[1]Baseem A. Aljashaami[#]

Sajjad A. Salih[#1]

Naseer T. Alwan[#1,2]

Mohammed A. Qasim[#1]

Milia H. Majeed[#1]

Ahmed H. Mola[#1]

Vladimir I. Velkin[#1]

Sergey E. Shcheklein[#1]

Advancing Environmental Sustainability: Integrating Renewable Energy Technologies in Iraq's Development

Abstract: - Iraq has undergone economic development and urbanization that has resulted in negative climatic impacts. This was done to meet the energy needs of current generations and at the cost of depleting resources, which will affect future generations. Iraq should consider finding new and substitute sources of energy, switching from the traditional economy model based on its natural resources to one that is renewable and clean. A coordinated and orderly transition is needed from deriving energy from oil, minerals, and other current energy forms to new sources to preserve the environment. The current study emphasizes the use of sustainable and renewable energy resources for government facilities. The study's premise is predicated on deriving 10% of its revenue from current energy resources that Iraq uses to finance its government. This portion will be utilized to finance renewable and sustainable energy projects. Iraq, a country with a long history and plentiful resources, is confronted by significant obstacles to its economic development and environmental sustainability. This paper explains why Iraq should incorporate renewable energy innovations into its advancement plan to decrease environmental harm, further develop energy security, and spur economic development.

Keywords: Environmental Sustainability, Integrating, Renewable Energy

1. INTRODUCTION

Integrating renewable energy technology into a country's development plan is a crucial undertaking at a time when environmental sustainability is a serious concern. Iraq is a country that has unique challenges in this regard. [1] It has always relied on oil as its main energy source because it is in a region with abundant fossil fuel resources. However, Iraq is now looking into alternative energy resources due to its need for sustainable growth and realization of the negative environmental impacts of fossil fuel consumption. Incorporation of renewable energy technology into Iraq's development trajectory thus becomes an urgent necessity. This is a complex task and an opportunity for change in Iraq's pursuit of environmental sustainability through renewable energy technologies. The nation has a long history and rich culture, but it also faces a variety of problems, including political unpredictability, economic limitations, and environmental degradation. A comprehensive strategy that considers development's social, economic, and environmental facets is necessary to overcome these obstacles and develop a sustainable energy future.

This introduction prepares the reader for a thorough examination of Iraq's efforts to use renewable energy technology to achieve environmental sustainability. It highlights the significance of this effort for Iraq as well as the worldwide fight against climate change and preserving the welfare of future generations. [2] As we examine the details of this transformation, it becomes clear that Iraq's development of renewable energy technologies represents not only a commitment to sustainability, but also a path toward energy security, economic diversification, and increased resilience in a world that is changing quickly. The enormous potential of renewable

[1] Department of Nuclear and Renewable Energy, Ural Federal University, Yekaterinburg 620002, Russia.

[2]Technical Engineering College of Kirkuk, Northern Technical University, Kirkuk 36001, Iraq.

energy offers a sustainable future for Iraq. This research aims to shed light on the plans, obstacles, and potential outcomes of this transformative journey.

1.1. Iraq's Potential for Renewable Energy

➢ **The potential of solar energy**

• On average, Iraq experiences 320 sunny days every year, which is abundant sunshine all year long.

• According to estimates, the nation's solar energy potential is among the highest in the area, making it an ideal location for growth of solar power.

• To take advantage of this potential, large-scale solar photovoltaic (PV) systems can be installed, both in residential and utility-scale facilities.

➢ **Energy Potential of Wind**

• There are several areas in Iraq that experience favorable wind conditions, especially in the western and northern regions.

• These regions have consistent wind patterns, especially during specific seasons, which makes them appropriate for development of wind farms.

• Wind turbines can take advantage of Iraq's wind energy potential, including both onshore and possibly offshore projects.

➢ **Potential of Hydroelectric Power**

• The Tigris and Euphrates rivers in Iraq, present a sizable opportunity for production of hydroelectricity.

• Along these rivers, dams and hydroelectric power plants can be built to offer a reliable supply of renewable energy.

• Additionally, there are smaller rivers and tributaries all around the nation that can be used to generate hydroelectricity.

1.2. Benefits of Renewable Energy for the Environment

➢ **Air pollution and greenhouse gas emissions reduction**

Mitigation of Greenhouse Gas Emissions: One of renewable energy's most important environmental advantages is its capacity to lower greenhouse gas emissions. Renewable energy sources like wind, solar, and hydroelectricity generate electricity that does not require fossil fuels and releases no carbon dioxide (CO_2) or other greenhouse gases into the atmosphere.

Reduced Air Pollution: In contrast to burning fossil fuels, renewable energy technologies do not release dangerous pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulates. [3] These contaminants harm public health and deteriorate air quality. Countries can improve air quality, lower the number of cases of respiratory ailments, and improve the general well-being of their inhabitants by switching to renewable energy sources.

Reduced Dependence on Coal and Oil: Coal and oil are the main energy resources in many regions. Countries can lessen their reliance on these carbon-intensive fuels by turning to renewable energy sources, which further lowers emissions and aids in the fight against global warming.

➢ **Beneficial Effects on Local Ecosystems, Water Resources, and Environmental Quality in General**

Ecosystem preservation: Extraction and combustion of fossil fuels can result in habitat destruction, soil contamination, and ecosystem disruption. Projects involving renewable energy, particularly those centered on wind and solar power, frequently leave less of an ecological impact. Solar panels can be mounted on existing infrastructure, and wind turbines can be placed on previously disturbed ground to reduce damage to the surroundings.

Conserving Water Resources: Conventional power plants, including coal and nuclear facilities, need large volumes of water for cooling. This puts a strain on nearby water supplies and damages aquatic ecosystems. In

contrast, most renewable energy technologies use less water or do not require it at all for operation. For instance, wind turbines and solar panels do not need water to function, which helps with water conservation.

Reduced Land and Resource Consumption: Huge renewable energy installations frequently utilize degraded land, including vacant industrial sites or low-yielding agricultural fields. By doing this, the need for additional deforestation or habitat disruption as well as land-use conflict is reduced.

Compared to some fossil fuel infrastructure, renewable energy technologies such as wind turbines and solar panels have comparatively little influence on visual impacts and noise pollution. Properly planning and siting renewable energy projects can further reduce these effects on nearby residents.

2. LITERATURE REVIEW

Abid and Younis (2020) [4] performed a comprehensive analysis of Iraq's potential for renewable energy and related policies. They developed a policy framework necessary for sustainable development and conducted a thorough assessment of the renewable energy resources already available in Iraq. The article offers a sound basis for additional research by providing insightful observations regarding Iraq's renewable energy sector.

The review by Majeed and Mahmood (2021) [5] explores the prospects and difficulties Iraq has in implementing the use of renewable energy. The report gives a nuanced understanding of the special circumstances and prospects for the adoption of renewable energy in Iraq by providing a thorough review. It is a useful tool for scholars and politicians who are trying to understand the difficulties of integrating renewable energy in the nation.

The report by Abdulrazzaq and Chaichan (2018) [6] offers a thorough overview of the current state of renewable energy in Iraq. It presents a fair view of the country's renewable energy landscape by addressing both the opportunities and challenges in this area. For individuals who are interested in comprehending the real-world implications of renewable energy adoption in Iraq, this assessment is an essential resource.

The study by Al-Saedi and Mahlia (2020) [7] focuses on how renewable energy might help Iraq achieve its sustainable development objectives. It emphasizes the important role of renewable energy in accomplishing more general environmental and socioeconomic goals. For authorities seeking to include renewable energy in Iraq's growth agenda while assuring sustainability, this research is crucial.

Al-Juboori and colleagues (2021) [8] examined how renewable energy technologies affect Iraq's ecology. Their analysis emphasizes the crucial impacts of ecological effects that need consideration when using renewable energy resources. This study is essential for a comprehensive evaluation of the nation's renewable energy initiatives.

A case study on the economic and environmental implications of integrating solar energy in Iraq was presented by Kazem and his team in 2019. [9] This report provides useful information about the viability and advantages of particular renewable energy systems. It can be used as a guide to gauge the viability of renewable energy initiatives in the area.

3. RESEARCH METHODOLOGY

To recognize and examine the most significant sustainable improvement indicators in Iraq, we will focus on three key approaches.

➢ Research design

To start, a careful literature survey was completed to assess the current situation for sustainable improvement in Iraq. Appropriate scholarly works, official documents, and global periodicals that investigate sustainable advancement metrics in Iraq are evaluated. Data about the sustainable advancement indicators used in Iraq or other practically identical regions is summarized. Close consideration is given to the indicators that worldwide associations such as the United Nations often use.

➢ Data Collection

There are several things to consider about data collection.

- It is necessary to find trustworthy sources of data for the chosen indicators. Administrative documents, records from different countries, scholarly research, and informational indices fall under this classification.
- A researcher in this area should assess trends and developments over time and then accumulate historical and current information for the selected indicators.

➢ **Data Analysis**

Data analysis has several goals. They are:

- To understand the present situation and future trends of the chosen sustainable improvement indicators in Iraq and analyze the information that has been gathered.
- To visualize information and feature the most significant conclusions, using graphs, charts, and statistical analysis.

4. DATA ANALYSIS

4.1. Iraq's Sustainable Development Indicators

We will focus on the most significant of these indicators, which are the accompanying three (3), because focusing on all indicators of sustainable development is unduly confusing.

4.1.1. Economic indicators

A. Per capita gross domestic product

Between 2012 and 2020, Iraq experienced a significant increase in per capita gross domestic product (GDP), rising from 1.75 million dinars in 2004 to 4.96 million by the end of 2011. The most substantial increase occurred in 2013 when it reached 7.05 million dinars. However, Iraqi per capita GDP witnessed a decline during the period from 2014 to 2019, dropping from 6.83 million dinars in 2014 to 4.88 million dinars in 2017. Figure 1 demonstrates that this decline was caused by the decrease in worldwide oil prices starting in the second half of 2014. Iraq's per capita income is typical for nations in its region.

B. The skewed relationship between investments and GDP

Public authority accounts for most of the investment in the Iraqi economy. Oil leases make up over 95% of the public authority's general spending plan revenues. The private sector still plays just a minor role. Oil price fluctuations and market developments fundamentally affect the private sector. [10] The typical investment-to-yield proportion from 2012 to 2020 was 17.9, which is low in contrast to other Middle Eastern countries. It is almost 30% in the UAE and Jordan and over 25% in general. [11] Indeed, the Iraqi economy earnestly needs to increase the cash set aside for investments in construction and maintenance.

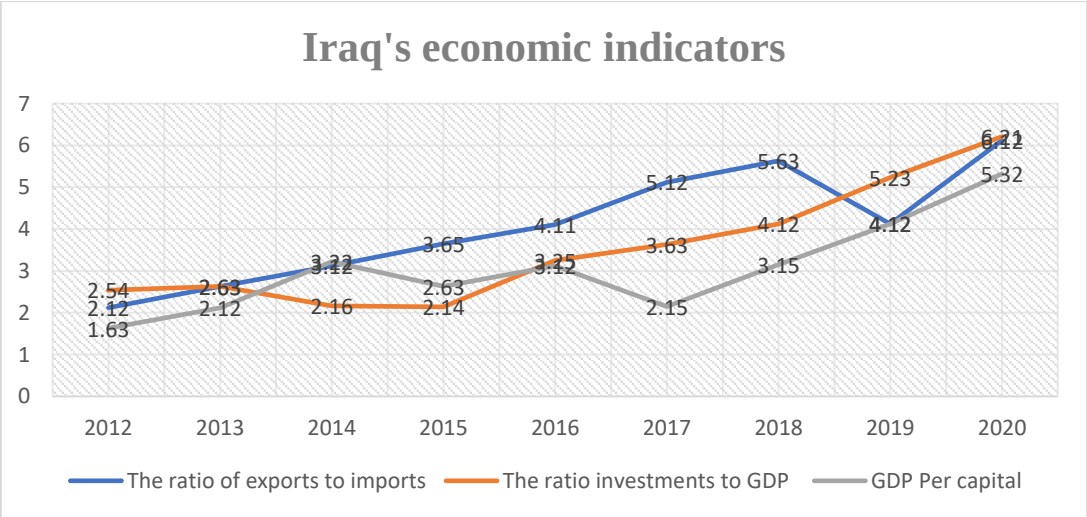

Figure 1: Iraq's financial indicators for sustainable advancement from 2012 to 2020

As indicated in Figure 1, Iraq's capacity to import during the period 2012-2020 is demonstrated by the high pace of exports, of which, over 98% are comprised of oil. This measure also illustrates how open the economy is to the outside world.

4.1.2. Social indicators

It is evident from Table 1 that the unemployment rate in Iraq exhibited some fluctuations during the period under study. In 2012, the unemployment rate was 23%, and it slightly increased to 24% in 2013. However, there was a significant decrease to 12% in 2017. It is notable that despite these fluctuations, the unemployment rate in Iraq remains relatively high compared to neighboring countries. [12]

For instance, when looking at specific demographics, we observe that the unemployment rate for young males aged 15 to 24 years increased from 20% in 2014 to 29% in 2020. However, there was a decline in the unemployment rate for females within the same age group, dropping from 64.8% to 38% during the same years. These trends highlight the need for a comprehensive analysis of the factors contributing to unemployment in Iraq, especially among young people. [13]

Table 1: The joblessness rate in Iraq for the period 2012 to 2020

Year	Unemployment rate (%)
2012	23
2013	24
2014	20
2015	40
2016	35
2017	12
2018	26
2019	18
2020	29

4.1.3. Environmental indicators

A sustainable system must maintain a consistent supply of natural resources and curtail their overuse. This involves safeguarding the ecosystem and all natural environmental systems, including the atmosphere. Environmental concerns such as climate change, ozone depletion, and air quality significantly impact the overall stability and equilibrium of the ecosystem.

It is necessary to protect soil and biodiversity, ensuring sustainable use of living resources such as animals, plants, and fish, without negatively affecting natural ecological balances. An integrated approach to ecosystem and land management must be employed to protect the land from pollution, degradation, desertification, and excessive depletion of natural resources.

Two key indicators to assess biodiversity are the conservation of species at risk of extinction and the extent of land covered by protected areas. Sustainable development also involves efforts to mitigate significant environmental changes and reduce greenhouse gas emissions, which are the primary drivers of these ecological challenges.

A. The amount of arable land

Agriculture is a cornerstone of sustainable improvement because it feeds the general population. In 2007, the ratio of cultivated land to arable land reached its highest levels in Iraq, achieving 48%, before declining to 38% in 2012 and 28% in 2017. [14]

In 2018, the rate reached 31% cultivation, showing a slight improvement. However, despite ongoing challenges related to land desertification, the primary driver of this issue is the high salinity of the land. Salinity affected 40% of the arable land in 2012. [15]

B. Biologically diverse protected areas

Safeguarded areas are lands or bodies of water with significant monetary, scientific, or sporting significance that have been provided lawful assurance to preserve their resources and support improvement. A total of 283,923 hectares, 2,847 km^2, or 0.67% of Iraq's total land area, are reserved. [16] This is viewed as one of the significant indicators of how much the state cares about its legacy.

C. Greenhouse gas emissions

Iraq's carbon dioxide emissions increased from 89.2 megatons per year in 2010 to 130.4 megatons in 2018. Subsequently, they rose to 143.8 megatons per year. When compared on a global scale, where emissions should ideally stabilize at 2.1 tons per person per year [17], the rate in Iraq increased from 2.9 tons per person in 2010 to 3.2 tons per person and then further to 3.5 tons per person in 2019. This increase in emissions is a matter of concern and needs attention for environmental sustainability. These trends are shown in Figure (2).

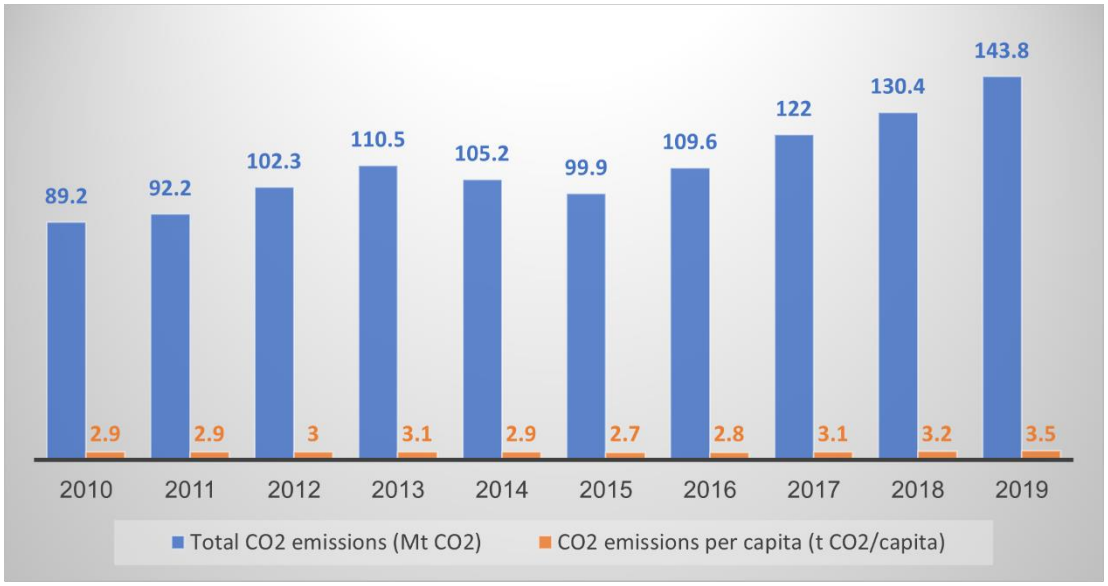

Figure 2: Iraq's carbon dioxide emissions and their per capita levels. [18]

4.2. Renewable energy and its impact on development in Iraq

Iraq has abundant oil and gas resources. The country is one of the largest OPEC producers of crude oil, ranking second after Saudi Arabia, with 17% of the proven oil reserves in the Middle East and 8% of global resources. Iraq's electricity sector is almost entirely dependent on fossil fuels, which account for more than 94% of power generation. In general, oil constitutes 65% and natural gas 33% of the total energy supplies in Iraq (Table 2).

Table 2: Total energy supplies in Iraq for the period (2012-2020) distributed by source (units TJ) [18].

Year	Oil	Natural gas	Hydro	Biofuels and waste	Wind, solar, etc.
2012	1382026	240635	15811	1745	0
2013	1435021	238891	17125	1794	166
2014	1369046	231111	10552	1844	205

2015	1273955	237597	9166	1892	205
2016	1369757	261357	12136	1938	205
2017	1504096	396378	7834	1982	206
2018	1617048	505818	6544	1977	206
2019	1626187	590634	17868	2008	206
2020	1206107	618336	17699	2039	206

In Iraq, finding new energy resources is not difficult because of the country's plentiful oil reserves. However, Iraq suffers from a growing electrical energy shortage due to its increased demand. Statistics indicate that the residential sector constitutes the largest share of electricity consumption, 62% (industrial sector 11%, commercial and public services 5%, and non-specified 22%). Electrical power generation stations fail to supply adequate power because of limited production capabilities and numerous problems that have arisen due to deterioration. Iraq's electricity infrastructure was severely damaged during the Gulf War, suffering from a lack of investment and available equipment while under sanctions that worsened following the invasion in 2003. Day after day, Iraq needs more energy due to increasing demand and population growth.

In terms of renewable energy, the indicators are very modest, as production by hydroelectric stations has declined to 5% of electrical production due to climate changes that have led to reduced river discharge. Although Iraq enjoys many hours of sunshine, the contribution of solar energy to electricity production does not currently exceed 0.06% (Table 3). Studies have shown that Iraq receives more than 3000 hours of solar radiance per year in Baghdad alone. The hourly solar intensity varies between 416 W/m^2 in January to 833 W/m^2 in June. Even the sunshine in Spain cannot compete with the levels observed in Iraq [19].

Table 3: Electricity generation in Iraq for the period (2012-2020) distributed by source (units GWh). [18]

Year	Oil	Natural gas	Hydro	Solar PV
2012	31349	10277	4392	0
2013	41309	12356	4757	46
2014	49963	14874	2931	57
2015	45660	20482	2546	57
2016	56262	20397	3371	57
2017	53712	31477	2176	57
2018	39991	40940	1818	57
2019	41271	42575	4963	57
2020	32222	54227	4916	57

Iraq plans to increase its share of renewable energy by 10% before 2030. Its most important sources are solar photovoltaic and wind energy technologies, which are easy and quick-to-implement options. Hydroelectric, bio-, and geothermal energy technologies provide supportive and cost-effective investment options in the medium term [20]. The use of renewable energy is essential in achieving sustainable development due to the following.

- The shift towards renewable energy systems helps meet the increasing energy demand.
- Renewable energy applications are environmentally friendly, and their adoption is at the core of sound management of natural resources.
- Renewable energy constitutes a sustainable energy source to mitigate global warming gas emissions, climate change, and the negative impacts on health and the environment.

- Renewable energy is an essential factor that contributes to increasing economic growth, reducing financial restrictions, and employing the workforce to reduce unemployment. Thus, it contributes to achieving economic and social development.

5. CONCLUSION

Renewable energy production in Iraq has not led to sustainable development that considers research results and economic realities. For instance, the reduction in the contribution of hydroelectric power to total energy consumption from 2012 to 2020 has had the unintended consequence of increasing per capita carbon dioxide emissions by 0.6 tons.

Governments play a significant role in adopting renewable energy projects and transitioning from an energy sector reliant on fossil fuels to one based on renewable sources. This shift requires development of policies and strategies that align with the state's capabilities.

Despite Iraq's immense potential for renewable energy, several barriers and challenges exist, encompassing technological, environmental, and economic aspects. It is crucial to emphasize the importance of promoting environmental sustainability by incorporating renewable energy technology into Iraq's development plans. This summary underscores the pivotal role that renewable energy can play in shaping Iraq's future.

Iraq can transform its energy sector and improve the quality of life for its citizens by reducing reliance on fossil fuels, mitigating climate change, enhancing energy security, and creating economic opportunities. Additional benefits of this transition include environmental protection, increased energy accessibility, and support for technological advancement. However, the path to a sustainable future is not without its challenges. It requires establishment of supportive policy frameworks, community involvement, and attracting investment, all of which necessitate careful planning and commitment. Iraq must also collaborate with international partners to leverage expertise and learn from global successes, while sharing knowledge and resources.

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