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Climate Change and Its Social, Economic, Environmental Implications: Case Study in Egypt

Abeer Mohamed Abd El Razek Youssef

Econometrics of Statistical Department, Faculty of Graduate Studies for Statistical Research, Cairo University, Giza, Egypt

Email address:
abeer_yussef@yahoo.com

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Abstract: The issue of climate change represents one of the most prominent crises that the world is experiencing at the present time, which has left devastating effects on life in many regions, and international organizations and institutions have moved for it, asking the major industrialized countries to limit their activities that increase global warming. During the past years, specifically in 2021, the world witnessed a series of natural disasters, resulting from global warming and climate changes, represented by unprecedented floods, fires, avalanches, earthquakes, and volcanic eruptions, and all of this resulted from an increase in global warming. Climate change is fundamentally a development issue. It threatens to exacerbate poverty rates and harm economic growth. At the same time, how different countries grow and the investments they make to meet the energy, food and water needs of their citizens either fuel climate change and increase risks around the world or contribute to finding solutions. This paper seeks to highlight the key aspects in the development and innovation to provide many important applications of nanotechnology in renewable energy systems. And the application of environmental nanotechnology solutions in climate sustainability. This paper provides a framework for addressing issues related to nanostructures, to give an overview of the role of nanotechnology in improving different sources of renewable energies, and to review current challenges to address climate change. This research highlights the role of nanotechnology in environmental treatment of pollutants and thus mitigating the impact of climate change.

Keywords: Greenhouse Gases, Risks to Health, Carbon Emissions, Clean Water, Nanotechnology, Egypt

1. Introduction

Global warming and changes in climate have major implications for agriculture, affecting ecosystems and the benefits they provide to societies. This increasingly affects crop and livestock production, agricultural soil and water resources, and food security. The effects of climate change are expected to intensify, causing more extreme weather events such as droughts, floods, heat waves and unpredictable rainfall distribution, all of which pose a threat to food security and can make agricultural production difficult, if it was not impossible. The situation could be further exacerbated by the acceleration in the release of greenhouse gases into the atmosphere from the soil, leading to global warming. Ecosystems that are already fragile will be affected, causing severe land degradation and further jeopardizing food security.

2. The Sources of Climate Fluctuations

Human activities have become the main cause of climate change, mainly due to the burning of fossil fuels, such as coal, oil, and gas. Burning fossil fuels produces greenhouse gas emissions that act like a wrap around the globe, trapping the sun's heat and raising temperatures.

Examples of greenhouse gas emissions that cause climate change include carbon dioxide and methane. These gases are produced, for example, by using gasoline to drive cars or coal to heat buildings. Land clearing of weeds, shrubs and deforestation can also release carbon dioxide. Landfills are a major source of methane emissions, and the production and consumption of energy, industry, transportation, buildings, agriculture, and land use are among the major emitters [1].

2.1. Indicators of Climate Change in the World

Climate experts have warned of a catastrophe threatening the planet due to climate changes, which will change the shape of the Earth as we know it at the present time. From the occurrence of water scarcity, followed by displacement, in addition to the extinction of various types of plants and animals [2].

The draft report warned of millions of people being exposed to extreme poverty, and an increase in displacement rates, especially by 2050, which could witness the displacement of hundreds of millions of coastal city dwellers due to rising sea levels, in addition to hundreds of millions who will face water scarcity, and in turn, severe heat waves will threaten Hundreds of millions of people [3].

Indicators of climate change and environmental degradation

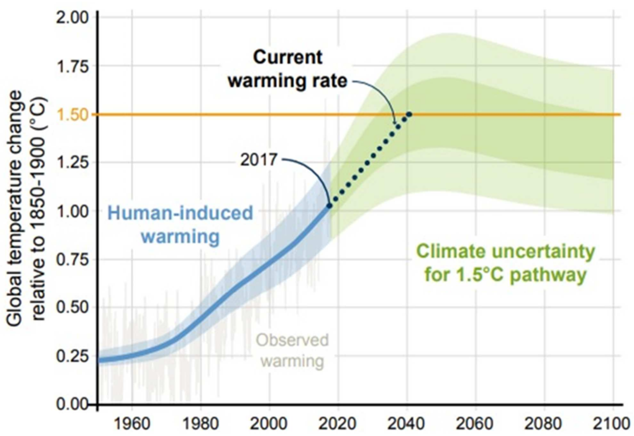


Figure 1. *Indicators of climate change and environmental degradation.*

This figure indicates human induced warming reached approximately 1°C above pre-industrial levels in 2017. At the present rate, global temperatures would reach 1.5°C around 2040. stylized 1.5°C pathway shown here involves emission reductions beginning immediately, and CO_2 emissions reaching zero by 2055. [4]

2.2. High Concentration of Greenhouse Gases in the Atmosphere

The concentrations of greenhouse gases reached new records in 2020, and the level of carbon dioxide concentration in the atmosphere reached 413.2 parts per million, which is about one and a half times higher than the levels it was in the pre-industrial period, while the level of methane doubled in the air two and a half times since then. The average global temperature for 2021 was above the average for the period between 1850 and 1900 by about 1.09 degrees Celsius. [5]

The figure shows that the global atmospheric concentration of gases on the left, and the composition of trace gases found in the atmosphere on the right. While trace gases make up less than 1% of our atmosphere's composition, it is dominated by carbon dioxide, a very powerful greenhouse gas. *Ozone makes up such a small percentage that it is not able to be illustrated on this chart. [6]

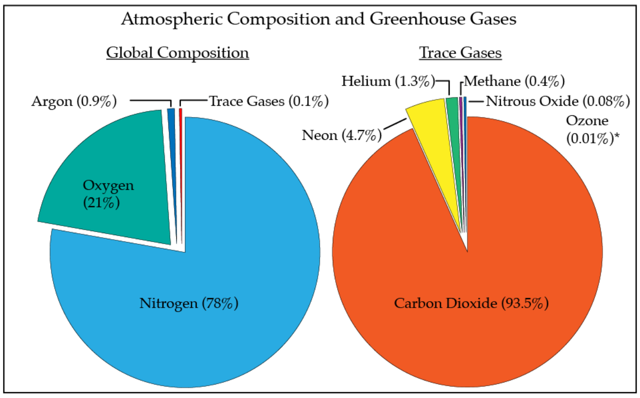


Figure 2. *Atmospheric Concentration.*

Atmospheric concentration is simple, it is the abundance or volume of gas which is present within Earth's atmosphere. The relative abundance of each gas changes in it's own way. For example, the increase in carbon dioxide comes from sources like burning fossil fuels, cement production, deforestation, and even chemical weathering and other geologic processes. GHG's are measured in parts per million (ppm), parts per billion (ppb), and sometimes parts per trillion (ppt). This is because the presence of GHG's in the atmosphere is still relatively small when compared to the entire composition of Earth's atmosphere (Figure 2). If the abundance of these GHG's are so low, then how can they possibly have an effect on climate? To answer this we must consider the following variables: residence time, and global warming potential. Think of it like this: a very small amount of hydrogen cynide can be deadly to most living organisms, however, it is not simply the quantity present, but the physical/chemical properties of the substance that make it dangerous [7].

2.3. Ocean Warming and Sea Level Rise

The oceans continue to warm to depths of up to 2,000 meters, setting records in 2019 and 2020. Most of the oceans experienced at least one "strong" marine heatwave sometime in 2021. Absorbing about 23% of annual carbon dioxide emissions, the oceans increased their acidity, thus reducing their capacity to store this gas.

2.4. Heat Waves

Various regions of the world have witnessed exceptional heat waves, many of which broke records in temperature exceeding 4 degrees Celsius. These heat waves were accompanied by many major fires in California, Algeria, southern Turkey, and Greece in particular, which led to the elimination of hundreds of thousands of hectares of forests.

According to the report, in the past ten years, the frequency of conflicts has increased, in parallel with the increase in the average incidence of extreme weather events. The combined effects of these risks, exacerbated by the COVID-19 pandemic, have increased hunger and thus undermined decades of progress towards improving food security, according to WMO experts [8].

Ecosystems have also deteriorated at an unprecedented rate, and this deterioration is expected to accelerate in the coming decades, limiting the environment's ability to support human well-being and weakening its resilience to adapt to climate changes.

Projections of 2100 global mean sea level rise

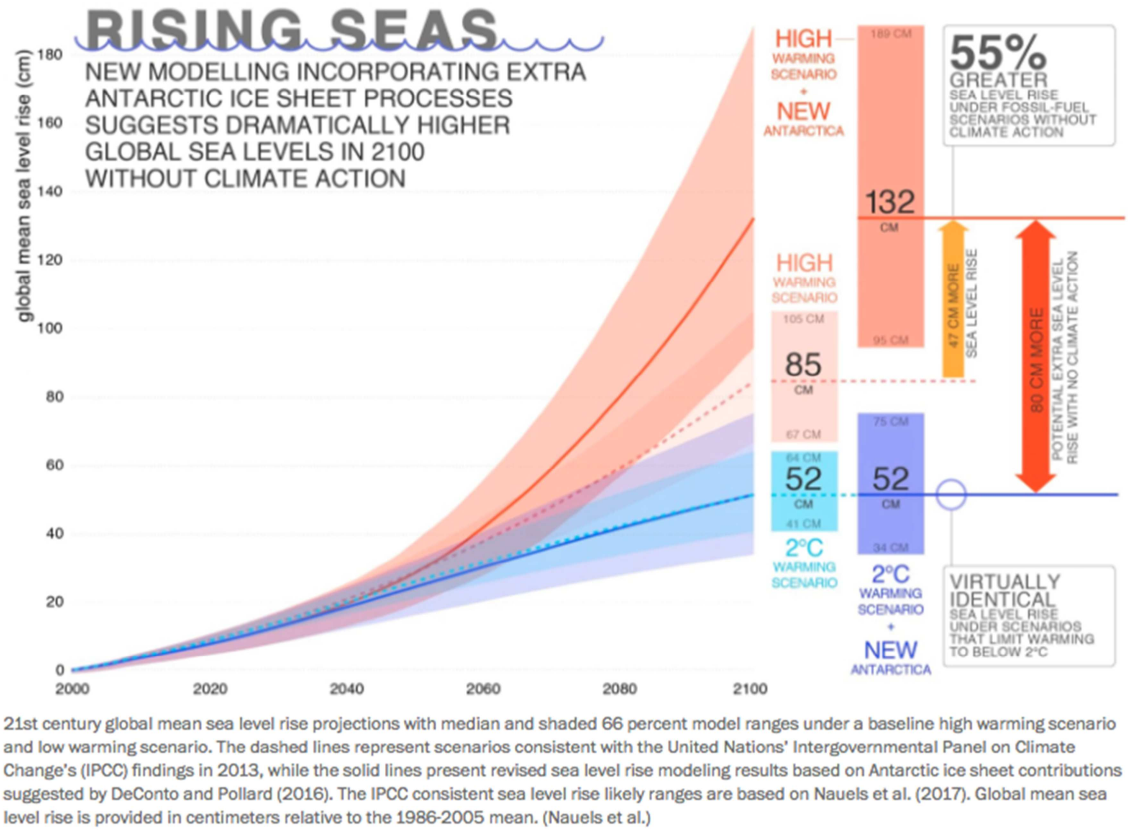


Figure 3. *Projections of 2100 global mean sea level rise.*

Major climate risks to ocean systems (Sea level rise) because of human-induced climate change is a major impact affecting oceans and coastal systems. Under temperatures rising by 2 degrees Celsius, we can look at sea level rise of 5 meters and more over the next 1,2 centuries. Only limiting warming below 1.5°C will keep sea level rise below 1 meter in the long run [9].

Warming above 1.5°C will significantly increase the likelihood of reaching critical tipping points of the Greenland and Antarctic ice sheets (1, 3). These tipping points are uncertain, but they are estimated at less than two degrees Celsius. Reaching these tipping points could lead to an unstoppable rise in sea level for several meters over the next centuries and millennia [10].

Sea-level rise will lead to a sharp increase in the risk of coastal flooding.

Under a warming scenario of two degrees Celsius by 2100, we can expect sea level rise of 50 cm, and coastal flooding will occur "one every fifty years" every year.

The risks are reduced below 1.5°C, but they are still quite large. Significant increases in coastal flood risk show the losses and damage caused by climate change even when warming is limited to 1.5°C [11].

3. Climate Change Risks to Health

Climate change is already affecting health in many ways, including causing death and disease because of increasingly frequent extreme weather events, such as heat waves, storms, floods, disruption of food systems, an increase in zoonoses, food, water and vector-borne diseases, and mental health problems. In addition, climate change undermines many social determinants of good health, such as livelihoods, equity, access to health care, and social support structures [12].

Figure 4. *Climate Change Risks.*

Climate change risks affect the health of the most vulnerable and disadvantaged, including women, children, ethnic minorities, poor communities, migrants or displaced persons, the elderly, and individuals with underlying health conditions.

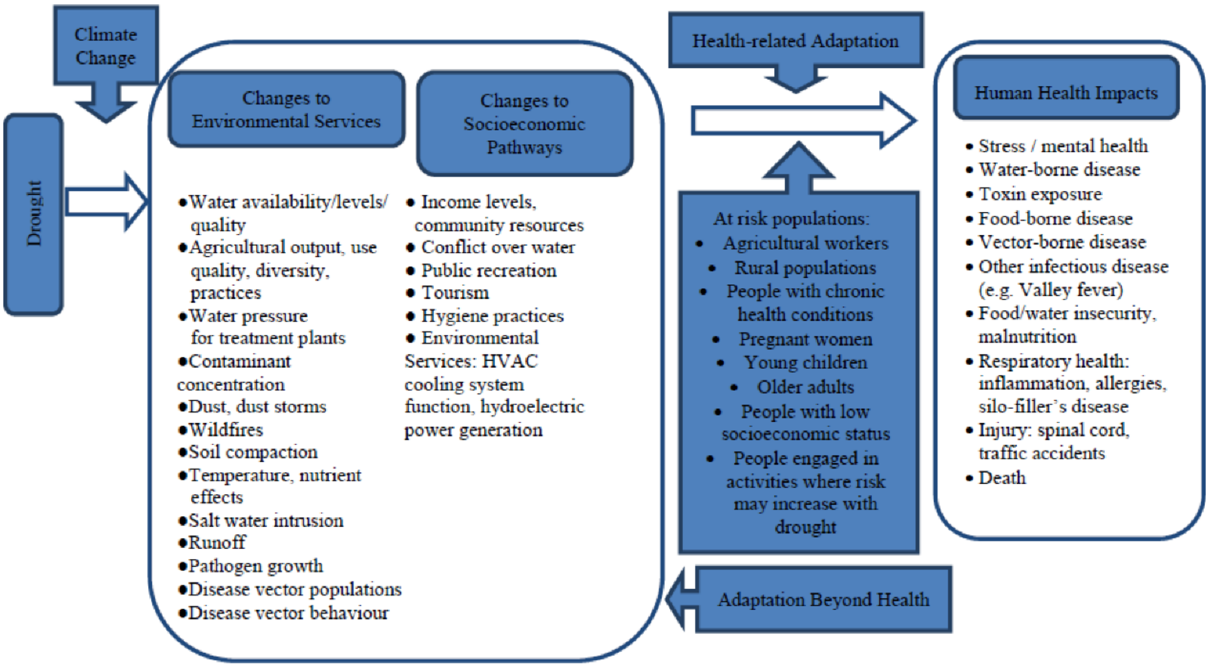


Figure 5. *Pathways through which drought impacts human health in the context of climate change.*

Changes due to global warming	Impact on human health
Warmer temperatures and stagnant air masses	Increased risk of heat strokes, heat exhaustion
Heavy precipitation events	Changes in vector borne transmitted diseases
Intense weather events (cyclones, storm)	Floods and water pollution
Air pollution	Loss of life, injuries, lifelong handicaps. Diseases outbreak. Overcrowding, poor sanitation
Ozone depletion	Increased skin cancers and cataracts

Figure 6. *Impact of global warming on health.*

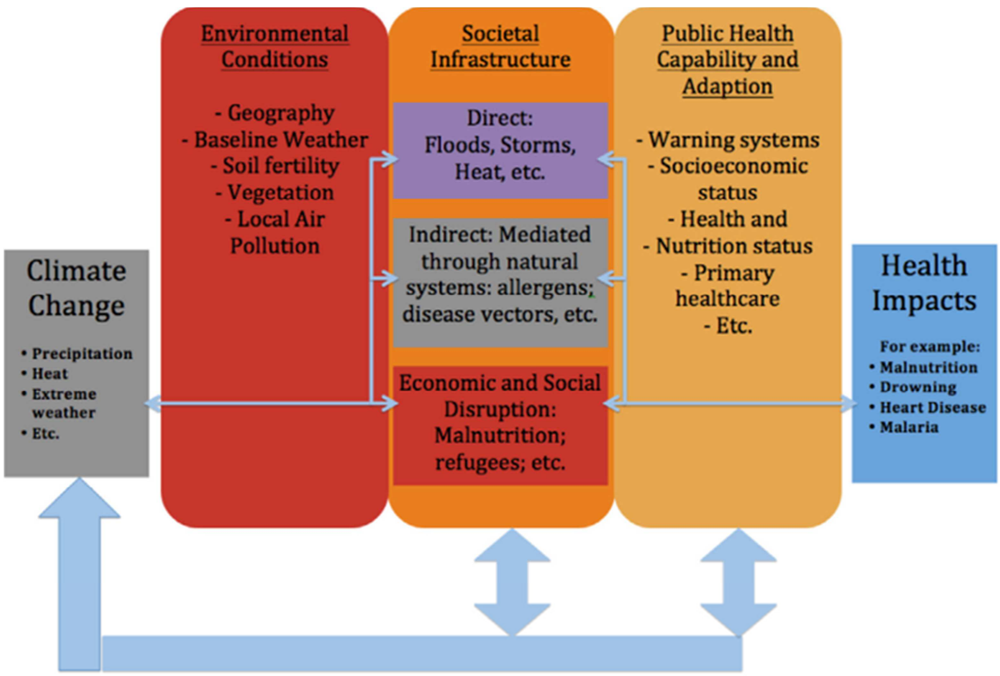


Figure 7. *The relationship between health and climate change.*

Although climate change clearly affects human health, it remains difficult to accurately estimate the magnitude and impact of many of the risks of climate change on health. Nevertheless, scientific advances allow us to gradually attribute the increase in morbidity and mortality to human-caused warming, and to define more precisely the risks and scope of these health threats [13].

In the short and medium term, the effects of climate change on health will depend mainly on the vulnerability and ability of the population to adapt to the current rate of climate change, and the extent and speed of adaptation. In the longer term, the impacts will increasingly depend on immediate, transformative action to reduce emissions and avoid dangerous temperature thresholds and potentially irreversible critical points [14].

4. The Effects of Climate Change on the World

Climate change poses the most serious threats to sustainable development in poor countries more than in rich countries. Because of the fragility of the economies of these countries in the face of climate repercussions; Multiple pressures result in a weak ability to take mitigation and adaptation measures. The higher the level of greenhouse gases, the more severe the climate change, and hence its impact. The following figure shows the distribution of carbon emissions in the world, and it is also clear that China has surpassed the European Union and the United States and has become the largest emitter of carbon in the world [15].

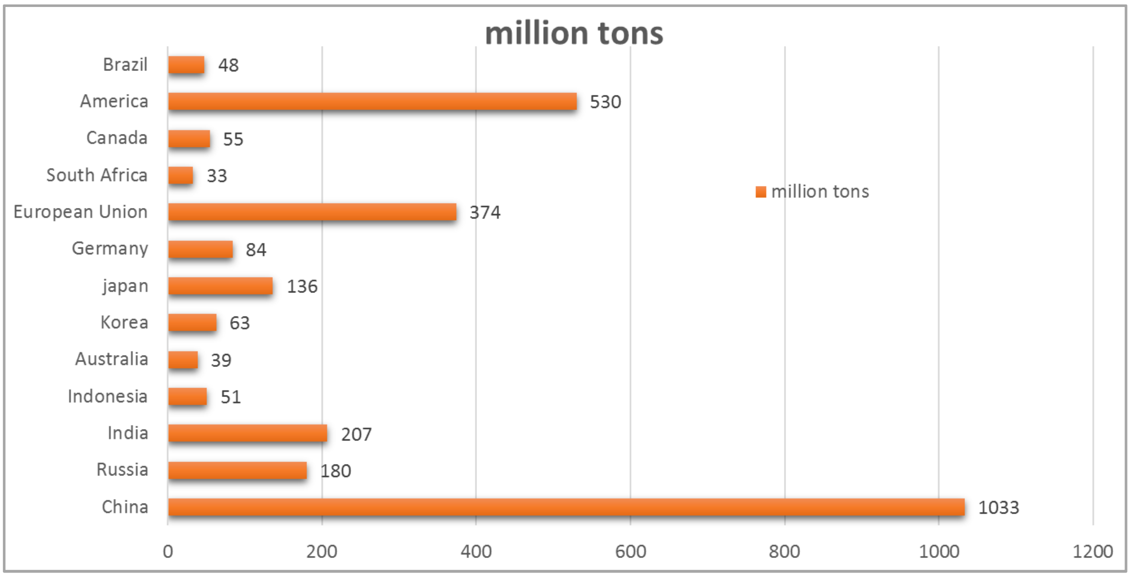
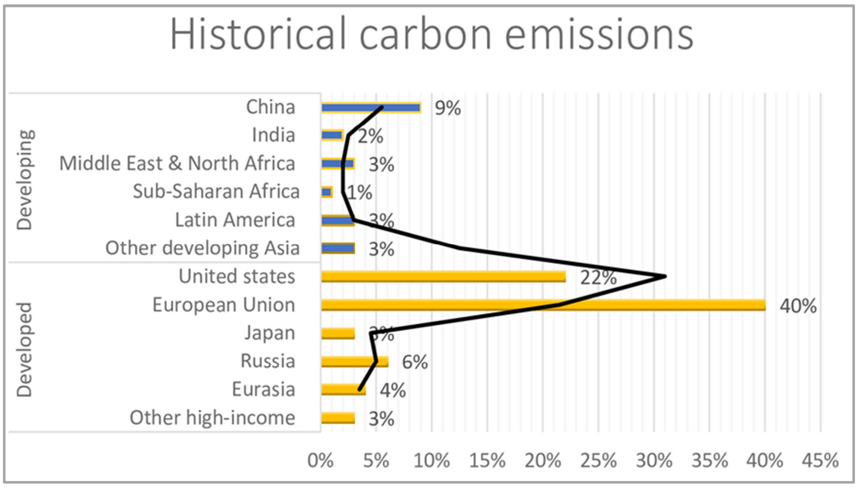


Figure 8. *Carbon emissions from the world's major economies.*

Source: Xing, T., Jiang, Q., & Ma, X. (2017). To Facilitate or Curb? The Role of Financial Development in China's Carbon Emissions Reduction Process: A Novel Approach. International journal of environmental research and public health, 14 (10), 1222.



Source: LUCEF, 1850-2011 (CAIT v2.0). https://doi.org/10.1371/journal.pone.0209532.g001

Figure 9. *Historical carbon emissions.*

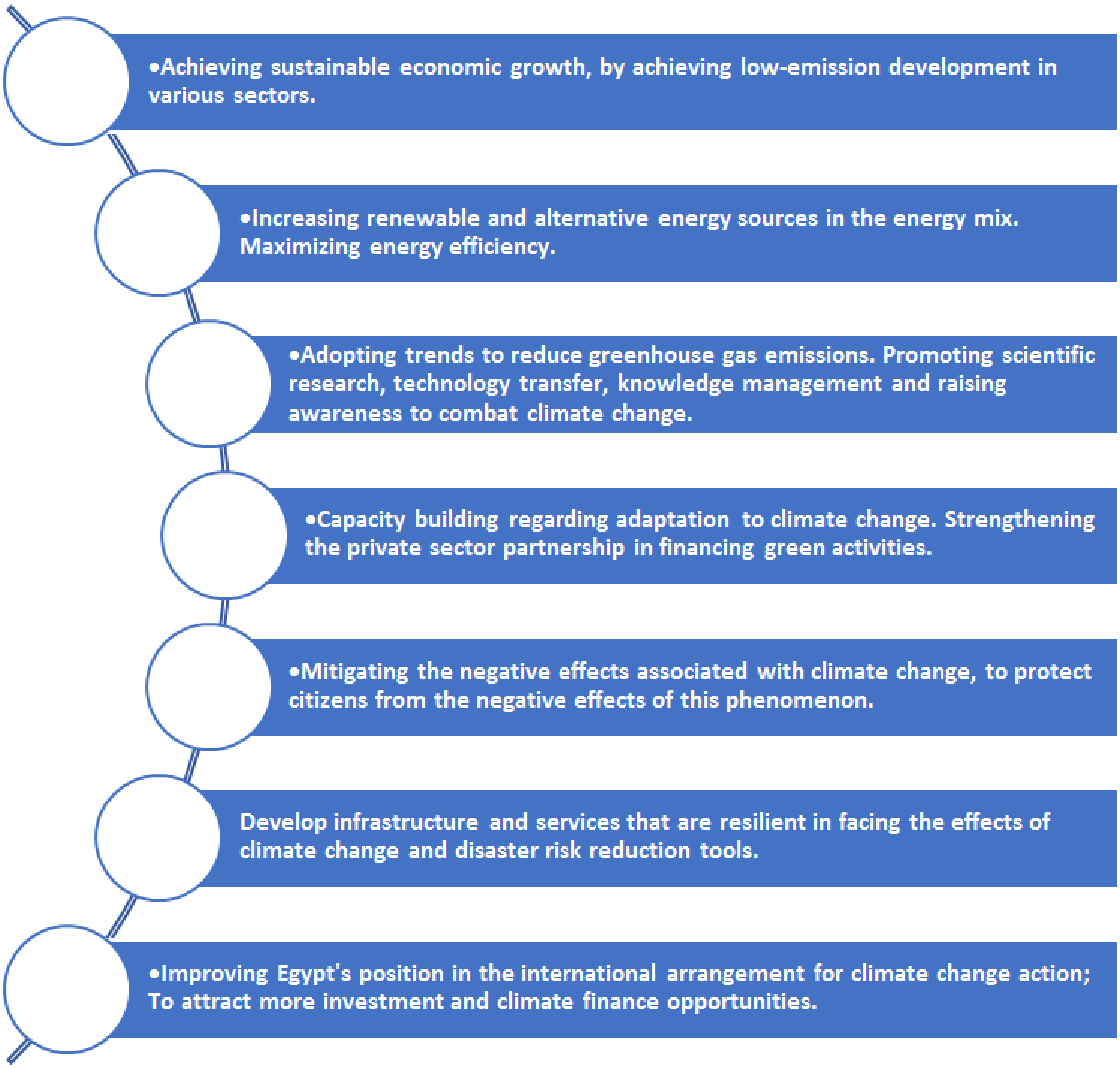


Figure 10. *National Strategy for Climate Change in Egypt.*

Moreover, 79% of developed countries are responsible for historical carbon emissions, with the USA accounting for 22%, the European Union 40% and China 9%. Five other countries top the list (China, the Russian Federation), Iran and Japan) accounting for 48.97%. It's a fifth, and the top polluters do it about the greenhouse gases responsible for global warming and their inflammation [16].

5. Objectives of the National Strategy for Climate Change

The figure illustrates five main objectives of the strategy: achieving sustainable economic growth and low-emission development in various sectors, building resilience and resilience to climate change and its negative impacts, as well as improving the infrastructure for financing climate activities. In addition to the above, the strategy works to improve the governance and management of work in the field of climate change, in addition to promoting scientific research, technology transfer, knowledge management and awareness to combat climate change [17].

The general objectives of the national strategy for climate change are: Egypt leads international efforts to address climate change.

6. The National Strategy for Climate Change in Egypt 2050 Strategy Objectives

Egypt is one of the country's most vulnerable to the negative effects of climate change on many sectors, including the coasts, agriculture, water resources, health, population, and infrastructure sectors, which leads to adding a new challenge to the set of challenges faced by Egypt in its quest to achieve sustainable development goals. Egypt 2030 is important to face the effects of climate change, through the existence of an integrated and sustainable ecosystem that enhances resilience and the ability to face risks [18].

The Egyptian state has launched a multi-dimensional national climate change strategy, commensurate with the seriousness of this issue, to become a road map to confront climate change, achieve a balance between sustainable growth and natural resources, improve the lives of citizens and confront the effects of climate change. The National Strategy: It targets several measures in all sectors of the economy in the country, including energy, agriculture, industry, transport, and waste. It also works to improve the governance and management of work in the field of climate change, in addition to promoting scientific research, technology transfer, knowledge management and awareness to combat climate change [19].

The National Climate Change Strategy in Egypt 2050 consists of five main objectives, from which sub-goals emerge:

1) Achieving sustainable economic growth and low-emission development in various sectors.
2) Building resilience and resilience to climate change and mitigating the negative impacts associated with climate change.
3) Improving the governance and management of work in the field of climate change.
4) Improving infrastructure for financing climate activities, promoting local green banking and green credit lines, as well as promoting innovative financing mechanisms that give priority to adaptation measures.
5) Promoting scientific research, technology transfer, knowledge management and awareness to combat climate change, facilitating the dissemination of related information, knowledge management among government institutions and citizens, and raising awareness about climate change among various stakeholders (policy and decision makers, citizens, and students) [20].

There are many sources of funding for the strategy's objectives, which mostly depend on the developed countries' fulfillment of their climate commitments, the state budget, and the participation of the private sector, which is called the financing infrastructure. The mitigation projects included in the strategy cost about $211 billion, until 2050, according to the priority package that It has been developed for several projects in the sectors of energy, transportation, agriculture, water resources and state sectors.

7. Climate Change in Egypt

Climate change is a global issue, and Egypt is considered one of the countries most affected by its negative effects, especially in terms of the agricultural sector, the ecosystem, water poverty and surface level rise, as well as its food security, in the absence of sufficient attention to this national issue.

Egypt deals with the issue of climate change with great interest, and studies its development on Egypt first, then on the region and on various countries of the world. On the principles of the Rio de Janeiro Declaration and the Bali Action Plan, especially with regard to the common and differentiated responsibility between developed and developing countries, and with regard to the responsibility of the pollution authorities in bearing the cost of pollution, and stressing the developed countries to fulfill their commitments to transfer technology, financing and capacity building to developing countries and not to shirk these obligations due to global financial crises [21].

Egypt is one of the countries most exposed to the risks resulting from the effects of climate change, although it is one of the least contributing countries in the world to greenhouse gas emissions globally, at 0.6% of the world's total emissions.

In its report on the state of the environment, the Environmental Affairs Agency, affiliated to the Ministry of Environment, identified 9 main risks to climate change to which Egypt is exposed: [22]

1) An increase or decrease in temperature from its normal rates, because of the Earth's temperature rising 1.2 degrees Celsius above pre-industrial levels.
2) Sea level rise and its effects on coastal areas, which will lead to saltwater entering the ground and polluting it, soil salinization, deterioration of crop quality and loss of productivity.
3) Increasing rates of extreme weather events, such as "dust storms, heat waves, torrential rains, and decreased rainfall."
4) Increasing rates of desertification.
5) The deterioration of agricultural production and the impact on food security.
6) Increasing rates of water scarcity, as the sensitivity of the Nile sources to the effects of climate change was monitored.
7) Climate change will affect the rainfall pattern in the Nile Basin, and the evaporation rates in the waterways.
8) Deterioration of public health.
9) The deterioration of eco-tourism, as the rise in sea level is expected to lead to the erosion of the Egyptian coasts.

The crisis lies in "that the system that rules the world is now converting all natural resources into a commodity, because the law of this world is unlimited growth, while the planet is limited, water is limited, and green space is limited."

Calculating the percentage, oil, coal, and gas are responsible for more than 80 percent of carbon emissions, so the solution lies in a new energy system, not based on oil, coal and gas, a genius solution, and a practical solution, while preserving the existing tree cover [23].

And that there are studies confirming that it is possible to achieve a complete radical shift in the balance of practical energy within the next 40 years, in addition to rationalization procedures [24].

7.1. Reduce the Incentive of Climate Change

7.1.1. Application of Climate-Smart Farming Practices and Forest Expansion

At the same time, they act as carbon sinks that help reduce emissions. Forests are also useful reservoirs for carbon capture and storage in soil, trees and leaves.

7.1.2. Carbon Pricing

Reducing carbon emissions starts with clear policy signals. Carbon pricing systems—such as emissions trading with caps or carbon taxes by the ton—send long-term signals to companies by creating incentives to reduce polluting behavior and to invest in clean energy options and low-emissions methods.

7.1.3. Ending Fossil Fuel Subsidies

Fossil fuel subsidies send a different signal that encourages waste and discourages low-carbon growth. By phasing out harmful fossil fuel subsidies, countries can reallocate their resources to the most needed and most effective areas, including targeted support to the poor.

7.1.4. Building Resilient, Low-Carbon Cities

With careful transportation and land-use planning, and energy-efficiency standards set, cities can be built in ways that prevent falling into unsustainable patterns. It can create jobs and opportunities for the poor and reduce air pollution.

7.1.5. Increasing Energy Efficiency and Using Renewable Energy

Through the Sustainable Energy for All initiative, modern energy is generalized to everyone, by doubling the percentage of improvement in energy efficiency, and doubling the percentage of renewable energy in the global energy mix.

7.1.6. Application of Climate-Smart Farming Practices and Forest Expansion

Climate-smart farming practices help farmers increase farm productivity and resilience to the effects of climate change such as drought [24].

Agricultural activity is the most affected by climate changes because it is the most vulnerable activity to the climate, and the weakest activities in infrastructure and basic resistance to any change in the climate. In Egypt, there is no such structure, and it is possible to say that Egypt is climatically "sinking in an inch of water, because there is no infrastructure to help confront this change," and developed countries compensate farmers for any losses, but in Egypt, farmers are not compensated for any losses of this kind [25].

7.2. These Changes Affect the Egyptian Food Security System and Increase the Volume of Imports of Strategic Crops

Egypt is a country that suffers from a major problem and an imbalance in the Egyptian food security balance. For the provision of many strategic commodities, we depend on imports, and this represents a great danger. Because any problem that will occur in the production of these crops that we import in the producing countries will affect our national security in a very strange way. As a result of the scarcity of agricultural resources of land and water, we have a problem in the production of strategic crops, as we import more than 33 million tons of agricultural and food materials [26].

So, Egyptian food security is threatened, and climatic changes have come and increased the size of this threat, and this imbalance in the food security system, and any losses in agricultural production as a result of climate changes, we will have to compensate for them with imports, as climate change is not completely in the interest of the Egyptian food security balance, and if we want to improve This system must solve the issue of climate change and its impact on agricultural production [27].

7.3. Implications of the Risks of Climate Change on Land and Water

Human-induced land degradation, water scarcity, and climate change are increasing levels of risks to agricultural production and ecosystem services at the times and places where economic growth is most needed [28].

Climate models predict the increase, frequency, intensity, and quantity of heavy precipitation with global climate change. Heavy rainfall increases the risks of landslides, severe erosion, and flash floods. This is illustrated by the following table:

Table 1. *Risks of Climate Change on Land and Water.*

Water scarcity is exacerbated by climate change		
coastal erosion	**dehydration risks**	**national food security**
Increased exposure of coastal areas to severe and prolonged storms will lead to land degradation and affect the structure and composition of coastal forests. Sea-level rise is already affecting coastal erosion and salinization, making these areas vulnerable to catastrophic weather events. The annual crop production cycle in these regions is greatly influenced by climatic fluctuations: long periods of drought, frequent and intense rainfall and accompanying floods.	Climate change increases drought risk by increasing the frequency and magnitude of extreme weather events, altering average weather conditions and climate variability, and generating new threats in regions that may have little experience in dealing with drought. Droughts are slow-developing and not easily identifiable at first, but they can quickly turn into a crisis when they create devastating and widespread effects and when their impacts on societies, ecosystems and economies are underestimated.	Because of less rainfall and changes in seasonal water availability, agricultural droughts have particularly negative implications for food security due to lower crop yields, lower pasture and forest productivity, and increased fire risks. This particularly affects smallholder families due to their inability to access adequate water harvesting or irrigation services, and this may lead to competition for dwindling resources.

7.4. The General Trend of Carbon Dioxide Emissions in Egypt

Climate change poses potential threats to economic growth and the potential for increased poverty in developing countries; Supporting accelerated economic growth and high standards of living around the world was based on the increasing use of natural resources, especially energy from fossil fuels, and thus was an essential component of climate change. Then promote the use of renewable energies. The figure shows an increase in carbon dioxide emissions in Egypt from 160.2 million tons in 2007 to 217.3 million tons in 2017, an increase of 3.4%.

It is worth noting that economic growth is the main factor that increases carbon dioxide emissions, mainly due to the existence of a positive relationship between economic development and demand for electricity, as the steady rise in demand for electricity leads to an increase in carbon emissions. Considering this, the government must establish a subsidy policy, a legislative protection system, and a standard for reducing carbon emissions. The carbon price is an essential component of any policy mix to stimulate the transition towards a low carbon economy. Moreover, the carbon price has the added advantage of raising public revenues, which can be used to promote development and increase the economic viability of climate policy [29].

Fossil fuels are not only a source of greenhouse gases, but also a source of various types of pollutants, so increasing energy efficiency and switching from carbon to renewable energy sources are the main tools for implementing a policy of climate change. In a better mix of electricity sources that reduce environmental degradation without harming growth, and to deal with climate change fossil fuel subsidies are removed. As the following figure shows, the electricity sector represents the largest source of carbon emissions, releasing 48% of the carbon.

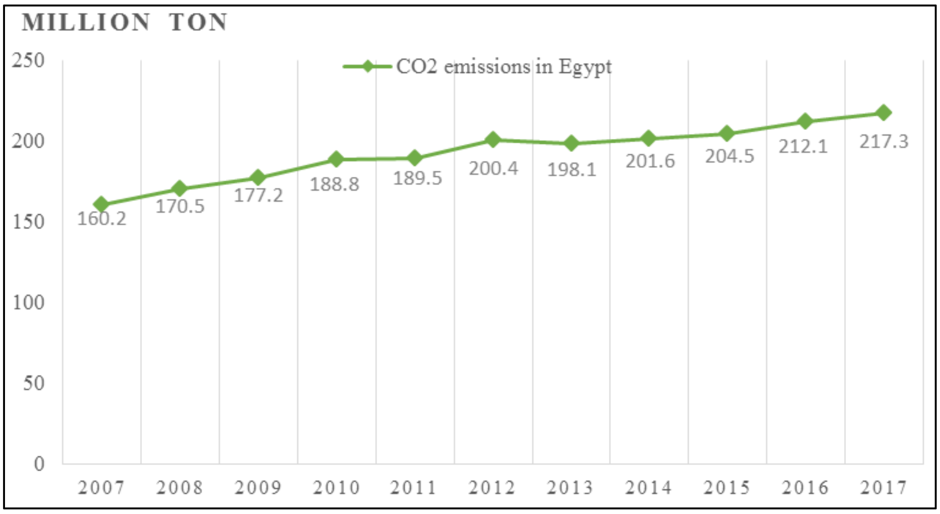


Figure 11. *Carbon emissions in Egypt.*

Source: BP review of world energy 2017. https://www.bp.com/content/dam/bp/en/corporate/pdf/energy conomics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf page 49.

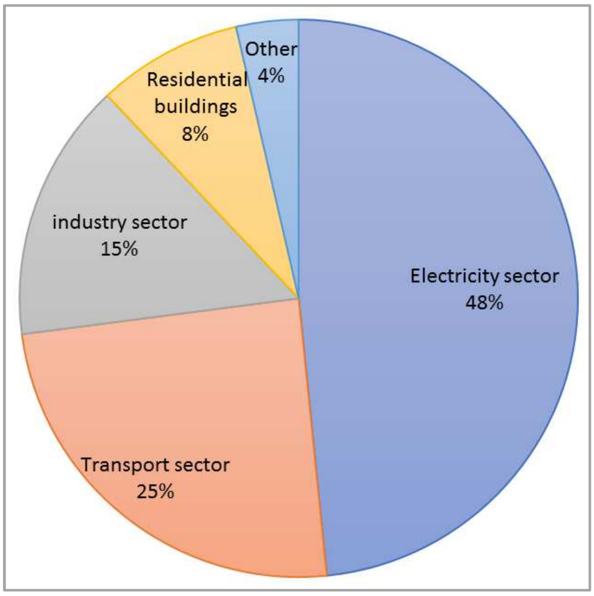


Figure 12. *Sources of CO_2 Emissions in Egypt.*

Source: ElShennawy, T., & Abdallah, L. (2017). Evaluation of CO_2 emissions from electricity generation in Egypt: Present Status and Projections to 2030.

The researcher believes that development and growth is one of the important tools that require an increase in the depletion of electrical energy, as Egypt is going through a period of tremendous economic and urban growth in light of the construction of new cities, the opening of economic projects and the construction of roads; Which requires a program to restructure the electricity sector and provide an infrastructure that bears more pressure on local consumption indicators, and this requires the government to build national policies in order to develop the power generation system based on renewable natural sources that reduce carbon dioxide emissions, by encouraging investment in them. Supporting reliance on nuclear energy technology and integrating it into the current energy system, to build more efficient systems, and supporting the localization of this technology in Egypt [30].

Note that the high prices of conventional energy will encourage investment in clean energy, and developed countries should bear the main responsibility for reducing emissions, and provide financial support to developing countries; Energy equity is a global systemic goal for efficiency, based on the design of a consistent share of energy resources, and the international commitment of developed countries towards developing countries is essential to enhance their resilience, economic preparedness, and adaptation to climate-related events.

In light of these indicators, nuclear energy is one of the most possible measures to meet the challenges of increasing energy demand, and the best solution to secure energy use for future generations, reduce environmental impact and climate change concerns, and provide a promising alternative to traditional energy sources for countries facing restrictions in meeting their electricity needs in The future, and in addition to this, the imperative to provide energy at affordable prices that ensure safe transportation and distribution to local consumers [31].

8. The Role of Nanotechnology to Reform Climate Crisis

8.1. Overview

Global warming of the Earth's average surface temperature in the wake of the Industrial Revolution has overwhelmed the productivity of the ecosystem, and thus negatively affected the economy. In addition, human activities such as burning fossil fuels, deforestation, transportation, excessive use of electricity and use of aerosols are responsible for increasing the Earth's surface temperature.

In this framework, global warming refers to the long-term warming of the Earth, while climate change refers to a wide range of global phenomena that have arisen mainly due to long-term warming, which include changes in the frost-free season, precipitation, melting glaciers, and the rise in the level of the sea, more droughts, heat waves, hurricanes. Based on the foregoing, it is likely that the continuous increases in temperature will increase public concern about climate change in the future [32].

This paper seeks to highlight the key aspects in the development and innovation to provide many important applications of nanotechnology in renewable energy systems. And the application of environmental nanotechnology solutions in climate sustainability. This paper provides a framework for addressing issues related to nanostructures, to give an overview of the role of nanotechnology in improving different sources of renewable energies, and to review current challenges to address climate change. This research highlights the role of nanotechnology in environmental treatment of pollutants and thus mitigating the impact of climate change.

8.2. Research Hypothesis

1) Nanotechnology offers the ultimate technical reform attempt for problems that require integrated social, economic, and political solutions. Nanotechnology will support a new wave of industrial expansion.
2) The use of nanotechnology can contribute to reducing global carbon dioxide emissions.
3) The use of nanotechnology contributes to ensuring environmental sustainability and solving the climate crisis.

8.3. Description of Scenarios

Industrialization along with the population explosion in developed and developing countries has accelerated the degradation of natural resources on a large scale, eventually leading to climate change. Since the environment is loaded with many pollutants and stubborn compounds, environmental remediation has become a major cause of concern today.

Nanotechnology has tremendous potential to provide innovative solutions to a wide range of environmental issues. These include improved approaches to reducing pollution, water treatment, environmental sensing, and remediation, and making alternative energy sources more cost effective; In terms of the unique properties of engineered nanomaterials, these new technologies enable them to address environmental challenges in a sustainable way. This paper focuses on the environmental applications of engineered nanomaterials in a sustainable environment and emphasizes the future opportunities for their application in natural ecosystems [33].

8.4. Nanotechnology to Mitigate the Effects of Global Warming

Nanotechnology plays a multifunctional role in finding solutions to reduce global warming. Nanomaterials have a tremendous ability to absorb greenhouse gases. Nanocomposites are also used in the manufacture of lightweight materials for transportation from the use of traditional fossil fuels and thus reduce global warming. The nano-catalysts store oxygen and promote complete combustion of the fuel, which helps reduce fuel consumption as well as the generation of greenhouse gases. In addition, nano-based lubricants and nano-coatings significantly reduce engine friction and wear, reducing fuel consumption by up to 2% and thus reducing CO_2 emissions [34].

8.5. Adopting Nanotechnology to Mitigate Global Warming

Nanotechnology (microparticle science) has emerged as a versatile platform to provide solutions to global sustainability issues. At the scientific level, the removal of carbon dioxide from the flue gas through adsorption processes requires absorbent materials with high selectivity and capacity. These properties are important to reduce the cost of carbon capture and storage. Nanomaterials exhibit unique physicochemical properties such as increased reactive surface area; High pore size and outstanding electronic, magnetic and optical properties. They can also be used with chemical combinations that selectively target greenhouse gases, a major cause of global warming [35].

8.6. Nanotechnology for Clean Energy Production and Energy Storage Alternatives

Clean energy refers to non-polluting and environmentally friendly energy sources. The inventions in nanotechnology pave the way for the development of new strategies and materials applied in the production and storage of clean energy such as hydrogen fuels, photovoltaic cells, biofuels, wind energy, ocean energy, and geothermal energy [36].

The impact of nanotechnology to boost the renewable energy industry.

Table 2. *Nanotechnology Application in Energy.*

Fuel type	Nanotechnology contribution
hydrogen fuel	Nanotechnology plays a role as a catalyst for hydrogen release and new anode catalysts for the electrochemical reaction taking place in fuel cells. It is also used to create membranes. Multi-component nanoparticles such as core-shell nanoparticles, alloy nanoparticles.
photovoltaic cells	Many researchers have exploited nanomaterials for a new generation of photovoltaic cells with high conversion efficiencies of solar energy with low manufacturing cost.
Biofuels	Nanotechnology is involved in the production of biofuels from plants that act as catalysts. Several studies have focused on the synthesis of an environmentally harmless nano catalyst for biodiesel production from animal fats and vegetable oils.
Wind energy and ocean energy	Lightweight nanocomposites are used in the manufacture of wind turbine blades, which are lighter, highly durable, and resistant to corrosion and natural disasters such as lightning, sunlight, rain, and sand.
geothermal energy	Nano coatings have shown good results in providing non-corrosive coatings in geothermal systems

Source: Prepared by the researcher based on previous references

8.7. Seven Ways Nanotechnology Can Help Combat and Halt Climate Change

8.7.1. Lightweight Nanocomposites

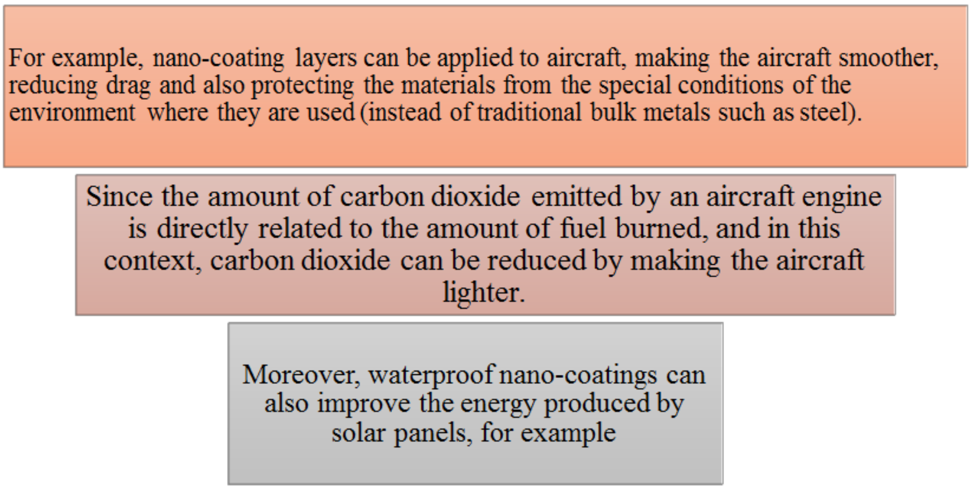
Source: Prepared by the researcher based on previous references

Figure 13. *Nano ceramic paint for cars before and after nanotechnology.*

Any effort to reduce emissions in vehicles by reducing their weight, and thus reducing fuel consumption could have an immediate and significant impact globally. It is estimated that a 10% reduction in vehicle weight corresponds to a 10% reduction in fuel consumption, resulting in a proportional reduction in emissions. In line with this, there is a growing interest worldwide in exploring ways to achieve weight loss in automobiles using new materials such as nanomaterials. For example, the use of lighter, stronger, and more rigid nanocomposites can significantly reduce the weight of the vehicle [37].

8.7.2. Nano Coatings

Nanotechnology coatings are a good short-term way to reduce emissions and increase clean energy production.



Source: Prepared by the researcher based on previous references

Figure 14. *Examples of nano coatings.*

8.7.3. Nano Catalysts

Nanotechnology has already been applied to improve fuel efficiency by incorporating nano catalysts, as it uses nanoparticles to store oxygen to promote complete fuel combustion, which helps reduce fuel consumption.

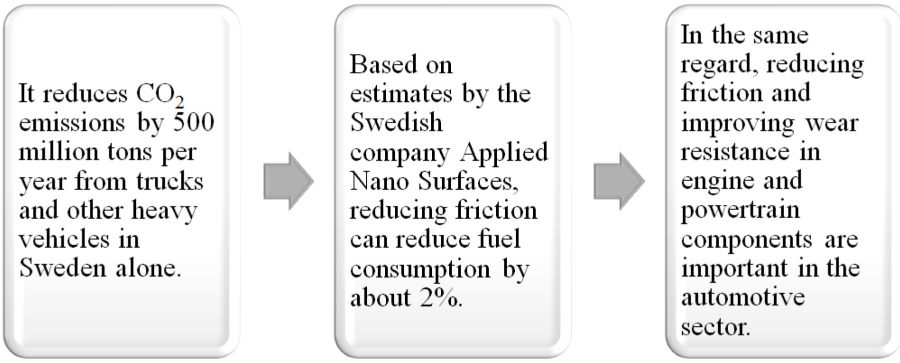


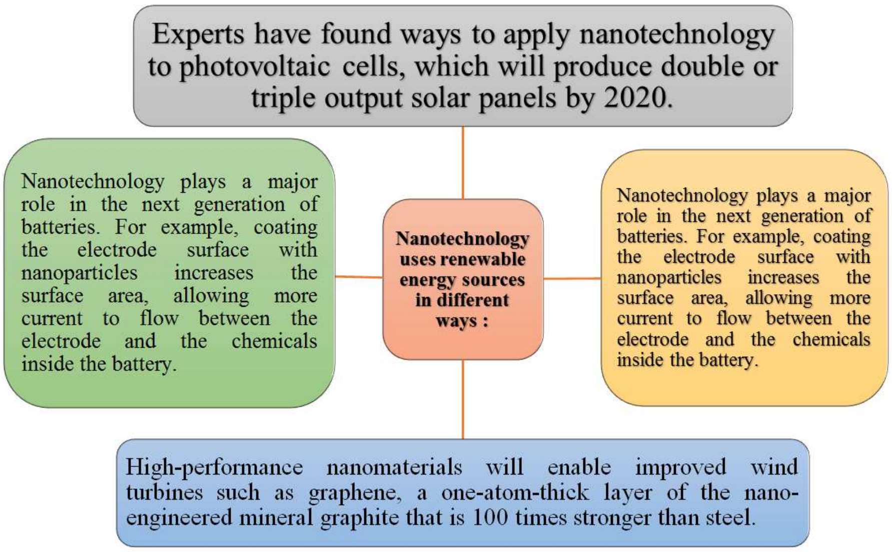
Figure 15. *Nano-catalysts.*

8.7.4. Nano-structured Materials

Thanks to nanomaterials such as silica, many tires in the future will be able to have the best energy rating. The features of nanostructured materials are as follows:

Source: Prepared by the researcher based on previous references

Figure 16. *Properties of nanostructured materials.*



Source: Prepared by the researcher based on previous references

Figure 17. *Nanotechnology and renewable energy sources.*

8.7.5. Enhanced Renewable Energy Sources

Based on that in the battery industry, these technologies contribute to increasing the efficiency of electric and hybrid vehicles by significantly reducing the weight of batteries. It goes without saying that nanotechnology can make a huge difference in many areas, especially in the field of energy where it brings significant and possibly surprising performance gains for renewable sources and smart grids, allowing intermittent sources such as solar and wind energy to provide a greater share of the total electricity supply without sacrificing stable [38].

8.7.6. Nanotechnology Sensors

Smart grid sensors can be used to detect problems early, to measure the degradation of underground cables or to lower the price of chemical sensors already available for transformers. Naturally, it will increase energy efficiency, reduce costs to consumers, and increase its effectiveness in combating climate change [39].

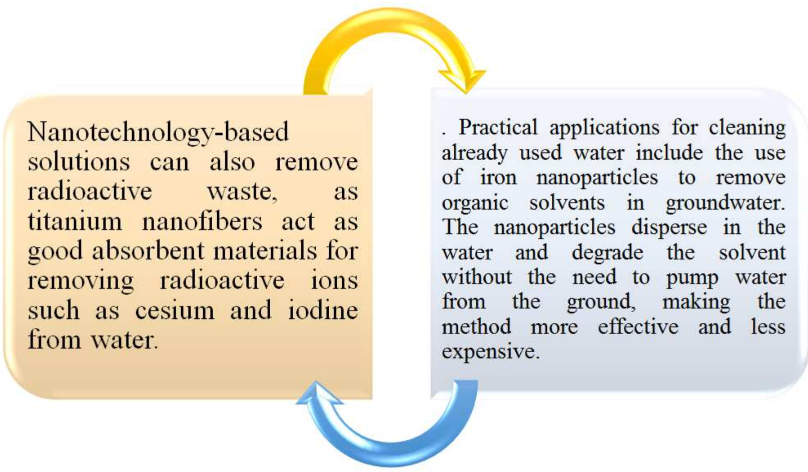
9. Desalination Clean Water

Nanotechnology-based solutions can contribute to the long-term quality, availability, and viability of water in several ways:

9.1. Treatment and Desalination Water

From this point of view, nanotechnology produces a new generation of nano-membranes to enable water purification and water desalination more and better means to remove or reduce water pollutants.

New and improved sensors capable of detecting chemical and biological contamination at low concentrations can be achieved using nanotechnology. Nanomaterials also make it possible to use electrochemical analysis, integrating photo response and chemical sensing for biomonitoring without the need for complex and expensive instruments and processes.



Source: Prepared by the researcher based on previous references

Figure 18. *Nanotechnology applications in water desalination.*

Reduce pollution It is worth noting that this includes not only "conventional" pollutants, but also waterborne infectious diseases. For example, nanotechnology can provide alternative chlorine-free biocides in the form of silver, and titanium dioxide catalysts for photo disinfection [40].

9.2. The Role of Green Nanotechnology in Mitigating Climate Change

Green nanotechnology is the specialized branch of nanotechnology that envisions sustainable development by means of many applications. Many nanoparticles are increasingly being used in many fields, but there is a growing interest in the biological and environmental safety associated with their production. Green nanotechnology offers tools and techniques to transform biological systems into green methods for the synthesis of nanomaterials, by integrating the principles of green chemistry, engineering and microbiology, green nanotechnology can produce safe and environmentally friendly metallic nanoparticles that do not use toxic substances in their synthesis [41].

The advancement of clean technologies for environmental regeneration and sustainable development for society is very vital nowadays. Consequently, nanotechnology can help develop clean and green technology with noteworthy benefits to human health and the environment. The field of nanotechnology is also now being investigated to find possible solutions to manage and mitigate water, land and air pollution, as well as to enhance the work of traditional techniques that help in remediation of the polluted environment [42].

9.3. Nanomaterials to Combat Climate Change and Reduce Pollution

Scientists around the world are working to develop nanomaterials that can efficiently use carbon dioxide from the air, capture toxic pollutants from water and turn solid waste into useful products. They are also effective and mostly recyclable catalysts. Thus, nanomaterials help reduce pollution [43].

Table 3. *Stages for Developing Nanomaterials.*

The beginning of the discovery	Slowing climate change	Nanoparticles	Scientific progress
First explored for applications in microscopy and computing, nanomaterials are materials that are made up of units thousands of times the thickness of a human hair. Moreover, tiny energy molecules pull carbon from the air, pigments from water and sludge from waste, and are useful in addressing threats to the well-being of people. our planet.	To help slow the climate-changing rise in atmospheric carbon dioxide levels, researchers have developed carbon dioxide nano harvesters that can absorb carbon dioxide from the atmosphere and diffuse it for industrial purposes. They are simple chemical or photochemical catalysts in nature that operate in the presence of sunlight.	Nanoparticles offer a promising approach to this because they have a large surface area-to-volume ratio to interact with carbon dioxide and properties that allow them to facilitate the conversion of carbon dioxide into other things. The challenge is to make it economically viable. Researchers have experimented with everything from metal to carbon-based nanoparticles to reduce cost, but so far, they haven't become effective enough for industrial scale application.	One of the most recent advances in this area is the development of a nanoscale carbon dioxide harvester that uses water and sunlight to convert atmospheric carbon dioxide into methanol, which can be used as an engine fuel, solvent, antifreeze agent and ethanol diluent.

Jain says the nanoCO_2 harvesting machine has a large molecular surface area and captures more CO_2 than a conventional catalyst with a similar surface area, making the conversion more efficient. But due to their small size, nanoparticles tend to clump, making them inactive with prolonged use. Jain adds that the fabrication of useful materials based on nanoparticles is also a challenge because it is difficult to make the particles a consistent size. Chattopadhyay says the efficiency of these materials can be improved further, offering hope for useful application in the future [44].

9.4. Nanotechnology and the Climate Change Crisis

Nanotechnology is the most visible and useful tool for confronting threats to the well-being of our planet. Nanomaterials are gradually establishing the foundations of clean and green technologies that can be useful in capturing toxic gases and chemicals from air and water, respectively, and dismantling solid waste into non-toxic components.

Experts, scientists, and innovators are drawing on this expertise to gradually mitigate the process of climate change. The extent of progress in this area of research is enormous, and because of that nanomaterials are now considered the most reliable and effective catalysts. These properties have spurred a series of new inventions in which nanomaterials play an essential and highly integrated role.

9.5. Key Areas of Research and Development in Nanotechnology to Mitigate the Effects of Climate Change

Nanotechnology by itself will not have a significant impact on climate change, but its incorporation into larger systems, such as the hydrogen-based economy, solar technology, or next-generation batteries, makes it a profound impact on energy consumption and therefore greenhouse gas emissions.

Table 4. *Key areas of nanotechnology applications relevant to climate change mitigation.*

Technology and applications	Wide categories of nanotechnology applications
hydrogen economy	Hydrogen as an energy source. Hydrogen generation by electrolysis. Hydrogen generation from photolysis. Hydrogen fuel cells used in transportation (eg cars and buses). hydrogen storage.
fuel efficiency	Fuel additives to stimulate fuel efficiency and reduce emissions. Nano cleaners to improve engine performance. Nanostructured coatings for turbines.
Photovoltaic cells for solar energy	Silicon nanosystems mimic photosynthesis. Encapsulation of nanoparticles in polymers. Molecular organic solar cells. Single-walled nanotubes in conducting polymeric solar cells

A recent report commissioned by the UK government shows that nanotechnology has the potential to contribute to efforts to reduce harmful greenhouse gas emissions, and thus help respond to climate change in a range of areas including:

1) Development of efficient hydrogen-powered compounds.
2) Improving photovoltaic cells and the cheapest cost of solar energy technology.
3) Development of a new generation of batteries and supercapacitors (i.e. devices that can store and release electricity at a later time) that can make electric cars more widely used.
4) Improving the insulation of buildings.
5) Fuel additives that can enhance the energy efficiency of motor vehicles. In the same vein, a recent study conducted by the United Nations Environment Program (UNEP) showed that nanotechnology provides important new means to transform energy production, storage, and consumption (particularly in the areas of solar energy) and better storage of emission-free fuels. Table 4 provides an overview of some of the major areas of scientific research and development in nanotechnology relevant to climate change.

On a procedural level, there is a greater potential for using nanomaterials to develop solar cells, practical fuel cells, and environmentally friendly batteries. It goes without saying that in technological development the use of nanowires instead of silicon improves the efficiency of solar cells. On the other hand, nanomaterials are also used in a hydrogen fuel cell to improve hydrogen storage and in batteries to make graphene supercapacitors with a high recharge rate; It is a nano-product with a greater scope in industries and research as it can be used in a variety of ways to sustain the environment.

Nanotechnology has the potential to improve the power and efficiency of various devices that are used to monitor and treat environmental pollution and produce renewable energy.

It has the potential to provide all the economic, social and environmental benefits to humans

It has the potential to reduce human impact on the environment by resolving issues related to energy, mitigating pollution and providing a solution to greenhouse gas emissions.

Nanotechnology offers tremendous opportunities for environmental benefits including clean, efficient and accurate industrial practices to reduce waste; A clean and abundant energy source in the form of wind energy and solar cells.

detection and elimination of contamination; reduce greenhouse gases and other pollutants from the environment; and remediation of environmental damage.

Source: Prepared by the researcher based on previous references

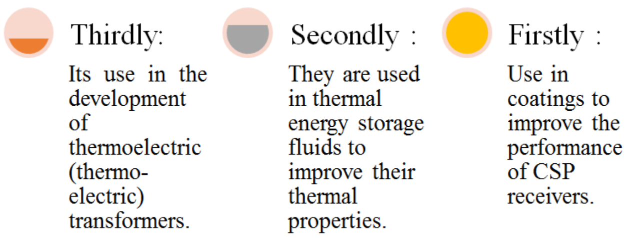
Figure 19. *The Developmental and Economic Effects of Nanotechnology.*

Furthermore, Below is a summary of nanotechnologies commonly promoted as solutions to the energy and climate crisis. In this sense, many of these technologies use nanomaterials or nano systems to extend or change the capacity of existing technologies. As with other technologies, nano applications are often incorporated into larger systems, for example nano batteries can be used in conjunction with nanoscale solar panels. In solar farms, nanocoating's, insulators, and energy storage devices can help store the energy produced.

Consequently, renewable energy technologies such as solar and wind energy provide important opportunities to move away from greenhouse-intensive fossil fuels. However, all renewable energy sources have an environmental footprint. Our interest lies in whether nanotechnology provides solutions that improve the functionality of existing technologies, the impact of nanotechnology uses on technology life-cycle emissions and energy requirements (whether its use saves energy or requires more), and the extent to which nanotechnology imposes a new environment.

9.6. Innovative Methods of Nanotechnology in the Development of Solar Energy

On a procedural level, companies are also selling nanomaterial-based coatings for solar thermal storage insulation. It should be noted that there are three main areas in which nanotechnology is proposed for use in solar thermal energy:



Source: Prepared by the researcher

Figure 20. *Developing innovative nano-photonics methods for controlling solar energy.*

How is nanotechnology used in solar cells?

Nanostructured solar cells play an important role in the fabrication of future generations of photovoltaic modules. Nanomaterials have an increasing surface area to volume ratio in addition to their novel optical and electrical properties; This allows them to capture more sunlight than silicone panels. Several nanomaterials that are incorporated into thin-film solar cells have the potential to increase the efficiency of solar cells by absorbing different wavelengths of light at the same time, which is not possible with other solar cell systems.

One of the major potential applications of solar heat nanostructures is the fabrication of CSP "receptors" and the development of high solar photo absorption materials and coatings; Accordingly, it can operate at high temperatures under highly concentrated flows of solar energy. As a result, nano-coating on the surface of the receptors can improve the heat capture and heat transfer properties as well as provide corrosion resistance.

Innovative nanotechnology methods for developing wind energy

Researchers are trying to use nanotechnology to create stronger, lighter, and more durable windmill parts. Nano coating is developed to protect windmill blades and extend their service life. The use of nano-lubricants to reduce friction and extend the service life of parts is also being investigated. Researchers are beginning to investigate nanoparticles for use in sensing techniques to alert damage to wind turbines.

How is nanotechnology used in wind energy?

Companies are trying to use nanotechnology to create waterproof coatings that can prevent the buildup of ice and moisture on wind turbines; This allows for increased energy production. Coatings based on nanotechnology also have the potential to extend the service life of windmill blades used in extreme weather conditions, for example at sea.

Nano-lubricants that act as micro ball bearings are also being developed; The researchers hope that they will reduce friction and wear in the turbines, making them more efficient and longer lasting.

9.7. Innovative Nanotechnology Methods for Developing Hydrogen Energy

The "hydrogen economy" is a hypothetical future economy in which hydrogen is the primary form of stored energy for vehicles and industrial applications.

The researchers hope that nanotechnology will help enhance efficiency and lower renewable energy costs for hydrogen generation, provide new means of hydrogen storage, increase capacity and efficiency, and reduce costs of hydrogen fuel cells.

Researchers are also studying the possibility of using hydrogen storage nanomaterials and nanobatteries to support renewable energy systems or to serve as supplemental energy sources in hydrogen cars. It is the most important role of nanotechnology in the development of hydrogen fuel cells, electrochemical devices that convert fuels such as hydrogen or methanol directly into electricity.

9.8. Nanotechnologies to Expand oil and Gas Extraction

Nanotechnology offers tremendous potential to the oil and gas industries and is our best hope for extending the lifeblood of our current energy resources. Nanotechnology provides numerous solutions for mapping new reservoirs, extracting more oil from existing wells, and making our fuel use cleaner and more environmentally friendly.

How is nanotechnology allegedly improving current technology?

Petroleum industry and government investors hope nanotechnology-based sensors, coatings, membranes, and devices will help find new oil and gas reserves, expand the extraction capacity of existing wells, reduce extraction and processing costs, and achieve efficiency gains. Nano-membranes are also being developed to better filter impurities from oil and gas. Other applications of nanotechnology in the petroleum sector include:

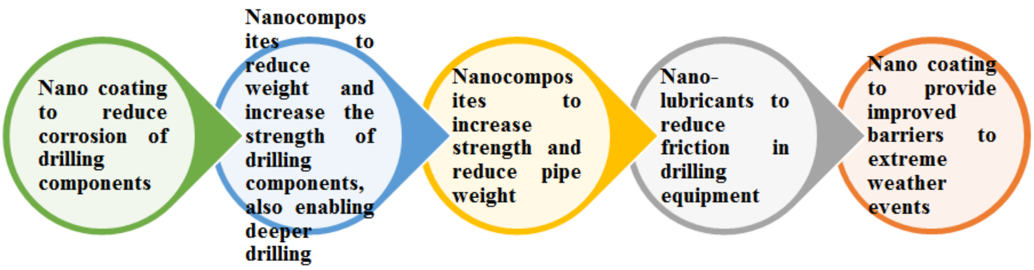


Figure 21. *Nanotechnology Applications In the Petroleum Sector.*

9.9. Innovative Nanotechnology Methods for Developing Nano Batteries

Nanotechnology enables the commercial production of smaller, lighter, longer lasting, and more powerful batteries. Most research efforts are directed towards creating more efficient and cheaper batteries for electric and hybrid vehicles. The use of nanomaterials for different electronics, to increase capacity, reduce recharging time, and discharge stored energy from renewable sources such as solar and wind energy devices. It is also hoped that nanotechnology will increase the safety of batteries subject to overheating and flammability.

9.10. Innovative Nanotechnology Methods for Developing Nano Coatings and Insulators

Nanomaterials are widely used in coatings that repel dirt and generate "self-cleaning" surfaces for structures, household surfaces, and buildings. Other nano coatings are antimicrobial. Nanostructured insulation can offer more effective insulation. Some nano-coatings are also used for insulation.

How does nanotechnology improve existing coatings and insulation?

Windows coated with nanomaterials such as nano-titanium dioxide can repel dirt and self-clean, reducing cleaning costs. Nanomaterials are also touted for their antimicrobial properties. Other nano-paints can protect buildings and highway structures from dirt, reducing maintenance and cleaning.

9.11. Innovative Nanotechnology Methods for Developing Fuel Catalysts

Catalysts initiate or speed up chemical reactions without being consumed by them (a process called catalysis). Catalysts added to the fuel can cause the fuel to burn completely. This allows the combustion engine to maximize energy extraction while reducing emissions.

Nanofuel catalysts reduce the amount of fuel wasted in the engines of cars, buses and other vehicles. Nanoparticles are attractive components in a fuel catalyst due to their increased surface area and increased surface reactivity. This can make the fuel catalyst more efficient by using fewer catalysts.

Based on the above, nanotechnology enhances spare parts for aircraft and cars; To illustrate this, carbon nanotubes are used to support specialized parts for aircraft and cars, high-performance plastics, and in fuel filters and electronic goods. Using ultra-strong, rigid, and lightweight carbon nanotubes for car and aircraft parts; They can achieve significant weight savings that reduce fuel consumption.

10. Research Conclusions and Recommendations

The effects of global warming are alarming with a sharp increase in the surface temperature of the Earth because of human activities. Increased greenhouse gases from fossil fuels and industries are leading to a marked increase in the average surface temperature of the Earth. Recent developments in the nanotechnology sector are paving the way for the manufacture of various materials such as MOFs, nano porous materials, nanocomposites, and nano polymers that help in reducing greenhouse gases in the atmosphere to reduce global warming. Nano catalysts, nanogenerators, and nano sensors aid in various processes such as biofuel production, hydrogen production, and fuel cell development to reduce the use of fossil fuels. Moreover, nanotechnology can be applied in many ways if it is explored from multiple perspectives. However, attention is required in a few areas where research gaps are identified, and they must be investigated to discover the full potential of nanotechnology.

The innovative nano building industry has the potential to enhance the competitiveness and climate potential of the environmental sector at the same time and could become a key strategic factor for the sector in the future. This paper discussed a wide range of potential nanotechnologies applicable in ecosystems with promising climatic impacts, however, most of them are at an early stage of development. Which indicates new climate solutions to achieve resource efficiency and the adoption of nanotechnology to mitigate global warming and because many of them can be applied in renewable energy fields where the climate potential is great. However, it is essential to meet the current knowledge gap on climate issues, environmental opportunities, and industrial dynamics if green nano building is to move from expectations to serious strategic objective for business and policy makers.

Acknowledgements

The author gratefully acknowledges the financial support of my father and mother for bearing hardships and stress on me during the exams, and for their service in difficult times, and for providing me the effort and time to allow me the opportunity to work hard and diligently day and night. I hope that God accepts their work and makes them worship the righteous and places them in the Paradise of Gannet in the company of the prophets.

The author would like to thank Dr. Hossam Elden M. Abdelkader, Associate professor Economic Dep., Faculty of Administrative Sciences, Ain Shams University, Egypt .I thank him for teaching the monetary policy course, benefiting from his knowledge, and teaching us advanced econometrics lectures in the preparatory year for the doctorate program, He is a distinguished young doctor, genius and a role model for the youth.

Appendix

Appendix 1. Carbon Emissions in Egypt, and the Contribution of Each Sector to it

The energy sector is the biggest cause of carbon emissions in Egypt: Data showed that the energy sector is responsible for producing 71.4% of carbon emissions in Egypt during 2016, as it produces approximately 221 million tons of carbon dioxide equivalent. The production of electricity and heat contributes to the largest part of this percentage (45%) compared to other activities in the energy sector, which contribute to the rest, and they are as follows: transportation (25%), manufacturing and construction (20%), the combustion of other fuels and fugitive emissions (9%). and bunker fuel (1%). Emissions from the energy sector in Egypt recorded an average growth of 3.5% during the period from 1990 to 2016.

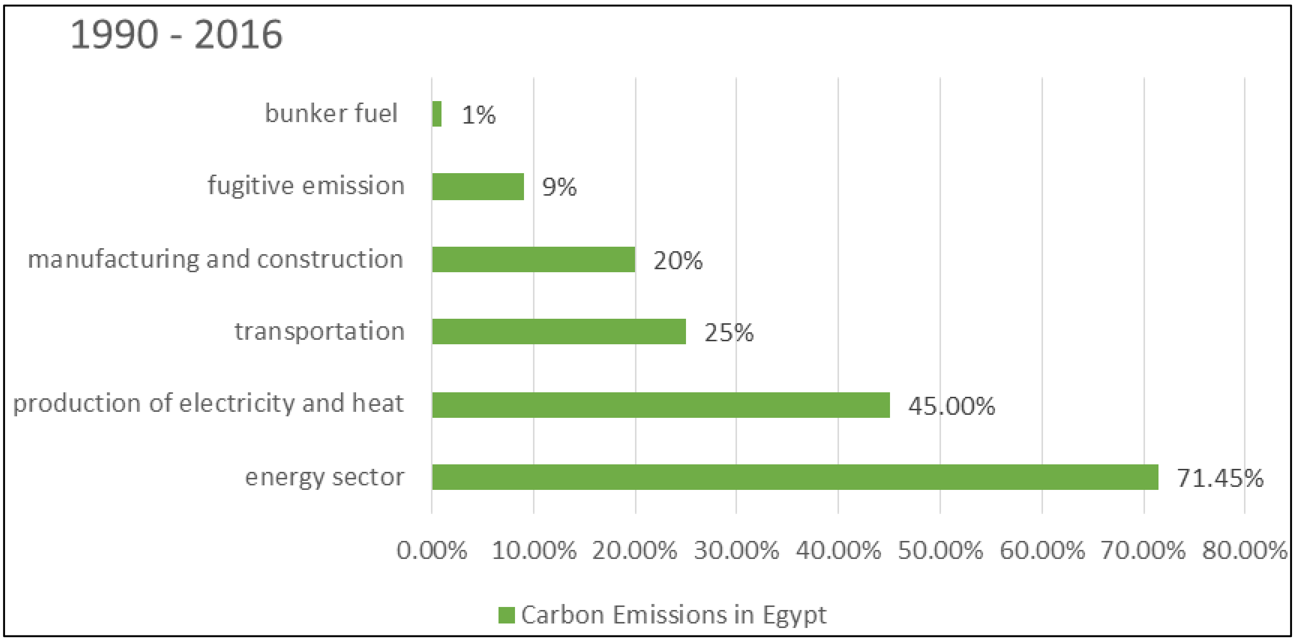


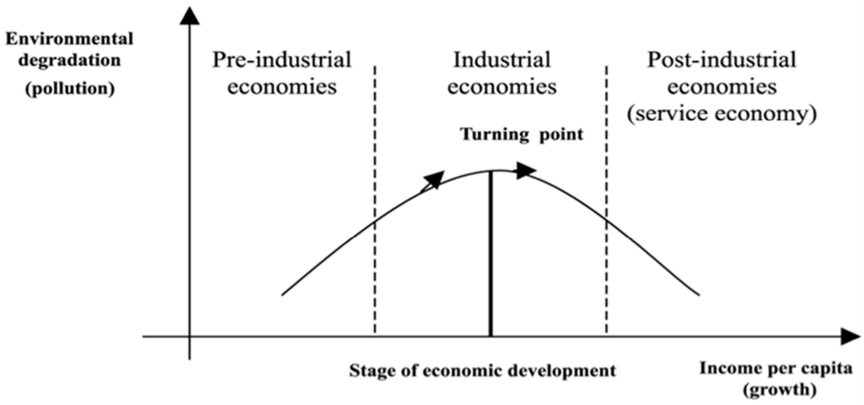
Figure 22. *Greenhouse Emissions by Sector In Egypt.*

Appendix 2. Application of Simple Regression: Case Study on Egypt

Aims to measure the impact of environmental pollution on economic growth, the case of the state of Egypt for the period between (1990 – 2022), where the gross domestic product, denominated in dollars, was used as an indicator of economic growth, and carbon dioxide emissions as an indicator of environmental pollution.

The results of the table 5 showed that the relationship between real GDP and carbon dioxide emissions is positive and not reverse (1.880848), and it has a significant (0.0000) relationship between the variables in the short term. This is the opposite of the hypothesis, as it is natural for carbon emissions to increase pollution and reduce GDP, but in the long term.

The EKC environmental Kuznets curve also shows a leading theory to explain the relationship between economic growth and environmental pollution. The theory states that initially, an increase in the growth rate and a rise in income leads to an increase in environmental pollution, this happens until a certain level of income is reached, and then with the increase in the growth rate the pollution rate decreases, which makes the Kuznets curve take the shape of an inverted U-shaped as shown in the following figure:



Source: Panayotou (1993)

Figure 23. *Environmental Kuznets Curve.*

Table 5. *Simple Regression for GDP__CURRENT.*

Dependent Variable: LGDP__CURRENT_US$_				
Method: Least Squares				
Date: 09/11/22 Time: 20:16				
Sample: 1990 2022				
Included observations: 33				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	3.117553	1.197062	2.604336	0.0140
LCO_2_EMISSIONS__KT_	1.880848	0.100038	18.80143	0.0000
R-squared	0.919375	Mean dependent var		25.61279
Adjusted R-squared	0.916774	S. D. dependent var		0.753666
S. E. of regression	0.217425	Akaike info criterion		-0.155235
Sum squared resid	1.465481	Schwarz criterion		-0.064538
Log likelihood	4.561377	Hannan-Quinn criter.		-0.124718
F-statistic	353.4938	Durbin-Watson stat		0.382895
Prob (F-statistic)	0.000000			

Source: Prepared by the researcher based on the statistical program EViews 10th Edition.

From the graph that refers to the shape of the environmental Kuznets curve, which shows the trade-off between economic growth, expressed as the average per capita GDP, and environmental pollution, expressed as the average per capita carbon dioxide emissions. In the first stage of growth, the movement of the average per capita output is observed Environmental pollution is on the rise and in one direction, as the growth movement during this stage is accompanied by an increase in the use of natural resources, and increasingly, this leads to an increase in the emission of gases that pollute the environment, and this situation continues until it reaches a certain level of growth at a point known as the turning point on the Kuznets curve It is located at the extreme end of the curve, after this point the growth rate increases until the economy turns from an industrial economy to a service economy that cares about environmental aspects and their sustainability.

Table 6. *Simple Regression for CO_2 emissions.*

Dependent Variable: LCO_2_EMISSIONS__KT_				
Method: Least Squares				
Date: 09/11/22 Time: 20:18				
Sample: 1990 2022				
Included observations: 33				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.559593	0.666173	-0.840012	0.4073
LGDP__CURRENT_US$_	0.488808	0.025998	18.80143	0.0000
R-squared	0.919375	Mean dependent var		11.96015
Adjusted R-squared	0.916774	S. D. dependent var		0.384212
S. E. of regression	0.110841	Akaike info criterion		-1.502743
Sum squared resid	0.380860	Schwarz criterion		-1.412045
Log likelihood	26.79525	Hannan-Quinn criter.		-1.472226
F-statistic	353.4938	Durbin-Watson stat		0.365726
Prob (F-statistic)	0.000000			

Source: Prepared by the researcher based on the statistical program EViews 10th Edition.

***Table** 7. Multiple Regression.*

Dependent Variable: LGDP__CURRENT_US$_				
Method: Least Squares				
Date: 09/11/22 Time: 20:35				
Sample: 1990 2022				
Included observations: 33				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	5.606183	3.491713	1.605568	0.1188
LCO_2_EMISSIONS__KT_	1.962884	0.147701	13.28954	0.0000
LAGRICULTURAL_METHANE_EMISSIONS	-0.360820	0.475135	-0.759404	0.4535
R-squared	0.920895	Mean dependent var		25.61279
Adjusted R-squared	0.915621	S. D. dependent var		0.753666
S. E. of regression	0.218925	Akaike info criterion		-0.113670
Sum squared resid	1.437841	Schwarz criterion		0.022377
Log likelihood	4.875549	Hannan-Quinn criter.		-0.067894
F-statistic	174.6217	Durbin-Watson stat		0.433884
Prob (F-statistic)	0.000000			

Source: Prepared by the researcher based on the statistical program EViews 10th Edition.

***Table 8.** Data of the Study Variables.*

year	**CO_2 emissions (kt)**	**GDP (current US$)**	**Agricultural methane emissions**
1990	87750	42978914311	12760
1991	89370	37387836491	13000
1992	90900	41855986519	13140
1993	92660	46578631453	13400
1994	87900	51897983393	14100
1995	93720	60159245060	13210
1996	98940	67629716981	14640
1997	106060	78436578171	15100
1998	110980	84828807556	14760
1999	116540	90710704807	15940
2000	114610	99838543960	16040
2001	126700	96684636119	16360
2002	129440.002	85146067416	16350
2003	133020.004	80288461538	16940
2004	144500	78782467532	17630
2005	162220.001	89600665557	17820
2006	170750	1.07426E+11	15810
2007	183399.994	1.30438E+11	14880
2008	189940.002	1.62818E+11	16110
2009	197660.004	1.89147E+11	16730
2010	200309.998	2.18984E+11	16090
2011	205770.004	2.3599E+11	15990
2012	215000	2.79117E+11	15380
2013	213860.001	2.88434E+11	15570
2014	219119.995	3.05595E+11	14770
2015	226279.999	3.29367E+11	13180
2016	231229.996	3.32442E+11	16800
2017	242229.996	2.35734E+11	16800
2018	247910.004	2.49713E+11	16800
2019	249369.995	3.03081E+11	16800
2020	249369.995	3.65253E+11	16800
2021	249369.995	4.04143E+11	16800
2022	249369.995	4.04143E+11	16800

The researcher notes from the table 6. that there is a direct relationship between carbon emissions and the fluctuating national product in Egypt during the period 1990-2022 with a coefficient B (0.488808), The reason is that Egypt relies heavily on hydrocarbon-based fossil fuels, manufacturing was the second fastest growing source of emissions in Egypt, and the growth in total emissions in Egypt during that period was three times faster than the global average, which became the largest contributor to climate change.

The table 7. indicates the existence of a first-order autocorrelation between the errors of the regression model. This is a false regression that cannot be relied upon or generalized.

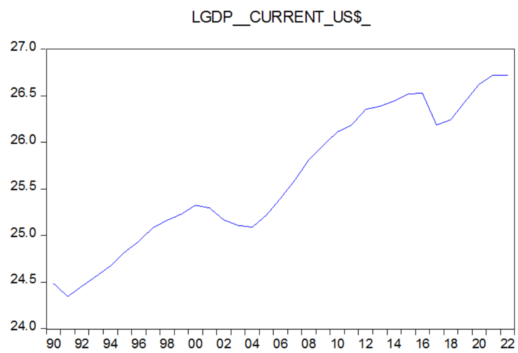


Figure 24. *Time trend of carbon emissions in Egypt.*

Source: Prepared by the researcher based on the statistical program EViews 10th Edition

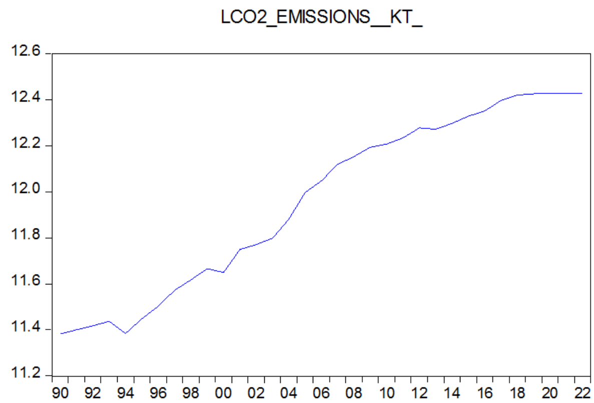


Figure 25. *Time period of carbon emissions in Egypt.*

Source: Prepared by the researcher based on the statistical program EViews 10th Edition

The researcher notes from the figure an increasing general trend of carbon emissions in Egypt with a series of developments and transformations of a volatile nature during the period 1990-2022, and the reason is that Egypt turned to the industrialization process in order to provide an adequate standard of living regardless of the environmental effects resulting from the industrialization process, which It put pressure on the capabilities of the Egyptian national economy, and affected the sustainable development targeted in it.

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