American Journal of Economics and Business Management

Vol. 8 Issue 9 | **pp.** 4480-4497 | **ISSN:** 2576-5973

Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Article

The Impact of Environmental Pollution on Economic Growth Prospects and the Attainment of Sustainable Development in Iraq: A Case Study of Basra

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Abstract: This study aims to investigate the direct effects of environmental pollution on growth opportunities and sustainable development in Iraq, basing a case study in Basra Governorate that embodies the unbalanced relationship between economic activities (especially oil and industrial activities) and natural resources. The study is also expected to determine the sources and types of pollution, measures available to counter its impact on health and quality of life as well as the prospects for economic growth, and what a shift toward a green economy would look like as a framework policy. This research is descriptive, analytical with data collection and analysis of the previous period from 2010-2023 referring to economic growth indicators in addition to the theoretical framework and literature. The results show that environmental pollution in the province has a negative impact on the quality of life as reflected on the increasing rates for respiratory and cancerous diseases, agricultural lands production declining and water and soil resources degradation. Interestingly, the study also shows an inverse correlation of pollution and sustainable growth: Fragile and unstable economic growth went hand in hand with increased carbon emissions, cautioning against oil dependence. Furthermore, the findings also prove that inadequate environmental legislation along with inefficient waste management are key pollutions drivers and pollution in turn is a hindrance to domestic and foreign investments. The aim of this study is to analyze the effect of environmental pollution on growth opportunities and economic development in Iraq globally, with a focus on Basra Governorate as a model and semi-finish for an unbalanced interaction between economic activities (oil and industrial sectors) and natural resources. This study will also identify the sources and aspects of pollution, investigate its impact on quality of life and prospects for economic growth, and consider the potential green economy transition as a strategic pathway into the future. The study is descriptive analytical and depends on the collection and analysis of data for the period (2010-2023) while linking it to the indicators of economic growth, in addition to reviewing theory and literature related to the topic. The results of this work showed that the existence of environmental pollutants in Basra led to a negative impact on the life (respiratory and cancerous diseases are increasing, agricultural productivity is decreasing, water and soil resources are deteriorating). The paper also show the negative connection between pollution and sustainable economic growth: carbon emissions are rising with fragile and unstable growth, shows the dangers of heavy reliance on oil. Furthermore, the findings indicate that relaxed environmental laws and inadequate waste disposal are key drivers of pollution, whereas pollution is also a limiting factor for domestic and foreign investments. Hence, this research highlights the need to enhance legislation and implement environmental monitoring; foster an economy green transition; renewable energy and clean technologies transfer; waste management improvement including agriculture sector protection as well as boosting environmental awareness and civic engagement. The diversification of Iraqs economy is also seen as a must to decreasing the countrys dependence on oil.

Citation: Saud, I. S. F. The Impact of Environmental Pollution on Economic Growth Prospects and the Attainment of Sustainable Development in Iraq: A Case Study of Basra. American Journal of Economics and Business Management 2025, 8(9), 4480-4497

Received: 03th Jun 2025
Revised: 11th Jul 2025
Accepted: 24th Aug 2025
Published: 05th Sep 2025

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Keywords: Environmental Pollution, Sustainable Development, Economic Growth, Green Economy ، Basra Governorate.

1. Introduction

The global issue of environmental contamination is growing. Its environmental, economic, and social impacts have garnered attention since the second half of the 20th century. We must face tremendous scientific and institutional hurdles to control pollution and its terrible effects as polluting rates rise and modern technology advance. In emerging countries like Iraq, where economic and social upheaval is underway, the environment has become a key component of sustainable development. Iraq has rich culture and natural resources but struggles to manage them sustainably. Even with Iraq's drive to achieve sustainable development goals and a sustainable economy.

Due to unrestrained industrial expansion, poor environmental legislation, and overuse of natural resources, Iraq has seen dangerously high environmental pollution levels in recent decades. This view is very prevalent in Basra governorate in southeast Iraq. Air, water, and soil quality have deteriorated due to oil activities and poor environmental laws and control, harming public health, standard of living, and community stability. Thus, this study examines the relationship between environmental pollution and economic growth and sustainable development in Iraq using the Basra Governorate as a realistic model of industrial environment interaction. It plans to examine Iraq's green economic transition as a strategy to reduce environmental impacts and achieve balanced and comprehensive sustainable development.

The Problem of the Study

For decades, Iraq — and Basra Governorate in particular — has seen a shocking rise in environmental pollution from uncontrolled industrial growth, rise in greenhouse gas emissions and declining natural resource management. Basra: Due to its geographical proximity to oil fields, ports and the concentration of economic activities associated with extractive industries, Basra is one of the most polluted cities in Iraq. Thus, the problem of this study arises through what extent is environmental pollution one of the determinants that have an impact on economic growth opportunities and sustainable development in Iraq, where Basra governorate represents a host case to be reflected as a clear model for an environmental imbalance resulting from overlapping natural resources and unbridled economic activities. This leads to the research problem crystallizing in this question:

How far, environmental pollution hinders growth and sustainable development In Iraq, focusing on Basra Governorates practical model?

Study Hypotheses:

The aims of this study are to test the hypothesis that:

1. Increased environmental pollution affects the quality of life in Basra, Iraq.
2. There is an inverse correlation between levels of environmental pollution and levels
3. growth and sustainable development in Iraq."

Study Objectives

The study aims to:

1. Investigate the nature of environmental pollution in Basra, its sources, causes and degrees and diagnose the economic and environmental sectors most affected by it.
2. Consequences of environmental pollution on economic growth opportunities in Iraq.
3. Impact of environmental pollution on achieving sustainable development in Iraq.
4. In this process of identifying the challenges and opportunities facing Iraq in achieving sustainableroute to a greener economy development.

Study Limits:

1. Spatial Limits: The research covers the Basra Governorate located in southern Iraq, between latitudes (29°05-31°20) north and longitudes (46°40-48°30)east. It is one of themostimportantIraqicitiesintermsofoilresourcesandeconomicactivities, making it a suitable field model for studying the effects of environmental pollution resulting from extractive industries.

2. Time Limits: The study covers the period from 2010 to 2023, as this period witnessed a significant increase in environmental pollution levels in Basra as a result of unregulated industrial and oil expansion.

2. Materials and Methods

The study relied on the descriptive analytical approach. This approach was used to collect information related to the reality of environmental pollution in Iraq, with a focus on Basra Governorate, analyze its causes and sources, and then explain its relationship to economic growth opportunities and the potential for achieving development and sustainable growth in Iraq.

Study Structure:

The study included three chapters, as follows:

Chapter One: Theoretical and Conceptual Framework of the Study

First Requirement: The Concept of Environmental Pollution and Its Causes:

Environmental and climate scientists have faced disagreement in determining a precise and unified definition of the scientific concept of environmental pollution. Despite the differing viewpoints, the core of the scientific understanding of environmental pollution is based on the idea of the balance of an ecosystem. Any imbalance resulting from inconsistent interference with the interacting elements within it leads to a decline in its efficiency and instability. This means that any quantitative or qualitative change in the composition of these elements leads to a disturbance in their internal system. In light of this, environmental pollution results from the addition of a new substance unfamiliar to the original environment or from a change in the quantity of one of its elements, whether by increase or decrease. This renders the ecosystem unable to adapt to these modifications, causing disruptions to its balanced composition. According to international law adopted by the United Nations in 1974, the term environmental pollution refers to human activities that lead to the introduction of new substances or energy into the environment. These additional inputs negatively impact, directly or indirectly, human health, well-being, lifestyle, or natural resources, potentially posing a threat to them. Pollution falls under several categories that affect various environmental elements, such as air, water, and soil pollution. The quantities and types of pollutants vary depending on the industries responsible for producing them [1].

The Organization for Economic Co-operation and Development (OECD) defines it as the negative environmental impacts that occur as a result of human actions, either directly or indirectly, resulting in harmful effects that impact environmental sustainability and may pose a threat to human health [2}. The term pollution also refers to all the ways in which human activity harms the natural environment. It can manifest as a visible phenomenon, such as emission of garbage or dense smoke from factories, or in an invisible form, characterized by odorless , tasteless substances. Some types of pollution can cause disturbances to human life , other living organisms without directly harming land, water, or air, such as noise from traffic or the operation of equipment. This is one of the effects of pollution that robs people of the beauty of life in society [3].

Pollution levels are classified according to their severity and effects into three main categories:

1. Acceptable pollution, which does not pose a direct threat to the ecological balance and does not cause tangible problems.
2. Harmful or dangerous pollution, which arises when the level of pollution exceeds the natural limit, leading to negative effects on the environment and public health.
3. Destructive pollution, which represents the complete collapse of the ecosystem as a result of a major , comprehensive imbalance, as exemplified by famous disasters such as Chernobyl in 1986 [4]. [5].

Based on this, the types of pollution vary according to their sources and various forms of effects. The following are the most prominent classifications related to pollution [6]:

A. Classification of environmental pollutants according to their emission source:
   1. Point Source Pollutants: These are pollutants whose emission points can be easily identified, such as exhaust from trucks or sewage flowing directly into rivers through specific pipes.
   2. Non-Point Source Pollutants: These are pollutants whose precise origin is difficult to determine, such as harmful substances carried by floodwaters into rivers without the ability to identify those responsible or their source.

B. Classification by Sector or Activity Causing Pollution: These include (transportation, household, industrial, agricultural).

C. Classification of Environmental Pollutants Based on Their Chemical State: Pollutants are classified according to their chemical state into gaseous, liquid, and solid pollutants caused by various human activities, such as agricultural and industrial activities.

From the previous concepts, we conclude that environmental pollution is defined as any change that leads to an imbalance in the ecosystem, whether at the quantitative or qualitative level. It results from the introduction of materials, the regulation of energy, or changes in natural proportions of environmental components, resulting from human activity or natural events. Such situations render the environment somewhat unable to adapt these developments. Pollution includes all visible and invisible forms, whether physical, chemical, radioactive, or even noise. It has direct and indirect impacts on humans, sustainability of resources, and the balance of ecosystems. Its consequences range from acceptable to dangerous levels that may reach the point of destruction. Within the above context, there are multiple causes behind the problem of environmental pollution in Iraq, the most prominent of which are:

1. Natural factors, represented by the following:

A. Dust and sand storms: In the last decade, Iraq has witnessed a significant deterioration in air quality due to the effects of climate change, particularly in urban areas. This is due to the dry climate and the scarcity of rain, which usually contributes to purifying the air of pollutants, in addition to the spread of arid deserts. These factors coincided with the worsening manifestations of climate change, such as increasing droughts, rising temperatures, and declining rainfall rates, which led to a marked increase in the frequency of dust storms [7].

B. Desertification: Reports from the Iraqi Ministry of Planning confirmed that the environment is witnessing a decline in the quality of soil elements and a deterioration in its physical, chemical, and biological properties. This has contributed to the transformation of large areas of agricultural land into unproductive or low-productivity lands. This deterioration results from human activities, and the such as uprooting trees that have had a loss of their coverage plant and so important environmental degradation. This has caused the fragility of ecological balance in these areas. About 83 percent of the area is exposed to excessive salinity. The Human Rights Documentation Center, said, despite the possession of two rivers Tigris and Euphrates, Iraq has turned into a desert country [8].

2. Human factors, represented by:

A. Steady population growth: The population doubled from 40.22 million in 2021 to 46.04 million in 2024, according to the World Bank. This population increase has significantly impacted the environment, as the population's needs for more food, housing, and water resources have increased, leading to an increase in the volume of waste and waste of all kinds, both solid and liquid. This has also resulted in a decline in natural resources by 2.9% of the gross domestic product [9].
B. Industrial Activities: Since the mid-twentieth century, Iraq has witnessed an industrial boom, marked by the flourishing of all types of industrial activities in various Iraqi cities, in addition to the expansion of the establishment of factories and industrial facilities, particularly in the oil and petrochemical sectors. The lack of commitment to environmental standards has directly led to an increase in greenhouse gas emissions within the country [10].
C. Agriculture: The excessive and uncontrolled use of pesticides and chemical fertilizers in Iraq has contaminated the soil and groundwater with toxic substances, threatening the ecosystem and negatively impacting public health and biodiversity [10]
D. Bad Waste Management: One of the most serious problems faced by most Iraqi cities is due to weak mechanisms for dealing with solid and hazardous waste. These wastes are disposed of indiscriminately in landfills or with surface burning, which spreads pollution across the area [11].
E. Wars and Military Activities: Iraq is a hot field of wars and military activities, starting with the Gulf War and ending with the US invasionin2003, follow edgy years of recurring unrest. Large amounts of heavy metals were released as a result of these catastrophes, which led to considerable infrastructure destruction. They reduced the amount of uranium in the soil and air, which raised pollution levels and had an impact on population health by causing diseases [8].

The second requirement: The concept & dimensions of sustainable development:

Sustainable development is characterized by a diversity of definitions and connections to various fields, reflecting the different assumptions surrounding it. concepts of sustainable development have formed a fundamental pillar in the intellectual history of economic, social, and environmental growth. term "sustainability" has roots closely related to economics. The term "sustainable" originates from the ancient Latin word "sustenere," which carries connotations of maintenance and continuity, protecting resources through their balanced use [12]. The term "sustainable" also has roots in forest management contexts in Germany during the eighteenth and nineteenth centuries, where it expressed a vision focused on the responsible long-term management of these natural resources. Robert Solow defined sustainable development from a perspective that emphasizes ensuring sustainability of productive capacity for future generations, adding importance of considering it from two main aspects: The material aspect related to the conservation of natural and material resources, and

The intellectual and cognitive aspects encompass how to invest, the quality of savings, and the conscious and thoughtful exploitation of resources that serve both the present and the future [13].

In recent decades, the concept of sustainable development has grown tremendously as a result of increasing understanding over its global importance and a major focus for both national and international activities. The current inspiring motto for the global movement around the achievement of sustainable development goals (SDGs) — "2030: Leave No One Behind"— embraces a powerful vision, combining and advocating diverse aspirations for all human beings without exception. The FAO describes in sustainable development as the management of, conservation and inventorying or allocation of these key resources to achieve what meets the needs of the present without compromising future generations' ability to meet their own needs, while emphasizing that this practice can be maintained across all sectors of economics without threatening environment [14].

The World Commission on Environment and Development, established by the United Nations to study this issue, presented a definition of sustainable development in 1987 in its report "Our Common Future." This definition is considered one of the most comprehensive and concise, stating that sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [15].

This means that it is a continuous development process encompassing all fields, provided that the resource rights of future generations are not compromised. The Brundtland Commission defined it in report of same year (1987) as a process of improving the current situation within limits that ensure that the resource potential of future generations is not compromised. This definition clearly presents general framework and fundamental principles of sustainable development [16].

The United Nations Development Program, in its 1992 World Human Development Report, provided a definition based on the need to develop economic, fiscal, and trade policies, as well as energy and agricultural resources, to establish development that achieves a sustainable balance in economic, social, and ecological terms [17]

In the context of the above, the sustainable development process represents a comprehensive approach aimed at directing national economy, social systems, and the environment towards the sustainability of available resources. This process relies on the integration of key dimensions, including: [18]

1. The economic dimension: which focuses on achieving efficient use of resources to balance the needs of current , future generations, with a focus on sustainable economic growth, capital efficiency, meeting basic needs, and achieving justice.
2. The social dimension focuses on raising the standard of living for society by promoting health, combating poverty, and ensuring community security to support local and regional development.
3. The environmental dimension emphasizes the conservation of natural resources as the basis for economic activity, relying on their sustainable use to support economic and social development while protecting the environment.

Sustainable development thus represents a comprehensive, ongoing process aimed at meeting the needs of present while ensuring the preservation of the ability of future generations to meet their own needs. It is manifested in management of natural, human, and material resources in a manner that achieves a balance between the economic, social, and environmental dimensions. Sustainable development is a general international strategy adopted by various organizations, countries, based on comprehensive policies that integrate economic development, environmental conservation, and improving living conditions, ensuring the continued well-being of individuals and society for both current and future generations.

The third requirement: The Relationship Between Environmental Pollution and Sustainable Development:

Economic studies indicate a positive relationship in the short term between increased economic activity and worsening pollution levels. This relationship is explained by the Environmental Kuznets Curve model, which shows that pollution increases during the initial stages of growth but declines upon reaching a certain level of income due to increased reliance on clean technology and increased awareness of environmental issues (Stern, 2004). However, achieving this pattern does not occur automatically; rather, it requires robust policy and regulatory interventions to ensure reduced emissions and improved efficiency in the use of natural resources.

In light of this, the relationship between economic growth, which, according to Edgeman, represents steady, long-term increases in real per capita income [19] , the environment is characterized by reciprocal effects directly linked to economic activities and natural resources.

Economic growth is affected by the availability of natural resources and the likelihood of their depletion in long term. On the other hand, economic growth, particularly

When it happens quickly, it has a beneficial effect. This puts a lot of strain on these resources, which might occasionally result in their direct deterioration or exhaustion. Production processes that depend on vital components including labor, capital, technology, and natural resources are how economic progress is expressed [9].

These factors therefore encourage the creation of worthwhile products and services.

However, these procedures result in hazardous byproducts that upset the environment's natural equilibrium. Growth is linked to social costs, such as environmental degradation, even though it is frequently assessed by its increasing real income and other economic advantages. In this regard, waste and harmful substances are produced by increased production and consumption activities and are stored in a variety of environmental resources, including soil, water, and air. These pollutants rise in direct proportion to economic activity or industrial scale [20].

In the same perspective, a key component of the idea of sustainable development is striking a balance between environmental preservation and economic growth. Adopting sustainable production and consumption practices is essential to realizing this vision, as is encouraging innovation in waste management, the circular economy, and alternative energy. A key instrument for striking this balance is effective environmental legislation, such as environmental levies and incentives for investments in clean technology [21]. Based on the above, we can say that there is a direct relationship between pollution levels and sustainable development in the short term. However, sustainable development aims to reduce this interdependence by shifting toward more environmentally friendly production and consumption patterns, which contribute to economic growth while ensuring the protection of environmental resources for future generations.

Section Two: A Case Study of Basra Governorate:

One requirement: Geographical Location & Climatic Characteristics of Basra Governorate:

Basra Governorate enjoys a unique strategic location that enables significant industrial growth. Located in the far southeast of Iraq, it is a vital hub for region. The governorate lies between longitudes (64.40° - 48.30°) east and latitudes (29.5° - 31.20°) north. [22] It is bordered to north by Maysan Governorate, while to the south it is connected to the Arabian Gulf, which represents its maritime border, in addition to the border between Iraq and Kuwait. To the east, Basra forms part of the political border separating the country from Iran, while to the west it is bordered by Dhi Qar and Muthanna Governorates. [2023]

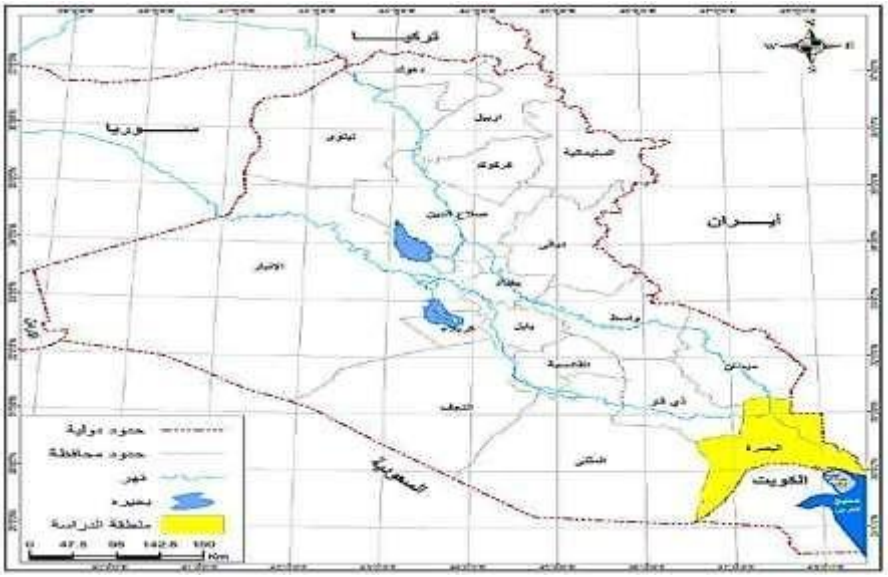
Basra Governorate is located on the western bank of Shatt al-Arab River, which originates at the confluence of the Tigris and Euphrates rivers and flows towards the Arabian Gulf, reaching its estuary over a distance of 110 kilometers. It is surrounded by various districts, such as Al-Qurnah and Shatt al-Arab to north , south, in addition to Al-Zubair, Abu Al-Khasib, and Al-Faw to the west and south. The governorate's location in the heart of the Mesopotamian plains makes it an important agricultural center for the production of numerous crops, such as rice, barley, wheat, and millet, as well as for livestock and cattle breeding (Encyclopedia Britannica).

Economically, Basra boasts significant oil wealth through prominent fields such as Rumaila and Shuaiba, in addition to being Iraq's only sea outlet to the Arabian Gulf.

Geographically, the governorate is characterized by a mixture of terrain, including plains, plateaus, mountains, and desert areas. Basra holds profound historical significance as part of ancient Iraq and Sumer. It is personally associated with the tales of Sinbad the Sailor, with the site being said to be the Garden of Eden. From a civilizational and cultural perspective, the city holds significant value for its role in important phases of Islamic history. "It was founded in the year 15 AH (636 AD), giving it historical significance and a rich cultural heritage that distinguishes it from other cities [24].

In light of the above, the following map illustrates the location of the city of Basra.

Figure 1. Map of the geographical location of Basra Governorate"



Data up to 10/2023 Source: Republic of Iraq, General Authority for Survey Administrative Map of Iraq Scale 1:100,000, 2019.

"The Basra Governorate is characterized by a scorching hot desert climate with considerable differences in temperatures during the year. Basra is characterized as being in the hot desert climate zone, with an annual average temperature of 24°C.The hottest month (July) sees temperatures peak at 34°C and most of the months between January and June stay below this mark; maximum temperatures rise markedly in August to about 41 °C" while minimum temperature falls downwards in notable amounts when taken in January 6.8°C[24]".

Rainfall is rare in Basra, with limited amounts recorded, totaling 140 mm annually. Rainfall is mostly seasonal, beginning slightly in October, with less than 1 mm per month, gradually increasing until December, reaching an average of 29.3 mm. It then declines again, reaching 7.8 mm in May, followed by a period of complete absence of rain between June and September. Relative humidity averages 60% annually, increasing significantly during the winter, peaking at 78% in January. These levels decline during the summer months, reaching their lowest at 48% in August. Solar radiation varies significantly from region to region, with the highest annual average recorded at the Al-Hussein station (461.86 kcal/cm²/day), due to the high average annual sunshine hours (67.8 hours). The lowest average was at the Airport station (455.52 kcal/cm²/day), due to the low annual average sunshine hours caused by frequent dust storms, in addition to the negative impact of fossil fuel combustion products emitted from oil wells, which reduce the amount of solar radiation reaching the Earth's surface [23].

Second Requirement: Sources of Pollution in Basra Governorate:

Basra Governorate is one of the areas most affected by environmental pollution in Iraq, due to diverse industrial activities concentrated there. Industrial pollution is the primary factor behind this problem, as industries related to oil, petrochemicals, fertilizer plants, ports, and metallurgy contribute to air, water, soil pollution, adding high concentrations of heavy metals and hydrocarbons to the environment. The most important causes of pollution in Basra are highlighted below:

1. Extractive (oil) industries: The extractive oil industries in Basra Governorate are one of most prominent pillars of the Iraqi economy, as they constitute a significant contribution to oil production nationwide. Basra is a major hub for oil production due to its large reserves, estimated at approximately 70% of Iraq's total reserves [25]. This governorate has witnessed significant developments in production levels, with its oil production increasing from 1,554,000 barrels per day in 2000 to 2,823,000 barrels per day by 2015 [26], doubling to approximately 3.25 million barrels per day by 2023, according to World Bank statistics. In this context, with the expansion of oil activity, the amount of greenhouse gas emissions has increased significantly. Between 2008 and

2014, the total amount of gases flared through refineries amounted to approximately 85,337.9 cubic meters, while the annual amount of flared gases reached approximately 39 billion cubic meters. For the South Gas Company, flaring levels reached approximately 156 million cubic meters annually [27]. With the growth in production, the volume of these gases doubled, resulting in the emission of approximately 30 million tons of carbon dioxide and 50,000 tons of hydrogen sulfide, according to the World Bank.

2. Petrochemical Industries: This industry is one of the most environmentally impactful industries due to the significant emissions emitted from its chimneys. This impact is particularly pronounced in the city of Zubair due to its proximity to these industrial facilities. The complex includes several factories, including an ethylene plant, a low-density polyethylene plant, and a high-density polyethylene plant, along with a gas-fired power plant and a chlorine production unit.

   This industry produces a variety of gaseous, particulate, and liquid pollutants. For example, approximately 114.9 tons of carbon dioxide and 43.2 tons of hydrocarbons are emitted annually [28]. Chlorine gas, one of the most dangerous environmental pollutants, is also emitted at a rate of 561.6 tons annually under normal operating conditions. During malfunctions, its emissions rise to 783.8 tons annually, representing approximately 42% of total emissions. In addition, methane gas is emitted at a rate of 136,000 tons annually, in addition to hydrogen sulfide at a rate of 41.7 tons, which is largely associated with the chlorine industry. These emissions, along with others, contribute to serious negative environmental impacts on the communities and areas surrounding the industrial complex. (Al-Saraifi, 2019, p. 35)

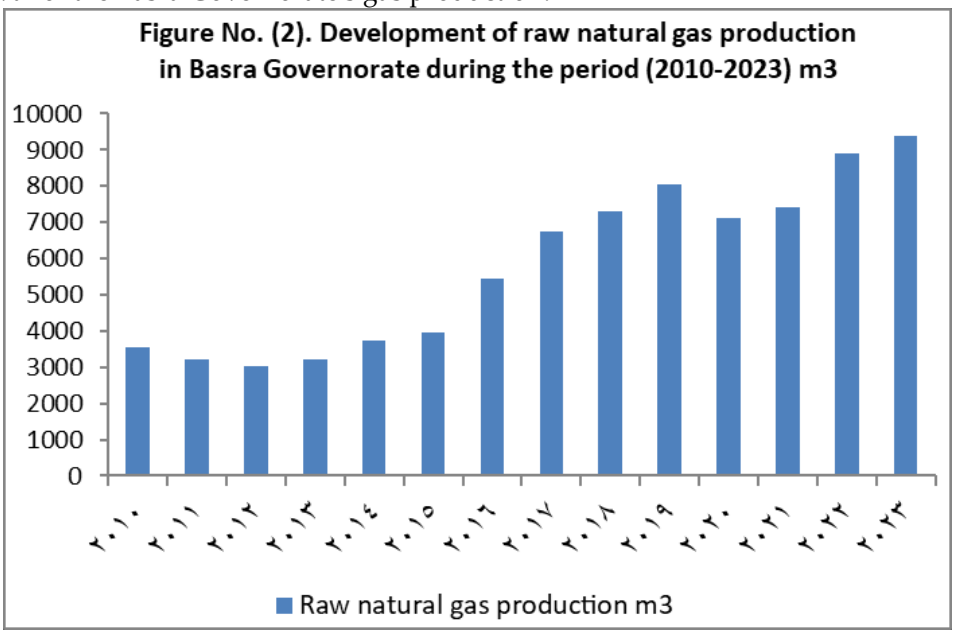
3. Construction industries: These represent one of the most significant industrial activities that have negative impacts on the surrounding environment, as they lead to the emission of harmful gases and vapors and the spread of large quantities of dust laden with heavy metals that have toxic effects that threaten the public health of living organisms. Studies have shown that the concentration of these elements in the volatile dust emitted by these industries exceeds safe levels, with the negative impact reaching between 70% and 80% [29].

   This volatile dust leads to accumulation of toxic substances in the soil and surrounding plants, resulting in the formation of a fine layer on the surface of plant leaves, preventing gas exchange , blocking leaf stomata. This phenomenon causes plant leaves to fall and dry out, leading to their death, in addition to the damage it causes to other living organisms within the region. Therefore, developing effective policies to reduce pollution caused by construction industries is an urgent necessity to ensure environmental sustainability and the safety of living organisms [27].

4. Natural Gas: The natural gas sector in Basra Governorate has witnessed steady growth since the beginning of production in 1948, following the extraction of crude oil from the Zubair field, which led to increased emissions of carbon dioxide and other greenhouse gases into the atmosphere. In 1949, the first gas isolation and pumping station was established in region, followed by the commencement of oil export operations from the Faw terminal in 1951 [30] .

In recent years, crude gas production in Basra has witnessed a significant increase; Production reached 3,558,255 cubic meters in 2010, jumping to 8,036,020 cubic meters by 2019. However, 2020 saw a decline in production levels due to the repercussions of the COVID-19 pandemic, declining to 7,131,789 cubic meters. With the improvement of the situation and the gradual return of economic activity, production rose again, reaching 7,421,714 cubic meters in 2021 [31]. According to the World Bank, production rose and seems to have continued to grow, reaching around 9.9 billion cubic meters in 2022–2023 alone and emitting the equivalent of about 30 million tons of CO2 along with enormous amounts of methane and nitrous oxide (NO). This demonstrated the necessity and eagerness of the efforts to develop and expand Basra's natural gas supplies. an essential source of energy in Iraq. With data scheduled through October 2023, you should still be able to see the diagram below.

growth of the Basra Governorate's gas production.



From: this volume, M. Nader; [30.32]48 Costs of Production in Barrel basra oil company, Basra Printing and Publishing Foundation, first printing; South gas company Productive Authority unpublished data

5. Electricity Sector: The electricity sector is a major player in Basra, as it drives economic growth and meets the need for energy. However, operating power plants goes hand in hand with greater emissions of pollutants, such as carbon dioxide, nitrogen oxides and fine particulate matter.. Since Basra contains many power plants, it is one of the Iraqi cities most exposed to air pollution resulting from these emissions. Basra Governorate has six power plants, including one steam plant and four gas plants located in the western part of the governorate, which rely entirely on natural gas [27]. Therefore, carbon emissions resulting from fuel combustion in power plants are among most prominent sources of pollution in Basra, contributing to elevated levels of pollution in atmosphere, including sulfur dioxide and other oxides [21]. Some environmental studies have shown that these emissions contribute to the formation of acid rain and the deterioration of overall air quality, negatively impacting vegetation and ecological balance in region [33].

6. Transportation Sector: Transportation is one of most prominent activities contributing significantly to air pollution in Basra Governorate. Improvements in standard of living have made many people more dependent on cars, particularly public transportation. Road expansion has also led to increased car use, negatively impacting the environment, economy, and society. The most prominent of these effects is increased traffic congestion and rising fuel prices. Transportation also releases large amounts of harmful gases and vapors due to inefficient fuel combustion. This pollution is steadily increasing with the increase in the number of cars, especially those running on gasoline, which contains lead at a rate of between 2 and 4 grams per gallon [34]. In contrast, other types of vehicles emit gases such as carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, and hydrocarbons due to inefficient combustion. Consequently, air pollution levels in the streets of Basra Governorate are high due to many old modes of transportation and poor maintenance, leading to the continued emission of harmful gases into environment.

7. Waste Management: Basra Governorate faces major environmental problems due to the weakness of its solid and liquid waste management system. The lack of strategic planning in this area leads to an increase in household and industrial waste, which increases environmental pollution and negatively impacts people's health and quality of

life. Scientific studies have shown that rapid population increase and the growth of industrial and oil activities have led to a significant increase in waste quantities in Basra. [35].Unregulated waste burning is considered one of the most prominent causes of air pollution in Basra, as it releases toxic gases such as carbon monoxide, dioxins, and fine particulate matter. These pollutants affect air quality and increase the incidence of respiratory diseases. Research has found that residential neighborhoods near landfills and indiscriminate waste burning suffer from higher levels of air pollution [33], [47].

The impact of environmental pollution on Basra Governorate:

Basra Governorate is one of the governorates in Iraq that suffers the most from environmental pollution resulting from industrial activities. The effects of environmental pollution can be summarized as follows:

1. High rates of air pollution: Basra Governorate has witnessed a continuous increase in industrial activities, leading to a significant increase in air pollution rates due to increased emissions of greenhouse gases, such as carbon dioxide, nitrogen oxides, and hydrogen sulfide, into the atmosphere. The majority of these emissions are attributed to increased activities related to oil and gas fields and waste incineration facilities. Basra District ranked first in recording the highest rate of carbon dioxide emissions during the period (1996-2020), at a rate of (70.6 ppt), surpassing all other districts. Al-Zubair District followed it with a rate of (40.8 ppt), then Al-Qurna District with a rate of (28.9 ppt). In addition, monitoring the concentrations of both carbon monoxide and nitrogen oxides in many areas confirms the direct impact of industrial and oil activities on air quality in the governorate [36]. Figure 3 illustrates the changes in the levels of some greenhouse gases resulting from these activities, underscoring the urgent need to adopt effective measures to reduce pollution and preserve the environment.

Figure No. (3). Change in some greenhouse gas pollutants in the air in Basra Governorate during the period 1996-2020.

	Al-Zubair District	Abi Al-Khasib District	Basra District	Al-Faw District	Al-Qurnah District
carbon dioxide CO2	40.8	10.6	70.6	5.2	28.9
hydrogen sulfide H2S	1.1	5.5	0.2	0.8	3.1
Nitrogen oxides NOX	1.09	6.8	10.6	0.2	2.6
carbon dioxide CO	5.5	16.6	4.5	1.6	12.4

Source: [36] Environmental Pollution in Basra and its Effects on Changing Agricultural Land Areas and Their Production, House of Representatives - Parliamentary Research and Studies Department, Briefing Paper, p. 5.

2. Changes in agricultural land area and productivity: Increased industrial activities in Basra Governorate have led to increased air pollution emissions, contributing to impaired plant growth and reduced crop yields. This impact occurs as a result of pollution, which leads to internal physiological changes, such as damage to plant pigments and changes in antioxidant enzyme levels [37]. As a result of these conditions, area of agricultural land in the region has witnessed a significant decline, with a significant decrease in winter crop production. This is due to several factors, including competition with imported products, weak financial support, and a large number of farmers leaving the agricultural sector , moving to other jobs. This shift has led to the sale

of land at high prices , its conversion into residential land, contributing to increased environmental pollution [36].

Furthermore, cultivated areas , crop productivity have decreased, leading to higher levels of carbon dioxide in the air and a decrease in oxygen levels. To illustrate this change, see Table 1, which shows the variation in the quantities of winter and summer vegetable crops in Basra Governorate according to its administrative units.

Table 1. Change in percentages of winter and summer vegetable crops in Basra Governorate according to its various administrative units during the period (2003-2020) (%)

%change in summer vegetable crops								
Administrative Units	Qurna District	Civil district	arta and Deir districts	Shatt al-Arab District	Abi Al-Khaseeb District	Al-Faw District	Al-Zubair District	Safwan District
rate of chPollution	-260	-203.4	-10.2	-39.4	-249.9	-96.2	-89.1	-31.3
%change in summer vegetable crops								
rate of change	-85.8	-39.9	+4.9	-179.3	-128.8	-69.1	+590.7	+164.5

Source: Prepared by researcher based on data from the Iraqi Ministry of Agriculture, Basra Agriculture Directorate, Planning and Follow-up Department, & data from several different years.

3. Spread of Diseases: Numerous medical studies have confirmed that Basra residents suffer from a high rate of respiratory diseases and cancers linked to air pollution. This is primarily due to emissions from power plants that use crude oil and heavy fuel oil. Statistics show that asthma and chronic bronchitis rates in Basra exceed the national average in Iraq due to the increased concentration of fine particulate matter [38].
4. The deterioration of waste management in Basra also leads to the spread of cancer, respiratory diseases, and skin infections, in addition to increased rates of diseases transmitted by insects and rodents. A field study has shown that residents living near waste dumps suffer from chronic health problems directly related to exposure to pollutants.
5. Thermal and Water Pollution: The electrical and petrochemical industries in Basra Governorate contribute to thermal and water pollution due to the discharge of hot water used to cool the plants into Shatt al-Arab. This waste heat creates higher water temperatures, adversely affecting aquatic biodiversity. Some fish species have been found to drop off in number from lack of beneficial environmental conditions [39]. Further, improper disposal of liquid and industrial wastes contaminates Shatt al-Arab and groundwater resources. Water pollution, as a consequence of leaking chemicals and heavy metals from landfill sites increases pollutant levels in the water, which impacts aquatic life, and leads to an increase in poisoning among residents who use this water for drinking purposes and agricultural resources [39].

Challenges & Future Prospects

Potential Environmental and Economic Challenges of Climate Change in Iraq

Pollution and climate change are among the most important environmental issues in Iraq. Over the last couple of decades, it has seen the droughts increase in duration, temperatures climb unprecedentedness like never before and rains decline to nothing. This has directly impacted water resources in particular given the heavy nature of consumption of Tigris and Euphrates Rivers. But climate change and local policies for water management are making their flows dwindle. This water shortage contributes to the acceleration of desertification and the degradation of agricultural lands, threatening national food security [40]. On the environmental level, extreme climate phenomena have led to increased rates of dust storms

, prolonged drought, which harm public health and reduce biodiversity. Studies indicate an increase in dust storms over past two decades and their associated health effects, most notably respiratory diseases. Rapid desertification also transforms vast agricultural areas into unsuitable lands (UNEP, 2021).

On economic , social level, climate change has negatively impacted the agricultural sector, which is a major source of livelihood in rural areas. Declining production due to drought and water scarcity has led to a decline in agricultural income and increased migration to cities, increasing pressure on urban infrastructure [41]. The Iraqi economy also faces a double challenge due to its heavy reliance on oil, given its price fluctuations and the global shift towards clean energy. This necessitates diversifying sources of income and enhancing adaptation to green economy [42]. Furthermore, rising temperatures and increased demand for cooling have exacerbated pressure on the fragile electricity grid, with consumption levels exceeding production capacity, exacerbating power outages and impacting economic activity. Furthermore, the deterioration of agricultural land and increased reliance on food imports constitute an additional burden on the public budget amid ongoing economic crises [43].

The second requirement. Pollution and Its Impact on Economic Growth Opportunities in Iraq:

During study spanning 2010 to 2023, Iraq witnessed a marked variation in fossil carbon emission levels and economic growth rates, reflecting complex relationship between economic activity , environmental pressures. Carbon dioxide emissions increased from about 111 million tons in 2010 to more than 193 million tons in 2022, resulting per capita consumption increase from 3.58 tons at that time compared to 4.40 tons in the previous periods (World Bank,2023). This is due to the fact that fossil fuels still dominate in power generation and industry, but cleaner sources are few (IEA, 2021).

Conversely, when comparing these indicators with economic growth rates, an unstable relationship becomes apparent. Some years, such as 2012 and 2016, witnessed high economic growth exceeding 13%, accompanied by increased emissions, while other years, such as 2017 & 2020, witnessed economic contraction despite continued increases in emissions (UNDP, 2021; [44]. This indicates the vulnerability of economic growth to fluctuations in oil prices , political conditions, that it has not always been compatible with environmental considerations (OECD, 2022)

In this context, it is clear that pollution from fossil fuel emissions imposes additional burdens on sustainable growth opportunities, as increasing energy consumption coupled with population growth exacerbates health , economic damage and reduces opportunities for economic growth [45].

Accordingly, the transition to a green economy and the adoption of renewable energy policies represent a strategic option to achieve a balance between growth and environmental protection. The experiences of some developing countries have shown that investing in solar energy and natural gas instead of oil and coal reduces emissions while maintaining stable growth [46] This makes restructuring environmental and economic policies in Iraq essential to achieving the 2030 Sustainable Development Goals. Table 2 illustrates the relationship between emissions and economic growth rates.

Table 2. Evolution of carbon dioxide emissions in Iraq and economic growth rates in Iraq during the Period (2010-2023)

years	Population (million people)	Carbon dioxide emissions from fossil fuels (million tons)	per capita carbon dioxide emissions	Economic growth rates (%)
2010	31,045,366	111,013,240	3.58	6.40
2011	32,161,424	115,463,740	3.59	7.50
2012	33,654,842	132,707,720	3.94	13.90
2013	35,281,989	142,782,490	4.05	7.60
2014	36,550,059	137,657,610	3.77	2.30

2015	37,560,535	137,045,650	3.65	2.60
2016	38,469,627	147,886,570	3.84	13.80
2017	39,337,353	161,380,690	4.1	-1.80
2018	40,265,624	173,965,500	4.32	2.60
2019	41,192,171	187,046,270	4.54	5.50
2020	42,116,605	169,583,860	4.03	-12
2021	43,071,211	179,929,540	4.18	1.50
2022	44,070,551	193,836,310	4.4	8
2023	45,070,000	196,658	4.28	0.50

Source: Prepared by researcher based on the World Bank database, available at https://data.albankaldawli.org [48]

The table shows an inverse relationship between carbon dioxide emissions from fossil fuels and economic growth rates in Iraq during the period (2010–2023). During the period of analysis (2010 to 2022), total emissions increased gradually from approximately 111Mtu in 2010 to roughly 197Mtu in 2022. This was as a result of population growth, planetary growth and economic expansion, particularly in oil and fossil fuel-related industries. In contrast, emissions per capita remained between 3.5 and 4.5 tons: says Marshall showing that population growth roughly equaled higher emissions

Economic growth rates fluctuated up and down so quickly. The Iraqi economy grew very rapidly in 2012 (around 13.9%) and also in the 2016 (13.8), and it shrank a great deal in both 2017 and 2020. Thus, significant increases in economic growth rates are typically accompanied by increases in emissions, while economic declines lead to a decrease or slowdown in emissions growth. This reflects the rentier nature of the Iraqi oil-dependent economy, where emissions are closely linked to the performance of the energy sector and oil production, which constitute the primary driver of growth.

Proposed Methods for Addressing Environmental Pollution in Iraq to Achieve Sustainable Development and Future Visions for the Possibility of Transitioning to a Green Economy in Iraq:

Reducing environmental pollution in Iraq is a prerequisite for achieving sustainable development, which requires integration between environmental legislation and economic and social reforms. The most important methods for addressing environmental pollution are as follows:

1. Working to improve natural resource management and reduce pollution, which supports sustainable economic growth in country.
2. Developing legislation and activating environmental oversight are crucial, as weak legal frameworks, absence of regulatory practices exacerbate pollution, necessitating updates to laws, implementation of strict monitoring and punishment mechanisms.
3. Striving to enhance waste management through recycling and applying waste-to-energy technologies provides practical solutions that reduce pollution and create new economic opportunities.
4. Establishing advanced waste treatment plants for industrial and agricultural waste is essential to protect rivers and soil.
5. Moving toward renewable energy sources such as solar and wind to reduce emissions and achieve energy security.
6. Working to attract and encourage investment in renewable energy sources, which represent a sustainable alternative to oil and gas.
7. Developing programs and initiatives aimed at spreading awareness and community participation, which enhances the effectiveness of environmental policies and promotes a culture of responsible consumption.

Thus, switching to a green economy in Iraq is one of the most effective solutions for both economic and environmental challenges associated with an overreliance on oil, and how local changes driven by its extraction also often alter regional economies and the environment. (UNDP, 2021)

Depending on a green economy promotes sustainable growth through the cultivation of new sectors such as renewable energy, water management, and environmentally intelligent agriculture, while enhancing existing ones. Using sustainable energy resources like solar and wind power is an integral part of supporting Iraq's shift away from the grey economy. Investing in these natural resources reduces our dependency on fossil fuels, curtails pollution, and spawns green jobs [43]. Improving the efficiency of energy use is also a major component of their 20% overall reduction in energy use over ten years (IEA, 2020). A significant piece of bringing people in and outside of the country into putting resources into sustainable power is then backing green projects through tax cuts and long haul financing.

Collaboration with the private sector for support of green innovation and investment, and financing environmental projects will further increase Iraq's attractiveness to investors particularly in areas such as waste management and sustainable agriculture However, there are also considerable issues too such as poor infrastructure, dependency on oil money, and limited environmental consciousness. Due to these challenges, laws must be enhanced and institutions reformed with a view to enhancing environmental management while ensuring that sustainable development concepts be embedded in future economic policies. This highlights that bringing about the transition to a green economy will soon require us to communicate strategies, initiatives and programs enabling people to change their consumption habits in ways that are more sustainable for our planet as well as future generations.

3. Results and Discussion

1. For example, Basra Governorate: Oil, petrochemical and industrial operations have made the air, water, and soil in Basra Governorate extremely polluted. Sure enough, high rates of lung diseases and cancer along with diminished cover for vegetation and a general decline in agricultural yield corroborates this. These impacts on health and environment have so dramatically reduced the quality of life in the governorate. Which supports the first hypothesis of this study.
2. Carbon emissions in Iraq increased from 111 million tons in 2010 to about 197 million tons last year. The economy of each country grew during the study period at varying rates. Consequently the rentier capitalist economy that depended on oil was weak, and pollution continued to rise even during recession years, indicating a lack of sustainability. Now, there must be an inverse correlation, the data revealed, with environmental pollution and sustainable development. This supports the second hypothesis.
3. The pollution situation in Iraq is exacerbated with the absence of any effective environmental policies and ineffective implementation of existing laws.
4. Soils decreased in agricultural regions have been reduced after air and water pollution impact of the yield of summer and winter cropping rates produced at the level of Basra Governorate. We have even seen some farming areas converted into home..
5. The absence of effective solid and liquid waste management systems has led to worsening pollution and the spread of pollutant-related diseases, especially in areas close to landfills.
6. The worsening environmental pollution is a deterrent to foreign and local investment due to health and environmental risks, weakening Iraq's ability to attract capital.

4. Conclusion

Environmental pollution in Iraq, particularly in Basra Governorate, represents a fundamental obstacle to achieving growth and sustainable development. Based on this, the study reached the following conclusions and recommendations:

Recommendations

1. Rely on more efficient technologies for electricity generation, such as using natural gas instead of heavy fuel oil, as well as expanding reliance on renewable energy to reduce air pollution rates in Iraq.
2. "An effort to increase environmental management and implement international standards for power plant emissions, which is a prerequisite for decreasing the harmful environmental and health impacts of the energy industry in Basra.
3. Developing waste management initiatives in the province of Basra, by applying integrated strategies including recycling mechanisms, reducing waste production at the source and investment in advanced treatment technologies such as waste-to-energy.
4. Updating and amending the environmental legislation in Iraq to be compatible with international standards and to apply strong monitoring and penalty systems to the polluters especially in the oil and petrochemical sectors.
5. Developing and implementing education and awareness initiatives in the local community to foster a culture of responsible consumption and promote healthy environmental habits, so empowering the community to participate in pollution reduction efforts". This will lead to a green economy, which represents one of the strategies for achieving sustainable development in Iraq.
6. Working to develop strategic plans to diversify national income sources by supporting alternative sectors such as ecotourism, green industries, and sustainable services to reduce the economy's vulnerability to oil price fluctuations and environmental impacts.
7. Working to promote investment in renewable energy (solar and wind) , clean technologies to reduce dependence on fossil fuels and limit carbon emissions, while providing tax incentives for environmentally friendly projects in Iraq.

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