simulation in Cairo

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Abstract: More recently, with the understanding of the climate change crisis and the energy problem resulting from the lack of renewable resources, many problems related to climate and greenhouse gas emissions have emerged The interior architecture sector of the buildings is the most energy consuming in the world, hence the need for a highly efficient interior design approach and the production of an indoor environment suited to the comfort and well-being of the individual and to the requirements of thermal adaptation and environmental requirements. In the context of Egypt's interest in and hosting of the World Climate Summit COP27 November 2022,and the modern growth trend aimed at stabilizing energy consumption, especially in urban areas, to achieve a low-carbon society, This research discusses solutions from different design strategies to reach zero energy interior space The basic objective is to promote society and its ability to improve internally, which is a fundamental Artacase tool for reducing emissions, thereby reducing its impact on the environment and providing rationalization solutions for energy and resource consumption. By selecting design materials from natural sources to improve internal climate quality as well as achieve energy efficiency and productivity s environmental and carbon footprint by reviewing how carbon footprint can be reduced to support sustainable development.

The research dealt with two parts to reach the research objective through a descriptive approach that addresses the identification and description of characteristics and variables specific to the study problem, as well as the relationships and differences between these variables: Autonomous variable - intermediary: environmental footprint and intermediate variable: carbon footprint reduction and dependent variable: Sustainable development objectives and the analytical and extractive approach to determine the impact of the environmental footprint on the achievement of sustainable development goals and its impact on the reduction of carbon footprint, which is the research mechanism's objective. And Through an applied study using simulation in Design Builder v 7.0 using green roofs in buildings in 10th of Ramadan City.

Keywords: *Sustainable Development - computer simulation - Environmental Assessment - Environmental Footprint - Carbon Footprint - CO2.*

1- Introduction:

The focus on environmental issues and their concerns has become a priority for everyone across various sectors. This is often accompanied by the concept of sustainable development. As environmental imbalances, depletion of natural resources, and pollution exceed boundaries and expectations, there is a need for a technology or indicator that allows the measurement of human consumption of natural resources in the environment and compares it with the biosphere's capacity for self-renewal. There is an interdependent relationship between the environment and sustainable development, as the environment provides the life systems that ensure our survival, including the natural resources used in production. Therefore, it is crucial to conserve and protect them through the use of environmental policy tools and highlighting their role in environmental preservation and addressing the main obstacles faced by the environment through international agreements for environmental conservation.

2- Problem:

The main challenge is to reduce the carbon footprint, reinforce sustainable development, and explore their implementation in the Tenth of Ramadan city.

3- Research Question:

How can we reduce carbon emissions and generate clean energy to enhance the environmental development indicators in the Tenth of Ramadan city?

4- Research Methodology:

The research methodology relied on the inductive and analytical systems to reach a set of terms and criteria that affect how technology is employed to serve urban spaces and attempt to improve them and the extent to which it is possible to improve the general condition of urban spaces and achieve the idea of sustainability. And Through an applied study using simulation in Design Builder v 7.0 using green roofs in buildings in 10th of Ramadan City.

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5- Theoretical Framework:

5.1 Historical Overview of the Ecological Footprint:

The beginning of the nineties of the last century witnessed the first attempts to calculate the land area and resources required to meet the needs of the population for resources and materials, as well as absorb their waste based on the geographical variation in resource consumption rates, which is known as the term ecological footprint, which appeared as one of the results of the Earth Summit held in Rio de Janeiro in 1992, after William Reyes published the first academic publications that addressed the impact of the urban economy and its relationship to the ecological footprint and biological capacity, which came under the title (Ecological Footprint and Appropriated Carrying Capacity: What Urban Economics Leaves Out),

who was able, in collaboration with Matthijs Wackernagel, to develop the concept of the "ecological footprint" as a planning tool to visualize and develop sustainability, to spread the use of the concept in environmental monitoring and resource use after publishing a book entitled "Our Ecological Footprint: Reducing Human Impact on Earth" (Wackernagel, 1994)

5.2 Ecological Footprint Concept:

The ecological footprint represents two sides: demand side and supply side. The demand side, the ecological footprint measures the demand of an individual or population for food products and plant fibers, animal products and fish, timber and other forest products, urban infrastructure area, and forests to absorb carbon dioxide emissions from fossil fuels. While the supply side represents the biological capacity of a city, state, or country to produce biologically productive land and sea, including forest land, pasture land, crop land, fishing grounds, and built-up land. (What is the Ecological Footprint, 2016)

5.3 The definition of sustainability

 The term sustainability was first used in the 1980s to mean human sustainability on planet Earth, which paved the way for the most common definition of sustainability and sustainable development, as defined by the United Nations Commission on Environment and Development in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." At the 2005 World Summit, it was noted that achieving this requires reconciling social, environmental and economic demands, which are the "three pillars" of sustainability. (World Commission on Environment and Development, 1987.)

 Sustainable development is defined as meeting basic human needs, integrating environmental development, achieving equality, ensuring social self-determination and cultural diversity, and preserving the environmental integrity of present generations while ensuring the rights of future generations to development (Klarin, Tomislav, (2018))

Diagram of the origin and development of the concept of sustainable development

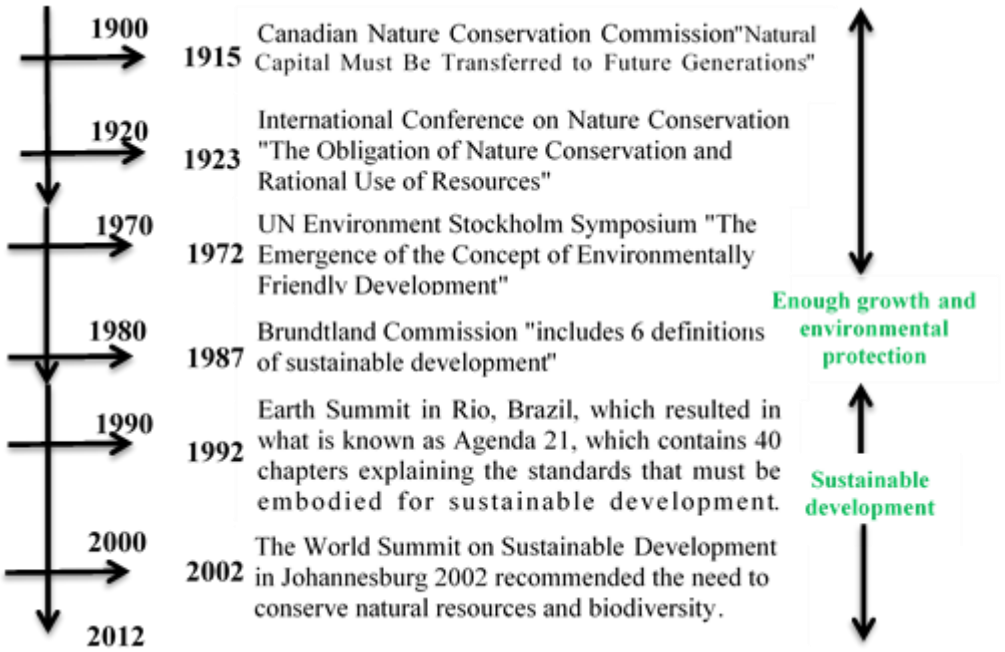

Fig No. (1)

Source: Extracted from (Shahrazad Zaghib and Lamia Omani, 2011)

5.4 Sustainable Development Goals:

The 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development officially came into effect on January 1, 2016, adopted by the world in September 2015 at a historic UN summit. Over the next fifteen years, countries will work with these new goals, which apply globally to everyone, to mobilize efforts to end poverty in all its forms, combat inequality and address climate change. Among the most important plans that have an impact on the environment are:-

1. Climate action

2. Life on land

3. Sustainable cities and communities

4. Clean and affordable energy

5. Industry, innovation and infrastructure

Source: (Sustainable Development Goals, 2015)

5.5 COP27 Conference:

The Minister of Environment called on everyone to participate in climate action and the state's efforts to prepare for the upcoming climate conference COP27, and to come up with an honorable model that shows the world Egypt's ability to lead climate action. It is worth noting that the National Environment Day is a national occasion that aims to raise awareness of environmental issues and challenges, encourage citizens to adopt positive behaviors towards the environment, confront national environmental challenges, and preserve natural resources for future generations. This occasion is a clear example of the growing interest at the official and national levels in Egypt in environmental issues and an affirmation of the role of civil society in highlighting its efforts to preserve and develop the environment, after the approval of Prime Minister Dr. Mostafa Madbouly, to adopt January 27 of each year to celebrate the National Environment Day in Egypt starting in 2020, as January 27 was chosen to commemorate the day on which the first law to protect the environment was issued in Egypt, which is Law No. 4 of 1994. It also represents a true partnership between the Ministry of Environment and civil society, and celebrates the efforts of a group of citizens keen on preserving the Egyptian environment and its advancement. (Source: Ministry of Environment)

Fig No. (2)

(Source: https://www.iucn.org/events/large-event/iucn-un-climate-change-conference-cop27)

The National Research Center indicated that a discussion session was held to present the results of a study entitled: "Preliminary Indicators.. Climate Change and the Awareness of the Egyptian Citizen", which came out with a number of recommendations for the participating experts, which were as follows: -

1. Rely on natural lighting whenever possible.

2. Put garbage and waste in designated places.

3. Turn off electrical appliances and lights when not in use.

4. Introduce climate change through school curricula.

5. Spread awareness of climate change.

6. Reduce the use of chemicals such as pesticides and cosmetics.

7. Walk or use a bike for short distances

Source: Ministry of Environment

5.6 Carbon footprint concepts:

- The European Commission defined it as the total emissions of carbon dioxide and other greenhouse gases, which are caused by individuals or institutions as a result of daily life, and which leave their impact on the surrounding environment.
- The Central Bank defined it at the COP27 Climate Summit as an indicator for measuring the rates of harmful gas emissions such as carbon dioxide, methane and other gases that cause global warming and climate change.
- The phenomenon of greenhouse gases is defined as "gases in the atmosphere that have the ability to absorb sunlight and retain heat on the Earth's surface. All gases in the atmosphere have the same ability, but carbon dioxide, methane, and water vapor come at the top because they have a greater capacity to retain and trap heat and their high percentage in the atmosphere compared to other gases.
- In English, Carbon Footprint is the total greenhouse gases resulting from industrial, service, or personal emissions. Measuring it is an attempt to reduce the

negative effects of those emissions. In most cases, the total carbon footprint cannot be calculated exactly due to insufficient knowledge and data on the complex interactions between the contributing processes, including the effect of natural processes that store or release carbon dioxide into the atmosphere.

- Kemp and Williams defined it as "a measure of the total amount of carbon dioxide (CO2) and methane (CH4) emissions for a given community or activity, taking into account all relevant sources, sinks, and reservoirs within the spatial and temporal boundaries of the community, system, or activity under study. It is calculated as a carbon dioxide equivalent using the relevant probability of a 100-year global warming event. It is known as an indicator through which the amount of carbon dioxide emissions resulting from the combustion of fossil fuels, including (petroleum and its derivatives, coal and natural gas (used in energy production (HARRIS, Apr 2015) is expressed)
- It is known as the amount of greenhouse gases emitted into the atmosphere due to a certain human activity, such as carbon dioxide, methane (CH4) and nitrous oxide (N2O), and also has a significant impact on global warming
- Many people use the energy footprint and the carbon footprint terms interchangeably, because most of the emissions of a person, product or institution come from the use of energy based on fossil fuels. (Matthew John Franchetti & Defne Apul, 2013)
- The global network of environmental footprints considers the carbon footprint as part of the ecological footprint. Carbon uptake is defined as the biological capacity required to sequester carbon emissions resulting from the consumption of fossil fuels through the process of photosynthesis. That is, it is the biological capacity required (such as forests) to absorb the amount of fossil carbon that the oceans cannot absorb.
- Refers to "the land area required to absorb the carbon dioxide produced by humans during their lifetime". The carbon footprint is calculated as carbon dioxide equivalent using the 100-year global warming potential (Pandey, D., Agrawal,, 2011)
- It is a term used "as a shorthand for the amount of carbon (usually in tonnes of carbon equivalent) emitted by any activity or organization. The carbon footprint combination goes beyond this definition by translating this amount of carbon dioxide into the area of forest required to absorb carbon dioxide emissions"

5.7 Carbon footprint measurement methods

The measurement is done through 3 steps:

1- Selecting the type of greenhouse gases required.

2- Setting limits.

3- Collecting data on the greenhouse gas emissions required for the study area.

(Pandey, D., Agrawal,, 2011)

- **A net-zero building**

is a building that has been designed, constructed, operated, and demolished/dismantled according to green building standards that ensure high efficiency in the use of resources and in return offsets all associated carbon emissions from renewable energy sources.

✓ **According to the World Green Building Council:**

Is a building characterized by high energy efficiency such that all remaining energy consumed is offset from renewable resources on-site or off-site. "According to the World Green Building Council. (Neutral buildings in Jordan, Energy and Climate Project, 2020)

5.8 Green Bonds

- It is defined as "a financial instrument issued by governments, the private sector, commercial banks, or international financial institutions (for example, the World Bank issued the first green bond in 2008), and the proceeds of these green bonds go only to support specific projects that meet pre-determined criteria for low-carbon development, and these bonds have been widely welcomed by environmentally sustainable investors" (Green Bonds, 2021)
- Green bonds are considered an independent variable in the research, and can be defined procedurally as: "A form of debt instruments, and a debt instrument is a legal contract for a borrowing relationship that can be traded by buying and selling between parties, and entities seeking financing have two main options for raising funds, stocks (ownership shares) and bonds, as bonds are a form of borrowing"

6- 1- Previous studies and global experiences at the city level UAE Experience - 2016

(Al-Rahman, 2016)

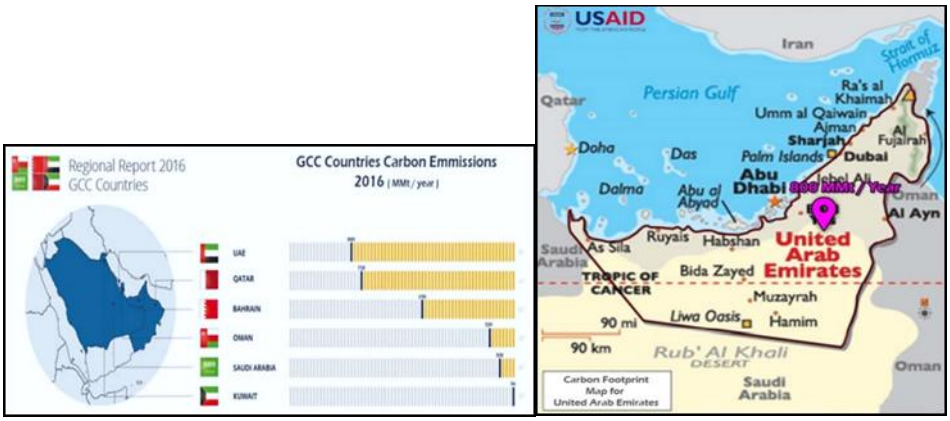

Fig No. (4)

Source: Prepared by the researcher based on (Clean Low-Emission Construction, 2016)

The United Arab Emirates is classified as one of the largest Arab countries exporting greenhouse gases, and it also ranks first in the Middle East and the Gulf Cooperation Council countries, according to the Gulf Cooperation Council reports for 2015, that the share of the Emirates alone in the volume of emissions amounted to about 760 million tons of emissions annually.

* The dry desert climate in the country is a case similar to the spatial conditions of the city of Tenth of Ramadan, and desert cities are among the cities that will certainly be affected by global warming in the medium term. (Clean, low-emission construction, 2016)

One of the most important manifestations of urban deterioration resulting from climate change in the UAE is:- (Desertification, which has several factors, the most important of which are):-

1. Overgrazing, which helps to remove the tree barriers that stand in the way of desertification.

2. Cutting trees, which reduces the green area, which opens the way for sand to expand, which acts as storage units for carbon dioxide gas.

3. Urban sprawl, environmentally unfriendly human activities and pollutants.

4. Climate impacts such as lack of rain and soil erosion.

To reduce desertification, the state has taken important steps, including: -

- Adopting a global plan to reduce desertification
- Developing vegetation cover and stopping its deterioration and removal in an unplanned manner
- Reducing the impact of soil erosion
- Following an urban policy based on environmental foundations and managing natural resources in a manner based on sound scientific foundations

*This is in addition to the sectoral problems resulting from industry, transportation and energy, as they represent the largest percentage of the state's sectors from which emissions are issued at all, at about 52% of the state's total emissions. (Clean, Low-Emission Urbanization, 2016)

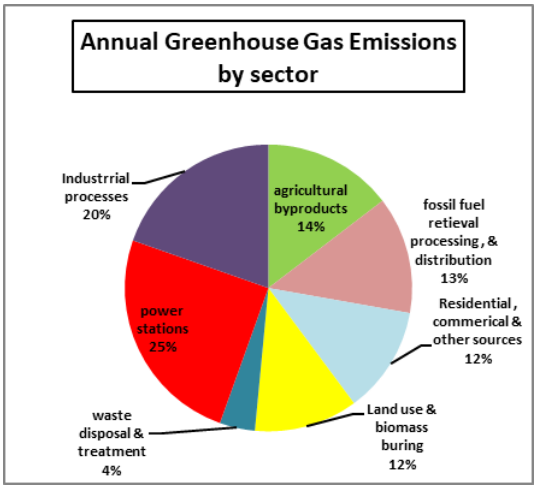

Fig No. (5)

Source: Prepared by the researcher

6.2 Acitywide experience

Beijing's Experience in China

China tops the list of the most polluted countries in the world, even the international media.

During the year 2010, I covered pictures of the capital, Beijing, covered in thick smoke, which affects daily life in Chinese cities, and China is considered number one in the world in producing global warming emissions. Beijing is one of the Chinese cities that suffers most from air pollution and high levels of carbon dioxide. The results of a study conducted by the Asian Development Bank showed that 7 Chinese cities are among the top 10 countries in terms of air pollution. Only 1% of the 500 major cities in China adhere to the World Health Organization's air standards, according to another study conducted by Peking University and Greenpeace.

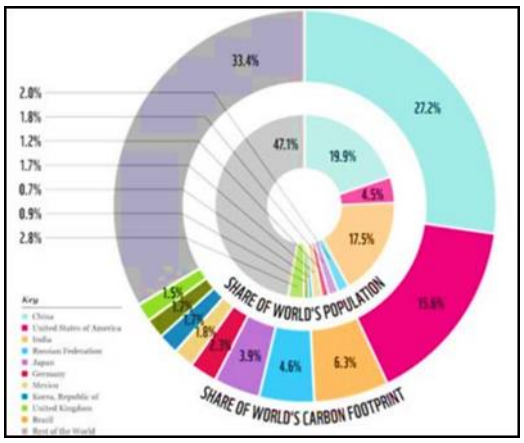

Fig No. (6) Source: Ali.2018

The most important measures taken by the Chinese government to mitigate the effects of harmful emissions over the next 10 years on the capital Beijing: (Ali, 2018)

1- Activating mechanisms and controls on major industrial societies regarding reducing pollution emitted from chimneys so that this rate reaches global rates, as these mechanisms include the following:

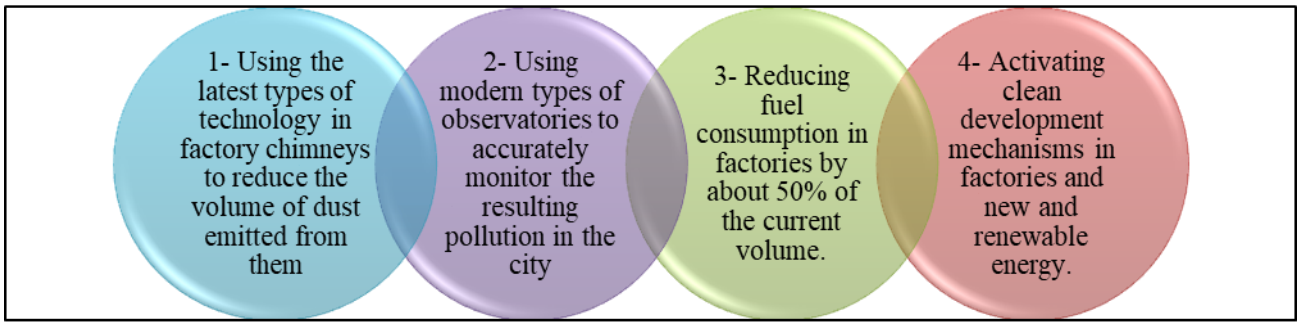

Fig No. (7)

Source: Prepared by the researcher based on Ali, 2018

This is in addition to enacting a set of strict laws that oblige decision-makers and factory owners to activate these mechanisms and procedures.

2- Using modern mechanisms in transportation such as clean transportation and sustainable transportation, the most important of which are:-

• Using electric cars.

• Activating the largest mass transportation system in Asia, including transportation by bus, tram and integrated railway lines.

• Reducing the amount of fuel annually in cars using fossil fuels.

• Using modern technology in transportation that reduces the amount of emissions.

Example:-

"Guangzhou" is one of the Chinese cities that has reached development in the transportation sector, to become more environmentally friendly, through the use of "Trans Lelano" buses, which is similar to the system followed in the Colombian capital, Bogota, which depends on a plan to operate buses on their own roads, and link them with roads that connect to the suburbs of other cities, in addition to building special roads for bicycles in the middle of large green spaces, to absorb pollutants resulting from buses.

3- The most important strategies followed in Beijing at the level of residential buildings:-

• China has been interested in activating green architecture systems in residential buildings.

• Reducing the annual electricity consumption.

Planting the roofs of public buildings and residential areas whenever possible to operate on air technology.

The most important recommendations followed to reduce the carbon footprint and greenhouse gas emissions through previous studies, which are:-

(Efforts to deal with climate change, 2021)

(At the state level)

1) Reaching a rate of 100% use of clean energy by establishing a number of renewable energy stations spread throughout the country, represented by (solar - wind - thermal energy)

2) Focus on mass transportation mechanisms and sustainable transportation to reduce the carbon footprint resulting from private vehicle fuels. 3) Reuse of treated wastewater by more than 95%

4) Raise the efficiency of water supply and rationalize consumption to the maximum possible limits

5) By 2030, the city will be completely free of all types of polluting industries and will move entirely towards technological industries.

6) Recycling waste: When recycling 1 kg of aluminum, we save 9 kg of carbon dioxide emissions, and recycling 1 kg of plastic saves 1.5 kg of carbon dioxide.

7) Planting the largest areas of afforestation and green oases in the country, and these areas act as natural reservoirs for carbon dioxide. 8) Approving the largest project in 2017 regarding storing carbon dioxide in huge reactors and reusing it again in reducing iron in manufacturing processes. 9) Developing a set of legislation and regulations aimed at preserving the soil, protecting plants, trees, biodiversity, and combating desertification. In this direction, the state has prepared agricultural lands and distributed them to citizens, as well as providing annual support to farmers, which has had a significant impact in encouraging agriculture, which in turn works to combat desertification.

(At the city level)

1) Using new and renewable energy to rely on energy production such as wind, sun, and water.

2) Reducing the use of nuclear reactors to produce energy.

3) Reducing the use of fossil fuels and petroleum derivatives in factories due to the damage they cause to the environment as a result of combustion.

6.3 The Tenth of Ramadan city:

10th of Ramadan City is one of the first new cities (first generation cities) that the state has planned and has grown over the past 30 years to become the largest industrial city in Egypt.

- -10 th of Ramadan City was established in 1977 as an integrated city with easy access to Cairo, Port Said, Ismailia and Suez.

1. -It is considered the largest industrial city, comprising about 1,400 factories, with an annual production volume of more than 75.42 billion pounds, and employing about 188,166 workers at present.
2. - The population is estimated at260000 people.

Fig No. (8)

Source: Team analysis, the included specializations, the city's apparatus data, the Central Agency for Public Mobilization and Statistics, the city's apparatus website

- Definition of the location of the Tenth of Ramadan City, the subject of the research study

It is a city located in the Sharqia Governorate in Egypt and is affiliated with the Urban Communities Authority. It is considered one of the first generation cities and one of the largest new industrial cities. It was established by Presidential Decree No. (249) of 1977 AD, in order to attract foreign, Arab and local capital in order to provide job opportunities for young people, as well as to attract population growth outside Cairo and the valley.

- General location of the city

The city is located on the Cairo-Ismailia desert road at kilometer 46 from Cairo, and is 20 km away from the city of Belbeis. It is connected to the regions of East and Central Delta, the Canal and Sinai by a network of expressways, in addition to its proximity to Cairo International Airport. The Tenth of Ramadan City is distinguished by its unique location among these regions, and the city has two entrances on the Cairo/Ismailia desert road, the first at kilometer 51 and the second at kilometer 56.

- The city's surface area is estimated at about 98 thousand tons according to the proposed strategic plan in 2009.
- The current population, according to the New Urban Communities Authority's estimate, is 680 thousand people and is expected to reach about 950 thousand people by 2030.
- The city's main economic base is industry.
- The number of factories operating in the city is estimated at about 1935 out of a total of 3118 factories with a construction rate of about 62% and operates in all types of different industries known in the Egyptian economy.

- Map of the distribution of industries in the city of Tenth of Ramadan for the year 2022

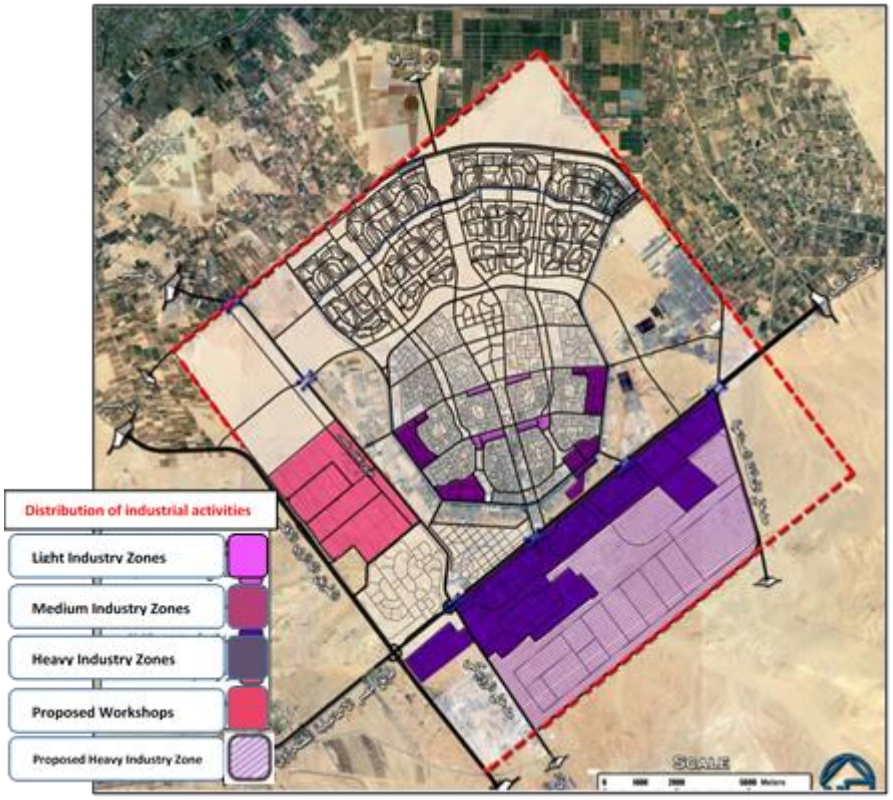

Fig No. (9) Source: Prepared by the researcher based on maps of the Industrial Development Authority

✓ **Formulating mathematical equations to measure the carbon footprint**

Source: (European Environment Agency .2015)

Emissions from all sectors during a year are calculated using the following mathematical equations:

1- Housing sector:-

Total emissions from the activities of residents in residential units in the city during a year:-

Total population * GDP per capita of national carbon footprint * FE

FE: Factor Effect of Co2 = 1

Total population emissions from breathing:-

Total population * 1 kg of Co2 per day * 365* FE

FE: Factor Effect of Co2 = 1

2- Industrial activities sector:-

✓ Electricity consumption emissions in the city:-

Total electricity consumption in all different sectors (kWh) * Emissions volume resulting from generating 1 kWh per year

Total Electricity use (k.w.h) per year * emissions of Co2 per (1 k.w.h) in year * FE

FE : Factor Effect of Co2 = 1

emissions of Co2 per (1 k.w.h) in year = 0.00094000 ton Co2

- ✓ **City** water **consumption emissions:-**

Total weater per year (m3) * emissions of Co2 per year per (1 m3) produce * FE

FE : Factor Effect of Co2 = 1

Emissions of Co2 per year per (1 m3) produce year = 0.00043345 ton Co2

- ✓ **City natural gas consumption emissions:-**

Total Natural gas use (Cubic feet) in year * emissions of Co2 per year per (1 cubic feet) * FE

FE : Factor Effect of Co2 = 1

Emissions of Co2 per year per (1 cubic feet) = 53 kg

- ✓ **City waste consumption emissions:-**

Total weight of waste per day * Total CH4 Emissions of 1 kg of waster per day * 365 * FE

FE: Factor Effect of CH4 = 25

Total CH4 Emissions of 1 kg of waste per day = 1.4 kg

3- Transport and Roads Sector:-

Total estimated amount of liters consumed during the year * Emissions resulting from burning one liter of gasoline (2.1 kg)

Total liters of gasoline per year * Emissions of Co2 per 1 liter * FE

FE: Factor Effect of Co2 = 1

Emissions of Co2 per 1 liter = 2.1 kg

4- Green Areas and Agricultural Soil Sector:-

Total area of the area required to calculate its emissions (in hectares) 8 Amount of nitrous oxide emissions according to the type of fertilizer used.

Total area of agricultural (Ha) * Emissions of N2O per (Ha) per year * FE

FE : Factor Effect of N2O = 310

(N2O) Emission of Farmland (Elizabeth Verhoeven , 2017)

5- Services sector and other uses in the city causing emissions:-

- All types of services in the city that cause emissions directly or indirectly are identified and their numbers are limited.

- Then their emissions are calculated using the following equation:-

Type of service * Number * Estimated emissions volume in one year

And through previous studies of international experiments and experiments at the city level, one model of which was presented, and indicators for measuring the carbon footprint were deduced and applied to the Tenth of Ramadan area, as shown in the following table.

Source: Prepared by the researcher (based on previous studies)

Table No. (1) Measuring the carbon footprint of each sector separately and the total for the city of Tenth of Ramadan using the rates

Total CO2 equivalent emissions in each sector (in tons equivalent/year) - (carbon footprint)	Gas impact factor			Total emissions in tons			Source of emissions from different city sectors	Type of emissions produced	Uses
ton Co2 equivalent	impact factor N2o	impact factor Ch4	impact factor Co2	N2o	Ch4	Co2			
286525	310	25	1	0	0	286525	Population (respiration(	Direct emissions	Housing

2085663				**0**	**0**	**2085663**	**Housing units**		
1106850				**0**	**0**	**1106850**	**Electrical energy consumption**	**indirect emissions**	
22805				**0**	**0**	**22805**	**Water Consumption**		
320900				**0**	**12836**	**0**	**Waste production**		
1823104				**0**	**0**	**1823104**	**Industrial activities**	**Direct emissions**	**Industry**
2391068				**0**	**0**	**2391068**	**Natural gas consumption**		
1660275				**0**	**0**	**1660275**	**Electrical energy consumption**	**indirect emissions**	
14999				**0**	**0**	**14999**	**Water Consumption**		
1163586				**0**	**0**	**1163586**	**Direct emissions**		**Road network and transportation**
226610				**731**	**0**	**0**	**Direct emissions**		**Green areas**
498082.5				**0**	**0**	**498082.5**	**indirect emissions**		**Services and other land uses**
11600467.5	**Total**								

To judge the size of the city's carbon footprint, the current status index of the footprint must be compared to the globally desired status index, which is the UNHABITAT classification index for cities with less than one million inhabitants and mixed uses, as follows:

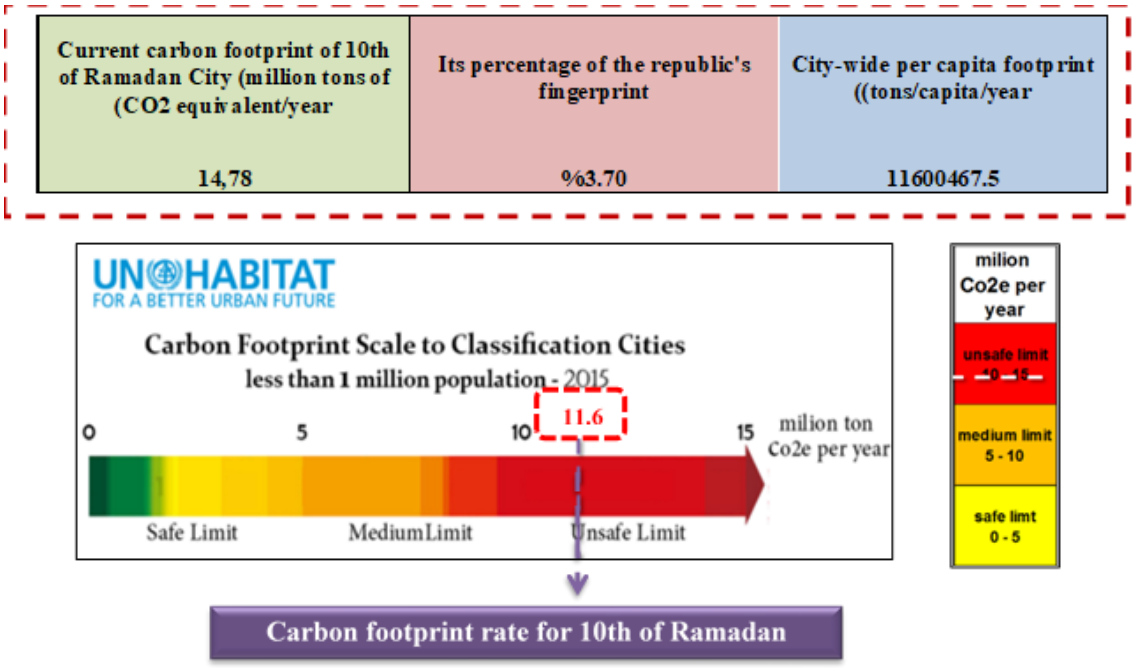

Fig No. (10)

Source: United Nations Human Settlements Programme

*The United Nations Human Settlements Programme (UN-HABITAT) index for cities under one million was applied to the city under study because its estimated population for the year 2023 is 680 thousand people. Through the above comparison of the carbon footprint of Tenth of Ramadan with the categories of the global index for the desired situation, it is clear that the city of Tenth of Ramadan falls into the unsafe category (10-15) million tons of emissions annually. This constitutes unsound environmental practices on global warming in the long term, as the city is under one million people.

7- Simulation study:

Simulation results for a building in the administrative office building in 10th of Ramadan city for the carbon dioxide emissions rate in the basic case and after using green roof for the building:

- the simulation was done using Design builder v7.0 for the carbon dioxide emissions rate in the base case and after using green roof for the building:

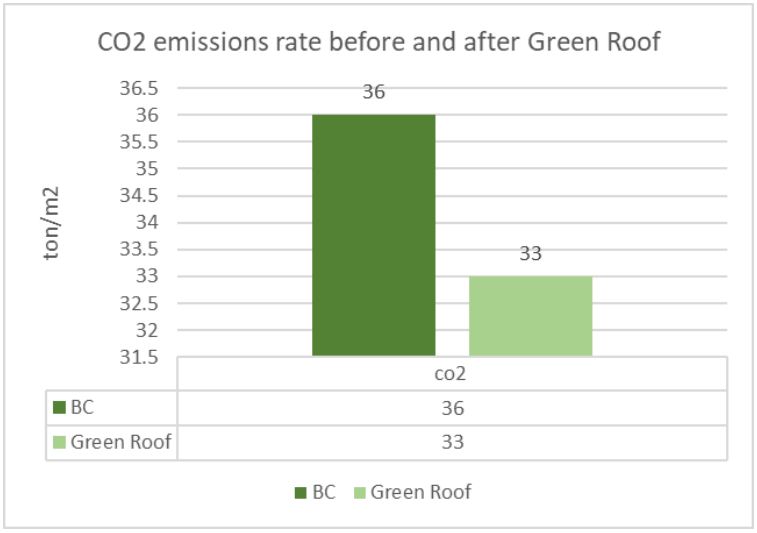

Fig (11) shows the rate of carbon dioxide emissions before and after using Green Roof for the building.

The results indicate a 8.33% reduction in carbon dioxide emissions compared to the base case after using Green Roof for the building

8- Conclusion:

To determine the environmental situation and address the various environmental problems, there are many challenges that stand in the way of protecting the environment, due to pollution, climate change and environmental imbalance, and in return, knowing the extent of achieving sustainable development, given that the topics are interconnected.

However, this did not prevent there from being indicators that can be relied upon to determine the extent of the possibility of achieving sustainable development and the ability of the natural environment to determine itself, and perhaps the carbon footprint is one of the most important things that can be relied upon, whether at the individual, international or continental level. It is an indicator that expresses the amount of CO2 emissions resulting from the combustion of fossil fuels and which are emitted into the atmosphere, and the level of sustainability of a particular society's lifestyle and the extent of its impact and harm to the environment is measured.

In order to integrate environmental indicators with sustainable development indicators, the carbon footprint was an important technology for this. From it, we conclude the following results:-

1. Reducing the carbon footprint is an important step in achieving sustainability by meeting the needs of current generations and preserving the rights of future generations.

2. The carbon and environmental footprint contributed to guiding the natural resources of the environment and preserving its renewable capacity.

3. The results of this type of measurement are not very accurate, because it measures a virtual ecosystem, but this does not prevent this type of measurement from contributing to the adoption, use and development of clean technology in order to achieve sustainable development, and considering it an alternative that has a role in reducing the carbon footprint.

4. By applying the extracted carbon footprint value to the image of the 10th of Ramadan area to the desired value in the UNHABITAT classification, it becomes clear that it falls into the unsafe category (10-15) million tons of emissions annually**.**

9- The most important recommendations and strategies concluded

1. Accelerating the enactment of energy laws and legislation in developing countries, with the help and support of international organizations, is necessary to stimulate the production of clean energy through housing and stimulate the exchange between the state's joint electricity grid and electricity generation units within the home, thus providing incentives for the production of electricity from clean local energy, which helps raise environmental development indicators.

2. Developing parallel development policies presented by developers and urban planners to improve the environmental quality of urbanization and meet population needs with sustainability as one of the main goals of urban development from an environmental footprint perspective.

3. Developing building requirements and codes for industrial zones in a manner that is consistent with and contributes to developing the environmental footprint of industrial zones in the Arab Republic of Egypt in light of Vision 2030.

4. The technology of generating electricity from solar cells and batteries for storage must be settled in developing countries, especially Egypt, which is one of the brightest countries and is trying to stimulate its use for the population and areas with an average standard of living, and disseminating it, and motivating its users to produce electricity, and providing soft loans for the repayment period.

5. Designing indicative development plans from the perspective of the environmental footprint for various sectors of cities according to the foundations and standards associated with them to facilitate the process of material development aimed at achieving sustainability.

6. Dividing the indicators related to the environmental footprint into indicators for developing and developed countries to obtain higher accuracy in the results of sustainability assessment from the perspective of the environmental footprint.

7. Developing a mathematical equation for the indicators of the environmental footprint for various sectors in urban development and dividing the indicators related to the environmental footprint into indicators for developing and developed countries to obtain greater accuracy in the results of sustainability assessment from the perspective of the environmental footprint, which is what the national procedures organizations related to the footprint sought (national footprint calculations).

8. Treating used water by converting wastewater or sewage water into water that can be reused for other useful purposes that may include irrigating gardens and fields.

9. Heating water with solar energy by converting sunlight into heat to heat water using a solar thermal collector.

10. Reaching the role of the competent authorities in collecting detailed data related to the various sectors in urban development, for example, the average number of daily visits on each road through the intersections that define it for higher accuracy of results. 11. Applying

sustainable transportation mechanisms to all roads, especially those that cause the highest rates of emissions (roads with high traffic pressure).

References

[1] The official portal of the UAE government. (2021). Efforts to address climate change. United Arab Emirates: Ministry of Climate Change and Environment.

[2] Amal Saad Al-Jawhari Al-Jawhari. (2022). Environmental impact assessment of industrial areas in new cities. Case study: 10th of Ramadan City. Journal of Architecture, Arts and Humanities.

[3] Sustainable Development Goals. (2015). Retrieved from the United Nations: https://www.un.org/sustainabledevelopment/ar/sustainable-development-goals/

[4] China's transition to a low-carbon economy and building resilience to climate change requires shifts in resources and technologies. (2022). Retrieved from World Bank: https://www.albankaldawli.org/ar/news/press-release/2022/10/12/china-s-transition-to-a-low-carbon-economy-and-climate-resilience-needs-shifts-in-resources-and-technologies

[5] Khairat Mohamed Barakat. (2018). Annual Bulletin of Environmental Statistics. Egypt: Central Agency for Public Mobilization and Statistics.

[6] Sarah Nouran, and Sarah Bani Yassin. (2020). Net-Zero Buildings in Jordan, Energy and Climate Project. Jordan.

[7] Shahrazad Zaghib, and Lamia Omani. (2011). Environment and Sustainable Development. Journal of Economics, Management and Business Sciences.

[8] 8Shaimaa El-Sayed Fadel El-Zalat. (2022). The Role of Green Growth in Supporting the Energy Sector in Egypt Challenges and Solutions. Egypt. Retrieved from /https://www.un.org/sustainabledevelopment/ar/sustainable-development-goals

[9] Ghada Mousa Razouki, and Maitham Hassan Mahdi. (November 2014). Sustainable urban development in the historic center of Karkh. Journal of Engineering, 1-28.

[10] Official website of the General Secretariat of the Gulf Cooperation Council. (2016). Clean, low-emission construction. Gulf Cooperation Council.

[11] . Mustafa Yahya. (2019). Assessing the sustainability of Egyptian urban communities using ecological footprint criteria. Faculty of Regional and Urban Planning - Cairo University.

[12] Nada Khalifa Muhammad Ali Al-Rikabi. (2022). Ecological footprint and planning to crystallize the environmental image of the Iraqi city. Al-Karrada Al-Sharqiya area.

[13] Alessandro Galli , J. W., G. C., & E. E. (1 September 2013,). A Footprint Family extended MRIO model to support Europe's transition to a One Planet Economy. Science of The Total Environment, Pages 813-818.

[14] Ali, G. (2018). Climate mitigation, low-carbon society and dynamism of educational institutes in a low-income country. Environmental Science and Pollution Research.

[15] Bastianoni, S., V. Niccolucci, & Elena Neri. (2013). Ecological Footprint as accounting tool for sustainable development. researchgate.

[16] 16. Bulkeley, H. (2010). Cities and the Governing of Climate Change. Annual Review of Environment and Resources, 229-253.

[17] Galli, A. (2023). Ecological Overshoot: Supporting state and nonstate actors to implement the Ecological Footprint. Global Footprint Network.

[18] HARRIS, D. (Apr 2015). THE ADVANTAGES OF DESIGNING HIGH-RESISTANCE SWIRL CHAMBERS. ONdrugDelivery Magazine, pp 10-13.

[19] Klarin, Tomislav. ((2018)). The Concept of Sustainable Development:From its Beginning to the Contemporary Issues. Zagreb International Review of Economics & Business, pp. 67-94.

[20] Matthew John Franchetti, & Defne Apul. (2013). Carbon Footprint Analysis Concepts, Methods, Implementation, and Case Studies. Taylor & Francis.

[21] Pandey, D., Agrawal,. (2011). Carbon footprint: Current methods of estimation. Environmental Monitoring and Assessment, 135–160.

[22] Wackernagel, M. (1994). Ecological footprint and appropriated carrying capacity : a tool for planning toward sustainability. University of British Columbia.

[23] World Commission on Environment and Development. (1987.). Report of the World Commission on Environment and Development: Our Common Future. United Nations General Assembly.

[24] Abdin, A. R., El Bakery, A. R., & Mohamed, M. A. (2018). The role of nanotechnology in improving the efficiency of energy use with a special reference to glass treated with nanotechnology in office buildings. Ain Shams Engineering Journal, 9(4), 2671-2682.

[25] Ali, M. A. M., & Khalifa, D. H. A. E. M. (2023). Enhancing Environmental Sustainability in University Buildings: The Role of Green Walls and Smart Agriculture in Mitigating Carbon Dioxide Emissions Across Varied Egyptian Climates. Journal of Survey in Fisheries Sciences, 10(1S), 7113-7128.