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Climate Change and Agriculture, Iraqi Case

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Abstract
Iraq is one of the most climate-fragile countries in the world, ranking fifth in terms of climate fragility. Iraq faces numerous challenges in the face of climate change, including declining water levels in the Tigris and Euphrates rivers, depletion of groundwater, the spread of desertification and sand dunes, and increased dust storms. These problems lead to a reduction in the area of arable land, which leads to an increase in the poverty rate, a decline in agricultural production, aggravation of food insecurity and environmental degradation, which leads to major social and economic consequences. This study attempts to gain a deep understanding of the problems facing agriculture in Iraq in light of climate change and to find some quick solutions to these problems.

Keywords: Climate-fragile; Surface water; Tigris river; Euphrates river
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1. Introduction

Climate change refers to long-term changes in the climate system, including temperature and precipitation trends for over decades or more. Climate change can be caused by natural processes or human activities, such as energy use and deforestation, that alter the composition of the atmosphere [1,2]. Currently, climate change presents a significant global challenge [3]. Since 19th century, temperature of earth has been growing with increasing the rate of global warming [4]. Over the 20th century, three factors have been specified as the essentially drivers for global warming, greenhouse gas emissions, increase population growing, and fossil fuels consumption [3]. Agricultural, as the essential for the human survival and evolution, is extremely influenced by climate change [5–7]. Global warming has a lot of effects on agriculture including extreme weather, erratic rainfall, floods and droughts, which reduce yields of crop [8]. Also, climate change disrupts the balance of ecology and influences the control and prevention pests and diseases [9]. Moreover, Climate change impacts rates growth of livestock, reproductive performance, egg and milk production, feed supply, morbidity and mortality. Furthermore, climate change leads to soil degradation and deficiency of land resources, which causes effect of the sustainable development of farming production [10]. This study aims to provide a unique comprehensive and passionate understand of climate change effects on agriculture.

2. Climate change affects crop yields and quality

Climate change impacts crop yields through higher temperatures, altered rainfall patterns, and extreme weather events. These factors are likely to lead to lower yields of major crops; rice, wheat, corn, and soybeans, with regional variations depending on latitude and practices [11]. Elevated temperatures and rainfall patterns change can lead to yield fluctuations and reduced agricultural productivity. Research that examines the influence of elevated temperatures on global cereal, showed that in some areas, elevated temperatures with dropping of precipitation and evapotranspiration, , leads to clear decrease in the crops yields like soybeans and maize, indicating a synergistic effect of both heat and drought on crops [12]. Another study confirmed that elevated one degree Celsius of global temperature, maize, wheat, rice and soybeans yields may globally decline by 3.4%, 2.4%, 0.3%, and 5.0% respectively [13]. Climate change has effects on crop cycle through its impact crops growing period, the flowering and grain-filling periods of crops [14–16]. Climate change can reduction in quality of staple crops through a decline protein, nutrients, vitamins and others compounds. For instance, the content of B1, B2, B5, and B9, and protein, zinc and iron content in rice were decline under a continuous rise in atmospheric CO2 concentration [17]. Another investigate of climate change on wheat revealed that starch and protein content and gluten percentage impacted by change of climatic conditions [18]. All these impacts represent a direct impact of climate change on agriculture (Fig. 1).

3. Effect of climate change on Water management and soil degradation

Climate change impairs the provision of ecosystem services, such as water availability and soil fertility, which are essential for agricultural productivity and food security. The loss of these services can exacerbate food insecurity and environmental degradation [19]. These impacts increase production costs, reduce food quality and quantity, and increase food prices, with significant social and economic consequences [19,20].

Increased rainfall intensity and extreme weather events exacerbate soil erosion and land degradation, reducing the land's ability to support agriculture and natural ecosystems [21]. Climate change also accelerates soil erosion, reduces organic matter, and alters soil structure, leading to decreased fertility and health [20]. Increased evaporation rates due to changes in rainfall and rising temperatures also affect the availability of irrigation water, leading to water management challenges and soil degradation. This impacts crop growth and agricultural productivity [22]. Rising temperatures and changing rainfall patterns also facilitate the spread of pests and diseases, affecting crops and livestock. This increases the risk of disease outbreaks and also reduces agricultural productivity [11]. Greenhouse gas emissions and deforestation with climate change, lead to damage ecosystems as a result of that the environmental impacts on agriculture are getting worse [21].

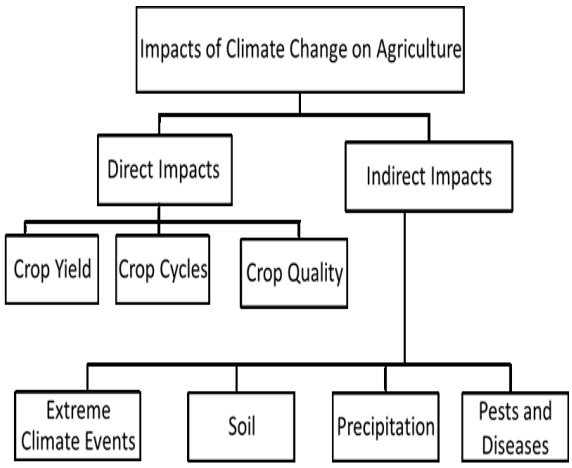

Fig. (1) Direct and Indirect impact of climate change on agriculture

3. Climate change in Iraq

Global analysis shows that rising temperatures and abnormal rainfall (droughts) significantly reduce the total productivity of agricultural factors of production, with developing countries, such as Iraq which is divided into three main climatic zones (Fig. 2), being more severely affected than developed countries [23]. Changes in rainfall patterns resulting from climate change are leading to water shortages, which are critical for Iraqi agriculture, which relies heavily on irrigation. Effective water management strategies and sustainable agricultural practices are essential to mitigate these impacts [24]. Rising temperatures in Iraq have been shown to reduce crop yields, especially for heat-sensitive crops. A study using the Root Zone Water Quality Model (RZWQM2) showed that higher temperatures (2°C and 4°C above normal) had a negative impact on wheat yield, as well as water and nitrogen use efficiency, highlighting the need for adaptive irrigation strategies [25]. Iraq has experienced significant climate change, including rising temperatures and altered rainfall patterns, which has accelerated desertification. These climate changes have led to the spread of sand dunes and the degradation of agricultural land, particularly in central and southern Iraq [26]. Extreme weather events, such as heat waves and droughts, are expected to increase in frequency and intensity, threatening agricultural production in Iraq. These events disrupt planting and harvesting schedules, leading to reduced yields and increased susceptibility to pests and diseases [27]. Unsustainable agricultural practices, such as improper irrigation and overgrazing, have also led to soil salinization and degradation. Population growth and urban expansion have increased pressure on land, exacerbating desertification [28]. Desertification has led to a significant decline in agricultural productivity, and fertile soils are becoming decertified. Desertification degrades soil, reducing its ability to retain nutrients and water, essential for plant growth. Soil degradation is often accompanied by increased salinity, which reduces agricultural productivity [29]. This deterioration threatens food security and the livelihoods of agriculturally dependent communities. Desertification and the spread of sand dunes have severely impacted agricultural populations. Due to the decline in the percentage of fertile soil from more than 80% in 1998 to 42% in 2022 [26]. In Basra, environmental degradation processes, such as desertification and vegetation cover changes, have accelerated due to climate change, contributing to the overall environment.

In Iraq, soil salinity is a chronic problem exacerbated by desertification and climate change, leading to a significant reduction in arable land [29]. Iraq also faces a severe water shortage problem. Since 1984, more than half of its water resources have been lost. Iraq experienced significantly increased drought, particularly between 1998 and 2009. At certain times, up to 87% of the country's area was affected by severe drought [30]. The persistence of atmospheric drought was observed, with years such as 2000, 2008 and 2022 being particularly dry, highlighting the frequency and severity of drought events [31]. For example, 50% decrease in rainfall resulted in negative vegetation anomalies across 62% In Dohuk

Governorate. This highlights the direct impact of drought on agricultural productivity [32].

Dust and sand storms are widespread in Iraq and have a direct negative impact on agriculture. Each additional day of such storms reduces crop production by 0.9% to 3%, causing significant economic losses. Dust and sand storms also reduce vegetation cover, impacting household well-being and exacerbating the challenges facing the agricultural sector [33].

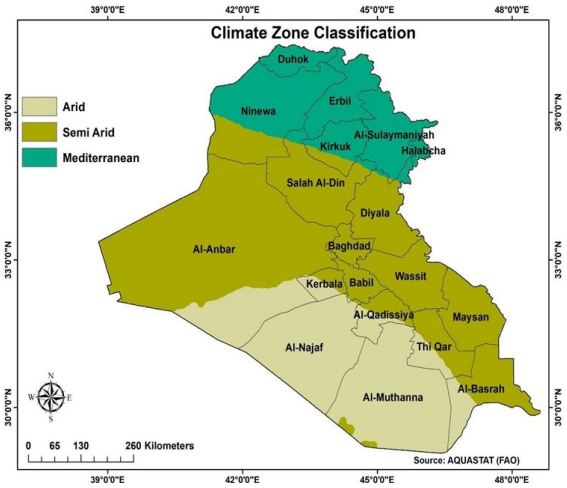

Fig. (2) Climate zone of Iraqi (Based on elevation and rainfall variations, Iraq is divided into three main climatic zones) Source: Iraq Climate Vulnerability Index Report prepared by UNDP Iraq (Effect climate change on Iraqi agriculture)

4. Discussion

Report of Climate Vulnerability Index of Iraq which was prepared by United Nations Development Programme of Iraq (UNDP Iraq), mention that "Iraq is becoming more susceptible to the impacts of climate change, including rising temperatures with more days exceeding 50°C and longer; and overall declining precipitation together with more extreme rainfall events. These changes threaten the country's ecosystems, water resources, and agricultural productivity".

Climate-related water availability (CWA) has declined significantly across Iraq. Water shortages were observed in all seasons except winter in the northern highlands, and crop water demand (CWD) increased, particularly for crops such as wheat, barley, and sorghum, indicating increased irrigation needs. Future projections indicate that crop water requirements (CWA) will further decrease, and that crop water requirements will increase, especially for summer crops, which may lead to increased water stress in agriculture [34]. The loss of water bodies and increased evaporation rates exacerbate water scarcity and pose risks to humans and the environment [26]. The drying up of rivers and lakes and the depletion of groundwater reserves have led to severe water shortages, seriously impacting crop irrigation and livestock production. Desertification leads to a loss of biodiversity, affecting essential ecological processes such as pollination and pest control. This loss further reduces agricultural productivity and resilience [28]. The loss of vegetation cover increases the frequency and intensity of dust storms, negatively impacting air quality and public health. These dust storms also exacerbate land degradation [35]. The degradation of land resources has economic consequences, including reduced agricultural yields and increased costs for land reclamation and water management. This places additional pressure on the Iraqi economy, already vulnerable to political instability [36]. Desertification exacerbates poverty and displacement, as communities lose their livelihoods and are forced to migrate in search of better living conditions. This can increase social tensions and ignite conflicts over scarce resources [28]. Developing climate-resilient crops and agricultural technologies is critical to building resilience to climate change. Strategies include producing drought- and heat-tolerant plants, using biotechnology, and adopting sustainable agricultural practices [27]. While the negative impacts of climate change on Iraqi agriculture are clear, some studies indicate that some regions may experience temporary benefits, such as longer growing seasons due to higher temperatures. However, these benefits are often offset by the negative impacts of extreme weather conditions and water scarcity. Therefore, a comprehensive approach that includes adaptation and mitigation strategies is essential to protect agricultural productivity and food security in Iraq and similar regions [37].

5. Conclusion

Climate change refers to long-term changes in the climate system, including temperature and precipitation trends for over decades or more. Climate change can be caused by natural processes or human activities. Iraq suffer from direct and indirect impacts of climate change. These effects can lead to a reduction in the area of arable land, an increase in the poverty rate, a decline in agricultural production, aggravation of food insecurity and environmental degradation. All these problems can lead to major social and economic consequences.

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